T H E S I S

CONTROL OF THE COMMON MEALYBUG PSEUDOCOCCUS CITRI RISSO IN GREENHOUSES

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INTRODUCTION

The profitable production of vegetables and cut flowers in greenhouses throughout the United States is seriously jeopardized because of the presence of certain destructive insects. Among the various insects that infest greenhouses, the mealybug (Pseudococcus citri Risso) is probably the most universally distributed and most destructive. It is also responsible for considerable damage to the citrus orchards in California.

For many years various methods of control have been attempted with varying degrees of success. It is difficult to kill the insect with sprays because the body of the insect is covered with a waxy secretion, which must be removed with a liquid under pressure, before the insecticide will be effective. Fumigation is dangerous because all types of plants will not withstand the concentration necessary to kill the mealybug.

Other methods of controlling the mealybugs have been tried, especially in the citrus orchards of California. The most outstanding achievement in this line was the introduction of the black ladybird beetle, (Cryptolaemus montrouzieri) Muls., which was successfully established in California in 1892. It was grown in captivity on potato plants, and the larvae liberated on the citrus trees. It resulted in a very satisfactory means of mealybug control.

Outside of the above biological control, nothing worthwhile has ever been accomplished on the control of

the mealybug. The recommended controls most frequently given today are to wash them off the plants with cold water under pressure, fumigation, or spraying with some compound with an oil base, none of which has given satisfaction, or could not be used under varying greenhouse conditions.

The handling of insect pests in greenhouses presents several factors not generally met with an insect control. The first and greatest obstacle is the varieties of different plants which vary so widely in characteristics, many of which will not withstand the general type of treatments recommended for insect control. With this in mind the following project was selected and the numerous experiments conducted in an attempt to find a satisfactory means for mealybug control and still protect the plants by applying different commercial sprays under pressure and different greenhouse conditions, such as temperature and humidity.

REVIEW OF LITERATURE

The citrus mealybug (Pseudococcus citri Risso) has been known to entomologists for many years as a troublesome greenhouse pest, but only in the last 15 or 20 years has it become a general pest. It was first recorded from citrus groves near San Diego in 1880. Cole, F. R. (11) records outbreaks in California in 1885. Since 1885 it has spread rapidly and by 1900 had become a general pest. Because of the severity of the outbreak, considerable attention has been directed toward an effective control.

However, little success in control has been accomplished even to the present time. (Up to 1930 this insect was considered one of the major pests of the citrus industry.)

R. D. Whitmarsh (59), in 1915 was the first one to recommend control of the mealybug. He suggested nicofume fumigation and spraying the plants with tobacco-soap solution. He further recommended a commercial product called "Aphine;" in a solution of which the plants were to be dipped. The method proved impractical because it was necessary to dip all plants at least two or three times.

In 1916 H. B. Weiss (58) showed that all previous recommendations were ineffective as most of them killed the insect only in the larval stage. (Practically all the recommendations were passed on by hearsay, and were based on very little investigation.) He recommended the destruction of badly infested plants at the time of repotting or pulling off of infested leaves and destroying the insects mechanically. For slight infestations, he recommended nicotine fumigation which was to be carried out by hanging up papers soaked in tobacco extract and burning them.

In 1922 C. A. Weigel (56) proposed several types of control, such as syringing with whale-oil soaps, strong soap solution, kerosene or nicotine oleate and even fumigation with HCN gas at the rate of 1/4 ounce of cyanide to 1000 cubic feet of space. The results of his work show conclusively that all recommended controls were

not at all times satisfactory.

E. I. McDaniels, 1924 (31) found that spraying the mealybugs with a strong stream of water was very effective and a cheap method of control. The use of lemon-oil emulsion as a spray, apparently only dislodged the insect from the plants and did not prove satisfactory. She was the first to use any oil preparation on this pest.

In 1925 F. M. Trimble (52) of Pennsylvania suggested kerosene-nicotine-oleate spray and sodium cyanide fumigation as the most favorable control measure. These, however, were not entirely satisfactory.

In 1928 Metcalf and Flint (33) gave the water syringing as the most effective and cheapest method, but found that all plants could not withstand this treatment; in other instances plants were sprayed with nicotine-oleate solution to kill the nymphs and fumigated with hydrocyanic acid gas to kill the adults and eggs.

In 1931, Bentley and Bartlett (3) made the following comment: "One of the most difficult problems which the grower of greenhouse plants has to face is the control of this pest. Nothing has yet been found to kill all stages, so repeated treatments are necessary." They advised two fumigations with calcium cyanide at the rate of one-fourth ounce to one thousand cubic feet of space, and suggested pyrethrum sprays and recommended a mixture of Volck and nicotine as an effective treatment for the nymphs.

F. R. Cole (11) in 1933 found the mealybug had

very few native natural enemies. However, he did find that there were two individual insect enemies, namely; the coccinellid beetle, Cryptolaemus montrouzieri Muls. and a hymenopterous parasite, Leptomastidea abnormis Gir. The former was introduced into California in 1892 from Australia and the latter from Sicily in 1912.

E. P. Breakey (7) in 1934 recommended an emulsion of 1% Halowax, a slight amount of sulphur, and 5% C.P.O. soap for control of mealybug nymphs, for which the emulsion was a hundred percent effective, but for adults it was ineffective.

Joseph M. Ginsburg (25) in 1934 recommended a low boiling petroleum distillate, applied both as a "fog spray" and by dipping house plants into it and then shaking off the excess oil. The dipping gave practically a hundred percent control of the mealybugs on such plants as begonia, coleus, cyclamen, Easter lily, and geranium. This treatment is not practical for greenhouse plants.

OUTLINE OF THE PROJECT

The Pest--its description and hosts:

The common mealybug, Pseudococcus citri Risso, belongs to the order Homoptera, family Coccidae. The adult is a flat whitish appearing insect, three or four millimeters long. The body color is pale yellow with a white waxy covering, which extends out into a tiny fringe beyond the body margin. It is slightly longer at the posterior end. The insect is very sluggish and when it finds a suitable place to feed it settles down and remains in one place for some time. The eggs are deposited in cottony masses upon which the female dies after oviposition.

It requires a week to ten days for the eggs to hatch, and the young remain about ten days in the cottony substance which covered the eggs. They are almost microscopic in size, and of a bright yellow to orange color. In about a week they emerge from the egg mass and begin to scatter out over the leaf surface and soon settle down to feed. By this time they have moulted once and are a light yellow color. The females moult four times during their period of growth but do not change in form. They merely increase in size and the waxy covering becomes heavier. The male forms a cocoon after its second moult, in which it remains from ten days to two weeks, finally emerging a tiny winged gnat-like creature. The life cycle requires a month to six weeks under greenhouse con-

ditions. As there are no regular periodic broods in greenhouses this insect is continuously emerging.

The common mealybug is a pest on a great many plants which are grown in homes and greenhouses. A few of the plants most commonly attacked are: coleus, fuchsia, fern, gardenia, begonia, citrus, geranium, oleander, orchid, poinsettia, umbrella plant, ivy, dracena, chrysanthemum and croton.

Method of Procedure:

Time and Place:--The actual work of plant spraying and taking the data was not begun until Jan 18, 1938, and was rechecked in corresponding months in 1939. This paper is based primarily on the latter experiments. The 1938 experiments were conducted in the entomology greenhouse at Colorado State College and were carried out with the minimum number of insects merely for the purpose of obtaining an indication as to the value of the insecticides available. The experiments were re-checked whenever the insecticides in question gave any satisfactory percent of insect control without burning the plants.

In April, 1938, a laboratory was obtained in a Denver greenhouse, in which further experiments were conducted. Most of these were final checks on the most promising experiments performed in Fort Collins. The number of insects sprayed in these experiments was greater per plant, on the average, than in the previous experiments.

The last group of experiments were performed in February, March and April, 1939, in a laboratory set up in Mt. Harris, Colorado. Over a hundred insects were used in each experiment.

Plants Used:

Most of the plants sprayed were coleus of different varieties. A few carnations were also used. Only the lower parts of these plants was available due to the drying of leaf surface resulting from the necessary resetting of the plants. The heavy infestation of the latter was ideal for kill percentage but the percentage of leaf burning could not be estimated. Of the two plants, coleus was in all cases except one, the more susceptible to burning. Gardenia plants were also used in the check up experiments.

Apparatus:

The spraying machine was a compressed air type consisting of a glass jar of 80 centimeters capacity fitted with a nozzle on its top and connected by a small rubber hose to an air tank holding fifty pounds of pressure. This tank was filled by a small electric, motor-driven, compressed air pump.

Pressure Used:

Usually only twenty and not over twenty-five pounds pressure was used in spraying the coleus as a higher pressure than this washed the insects from the plants before it removed their waxy covering, which removal is necessary before the insecticide becomes effective. Thirty

pounds of pressure was used on the carnations because the egg masses were so thick that they could not be penetrated at a lower pressure.

Number of Applications Used:

When the first application failed to give a satisfactory percent of insect control, the plant was sprayed a second time after approximately six days. This second spray was a better indication of the effect of the insecticide upon the insects. The second date given under the experiments is the date of the second spray.

If the first application burned the plant without killing the insects a second spray was not applied, because it was obviously impractical to use a spray which burned the foliage. This factor also determined what dilutions should be used in the experiments. If a certain dilution burned the foliage, stronger concentrations were omitted.

In order to be effective in the control of mealybugs, a spray should give eighty to one hundred per cent kill with the second application. Any percentage of control less than the above is not satisfactory, on account of the rapid multiplication of the insects.

Computation of the Number of Insects Used in Each Experiment:

Before the plants were sprayed, the insects were carefully counted, and recorded. In the presence of the egg masses and a great number of nymphs it was impossible to actually count them, they were, however, counted as far as possible and the other materials, (nymphs and egg masses)

were carefully estimated.

After both the first and second applications, the living insects were recorded. A microscope was used to determine the condition of nymphs which were sprayed before they left the cottony-covering of the egg mass.

Computation of Leaf-Burn:

The percentage of leaf-burn and tip-burn was estimated by comparing the percentage of the burned surface to the total leaf area sprayed.

Cause of insect death from insecticides:

There are only two ways in which an insect may be killed by an insecticide: by a stomach poison, or by a "contact" spray. A stomach poison is used to kill insects which have chewing mouth parts, such as grasshoppers, ants, and the larvae of various lepidoptera. In the case of insects that suck the juices from the leaves of a plant, a stomach poison would be of no value, because the mouth-parts of the insect are inserted through the poison and the food is taken from below the surface of the leaf. This is the case with such insects as mealybugs, aphids, and scale insects, etc.

In the case of a contact spray, death probably results from the suffocation of the insect brought about by closing the spiracles thus preventing the insect from obtaining oxygen through them, or by the specific insecticide in question attacking and destroying the insect tissue. The specific reaction of nicotine, thiocyanate, pyrethrum, derris and other contacts upon insects has not been def-

initely determined.

Temperature and Humidity:

In this series of experiments a record was kept of the temperature and humidity of the room at the time the plants were sprayed. From these data it is evident that a high temperature and high humidity made the sprays more effective in killing the insects.

MATERIALS USED TO DETERMINE THE VALUE OF THE VARIOUS INSECTICIDES

Twenty-five commercial insecticides were used in this series of experiments, all of which were used at the dilutions recommended by the manufacturers. If the insecticide showed promise of being effective, it was used at greater dilutions than those recommended. Lower dilutions were used wherever there was any possibility of obtaining a percentage of effectiveness without burning the plant. Such cases were few, however, because insecticides that were not effective at a dilution which the plant could withstand, showed little or no promise in lower dilutions.

The various insecticides will be briefly discussed as they come in alphabetical order. The tabulations will give the results of their effectiveness. The constituents of the commercial product will be given for all as far as available, from data taken from their containers and that obtained from the manufacturer. It must be borne in mind that this data will be rather meager because commercial companies are not prone to divulge their trade secrets.

Aresket 240: A light miscible oil containing its own emulsifier. It is a mono butyldiphenyl sodium mono-sulphonate. No recommendations for its use given on the container. It was used at a dilution beginning at one part to a hundred parts of water, and in greater dilutions until no insecticidal value resulted from the experiment. Carnations are used in Experiment 42a. The details of these experiments are tabulated below:

Table I. SHOWING THE EFFECT OF ARASKET 240 ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
42a	3-27	1-100	150	75	24	38	25	0
42a-1	3-6	1-100	50	78	32	15	30	0
	3-11	1-100	35	98	18	8	22.8	0
42a-2	3-6	1-100	60	78	78	20	33	0
	3-11	1-100	40	90	18	12	30	0
42b	4-12	1-100	50	68	20	0	0	10
43	2-16	1-200	45	56	48	0	0	0
	2-22	1-200	45	70	38	0	0	0
43-1	3-6	1-200	50	78	32	5	10	0
	3-11	1-200	45	90	18	9	20	0
43-2	3-6	1-200	100	78	32	80	20	0
	3-11	1-200	80	90	18	20	25	0
43-3	3-6	1-200	75	78	32	18	24	0
	3-11	1-200	57	90	18	14	24.56	0
43-4	3-6	1-200	55	78	32	11	20	0
	3-11	1-200	44	90	18	8	18	0
43-5	3-6	1-200	50	78	32	15	30	0
	3-11	1-200	35	90	18	8	22.8	0
43-6	3-6	1-200	60	78	32	6	10	0
	3-11	1-200	54	90	18	9	16.6	0
44-1	3-6	1-300	40	78	32	4	10	0
	3-11	1-300	36	90	18	6	16.6	0
44-2	3-6	1-300	50	78	32	5	10	0
	3-11	1-300	45	90	18	5	11	0
44-3	3-6	1-300	50	78	32	7	14	0
	3-11	1-300	43	90	18	8	18.6	0
44-4	3-6	1-300	45	78	32	7	15	0
	3-11	1-300	38	90	18	8	21	0
44	2-16	1-300	30	56	48	0	0	0
	2-22	1-300	30	70	38	0	0	0
45	2-16	1-400	25	56	48	0	0	0
	2-22	1-400	25	70	38	0	0	0
45-1	3-6	1-400	90	78	32	27	30	0
	3-11	1-400	73	90	18	21	28.7	0
45-2	3-6	1-400	100	78	32	25	25	0
	3-11	1-400	76	90	18	18	25	0
45-3	3-6	1-400	75	78	32	15	20	0
	3-11	1-400	60	90	18	12	20	0

From the above it is evident that Aresket 240 can not be recommended for the control of mealybugs, as the maximum precent of control was only 30. If used at a dilution strong enough to obtain even this partial control, it is injurious to the plant. Carnations did not show any burning after one application at a dilution of one part to a hundred parts of water, but the same dilution when used on coleus caused so great a leaf-drop that a second spray was not attempted, as there apparently was no insecticidal value from this product.

Black Leaf 40: A heavy oil containing 40% nicotine sulphate. It is an insecticide which can be used either as a contact spray or a fumigant. For the former, in greenhouses it is recommended to be used at a dilution of one part to fifty parts of water. This material does not emulsify readily in water, therefore it was necessary to add a little fish oil soap in these experiments.

Table IIA. SHOWING THE EFFECT OF BLACK LEAF 40 AND SOAP ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
9a	3-12	1-50	60	88	21	24	40	0
	3-22	1-50	36	80	19	18	50	0
9b	3-12	1-50	75	88	21	42	56	0
	3-22	1-50	33	80	19	28	85	0
9c	3-12	1-50	68	88	21	54	79.4	0
	3-22	1-50	13	80	19	13	100	0
9d	3-12	1-50	50	88	21	35	70	0
	3-22	1-50	15	80	19	12	80	0
9e	3-12	1-50	70	88	21	7	10	0
	3-22	1-50	63	80	19	31	49.2	0

Black Leaf 40, when used with soap, gave a fairly high percentage of kill without injuring the plant. These precentages varied somewhat due to thoroughness of application. The average control is 60% to 75%.

Cubor Spray:- A stomach poison which contains twenty-nine percent alcohol, fourteen percent acetone, rotenone. 2.5% Cube resins 5%, sulphur 14%, water 35.5%. This could have very little, if any, effect as a contact spray. However, one experiment was set up using it. The results are shown below.

Table III. SHOWING THE EFFECT OF CUBOR SPRAY ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
4	1-19	1-100	50	70	47	0	0	0
	1-28	1-100	50	70	45	0	0	0

Derrisol: A heavy oil containing one to one and one-half percent derris extract, four percent sulphonated Castor oil, and ninety-five percent inert matter. Several tests at various strengths were made as follows:

Table IV. SHOWING THE EFFECT OF DERRISOL ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
65a	2-26	1-500	100	70	44	90	90	0
65b	3-5	1-500	50	90	20	0	0	0
	3-9	1-500	50	88	26	0	0	0
65c	4-23	1-500	60	72	23	60	100	0
65a-1	2-20	1-500	40	60	16	4	10	0
	2-26	1-500	36	98	18	32	88.8	0
65a-2	2-20	1-500	50	60	16	5	10	0
	2-26	1-500	45	98	18	42	93	0
65a-3	2-20	1-500	58	60	16	19	32.7	0
	2-26	1-500	40	98	18	37	92.5	2
65a-4	3-6	1-500	200	78	32	190	95	0
	3-12	1-500	10	88	21	10	100	0
65a-5	3-6	1-500	100	78	32	90	90	0
	3-12	1-500	10	88	21	10	100	0
65a-6	3-6	1-500	150	78	32	140	90	0
	3-12	1-500	10	88	21	10	100	0
64	2-26	1-600	90	70	44	0	0	0
	3-5	1-600	90	82	32	0	0	0
63a	2-25	1-700	80	74	42	15	18,7	0
	3-5	1-700	65	85	30	13	20	0
63b	4-23	1-700	100	72	23	0	0	0
	4-28	1-700	100	69	24	0	0	0
63a-1	3-12	1-700	100	88	21	10	10	0
63a-2	3-12	1-700	150	88	21	7	4	0
	3-22	1-700	80	80	19	7	8.2	0

Derrisol was ineffective in the control of the mealybugs when used at greater dilutions than one part to five hundred parts of water.

In the first three experiments performed with it at the dilution of one part to five hundred parts water (65a,65b,65c) the results were somewhat contradictory. The first and third experiments gave from 90 to 100 percent control with the first spray. In the second experiment two applications were ineffective. The latter experiment was performed in a much higher temperature and greater humidity than the first and third, which may account for the results obtained; but the dilutions were the same.

A very satisfactory control can be obtained spraying with a mixture of 1 to 500 parts water when the temperature ranges from 78 to 88°F.

Dibug: A commercial preparation of light oil and pyrethrum extract in sprayene, containing no emulsifier. A small percentage of it will go into solution with water, but it quickly separates. To obtain the best results it must emulsify with soap; fish oil soap is preferable. The latter was used in these experiments. Dilutions and results are as follows:

Table V. SHOWING THE EFFECTS OF DIBUG ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
57a	2-24	1-100	55	71	47	45	81.8	0
	3-2	1-100	10	86	14	10	100	0
57b	3-17	1-100	100	76	40	0	0	0
	3-23	1-100	100	81	22	0	0	0
57c	3-7	1-100	150	70	45	15	10	0
	3-14	1-100	135	68	32	99	73.3	0
57d	4-8	1-100	100	60	30	0	0	2
	4-14	1-100	100	67	20	50	50	0
57e	4-23	1-100	60	72	23	0	0	0
	4-28	1-100	60	69	26	0	0	0
57f	2-20	1-100	200	80	14	160	80	0
	2-26	1-100	40	98	18	32	80	0
57g	2-20	1-100	150	80	14	105	70	0
	2-26	1-100	45	98	18	39	86	0
57h	2-19	1-100	200	60	17	180	90	0
	2-26	1-100	20	98	18	19	95	0
58	2-24	1-200	50	71	47	0	0	0
	3-2	1-200	50	84	14	0	0	0
60	2-24	1-200	75	71	47	8	10	0
	3-2	1-200	67	84	14	7	10	0
60a	3-6	1-200	200	78	32	80	40	0
	3-11	1-200	120	90	18	118	98	0
60b	3-6	1-200	100	78	32	50	50	0
	3-11	1-200	50	90	18	46	92	0
60c	3-6	1-200	150	78	32	42	28	0
	3-11	1-200	108	90	18	76	70	0
60d	3-6	1-200	200	78	32	80	40	0
	3-11	1-200	120	90	18	96	80	0
61a	3-6	1-300	50	78	32	16	32	0
	3-11	1-300	44	90	18	16	36	0
61b	3-6	1-300	75	78	32	8	10.6	0
	3-11	1-300	67	90	18	22	32.8	0
61c	3-6	1-300	64	78	32	18	28.1	0
	3-11	1-300	46	90	18	20	43	0
61d	3-6	1-300	50	78	32	6	12	0
	3-11	1-300	44	90	18	13	29.5	0
61e	3-6	1-300	100	78	32	50	50	0
	3-11	1-300	50	90	18	44	88	0
59	2-24	1-400	80	71	47	16	20	0
	3-2	1-400	64	84	14	13	20	0
59a	4-23	1-400	40	72	23	0	0	0
	4-28	1-400	40	69	24	10	25	0
59b	3-6	1-400	100	78	32	0	0	0
	3-11	1-400	100	90	18	95	95	0
59c	3-6	1-1400	100	78	32	0	0	0
	3-11	1-400	100	90	18	100	100	0
59d	3-6	1-400	60	78	32	0	0	0
	3-11	1-400	60	90	18	60	100	0

Dibug, when used at a dilution of one part to one hundred parts of water gave results varying for the first spray from zero to ninety percent control, while the second application ranged from zero to one hundred percent control, depending somewhat on the result of the first spray and the temperature. The first experiment showed a hundred percent control after a second spray was used. Considering these results, Dibug is only partially effective as a control measure for the mealybug, and therefore cannot be recommended.

Evergreen:-A heavy oil containing a combination of pyrethrins totaling 1.8% by weight; pine oil, potassium, soap, etc. It is recommended for dormant spraying out of doors. This product was not effective against mealybugs, although the dilution of one part to five hundred parts of water did not burn the foliage. The three cases of leaf burn at a dilution of one to two hundred parts water are unexplained. Fifteen experiments were conducted, with various dilutions of the insecticide. Dilutions of over one part Evergreento two hundred parts of water were ineffective.

Table VI. SHOWING THE EFFECT OF EVERGREEN ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
52	2-24	1-100	40	71	27	6	15	0
	3-2	1-100	34	88	14	17	50	0
52a	3-6	1-100	44	78	32	22	50	0
	3-11	1-100	22	90	18	12	54.5	0
52b	3-6	1-100	60	78	32	54	90	0
	3-11	1-100	6	90	18	0	0	0
52c	3-6	1-100	64	78	32	6	9.3	0
	3-11	1-100	58	90	18	9	15	0
52d	3-6	1-100	60	78	32	60	0	0
	3-11	1-100	60	90	18	9	15	0
53	2-24	1-200	100	71	27	10	10	0
	3-2	1-200	90	88	14	18	20	0
53a	3-12	1-200	100	88	21	25	25	0
	3-22	1-200	75	80	19	22	29	0
53b	3-12	1-200	60	88	21	6	10	0
	3-22	1-200	54	80	19	46	85	3
53c	3-12	1-200	80	88	21	72	90	0
	3-22	1-200	8	80	19	0	0	2
53d	3-12	1-200	75	88	21	56	74.6	0
	3-22	1-200	29	80	19	17	58.6	3
54	2-24	1-300	50	71	27	0	0	0
	3-2	1-300	50	86	14	0	0	0
54a	3-22	1-300	50	90	23	5	10	0
54b	3-22	1-300	100	90	23	10	10	0
55	2-24	1-400	40	71	27	0	0	0
	3-2	1-400	40	86	14	0	0	0
66	2-24	1-500	35	71	27	0	0	0
	3-2	1-500	35	86	14	0	0	0

When using Evergreen at a dilution of one part to one 100 parts of water, one-half of the insects were killed as a result of two applications and even lower kill followed when the insecticide was applied at the rate of one part to two hundred parts of water; the first application of the latter killing an additional twenty percent. In dilutions greater than one to two hundred parts of water, the spray possessed no insecticidal value.

Isco:-A very light oil spray with a pyrethrum base, supposed to contain one hundred percent active ingredients. It is easy and pleasant to use, spreads quickly, and a fine misty spray can be obtained at a pressure of twenty pounds. It adheres to the plant very well, and if applied with care there is very little run off, but it does not emulsify readily when diluted with water, consequently in each experiment a little fish oil soap was added to the mixture as an emulsifier. Because of its oily nature it cannot be used on plants without a special sprayer which finely atomizes the oil. Such a sprayer was not available for these experiments, and where the plants were not injured, it was because they did not get enough oil on them to burn the tissue. For the best results it is recommended to be used without dilution, but for the sake of experimentation it was also used at a dilution of one to one, and one to two parts of water. This material was one of the most effective of the control materials as will be noted by the table of results that follows.

Table VII. SHOWING THE EFFECT OF ISCO ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
39a	2-15	Straight	40	66	44	36	90	0
39b	2-15	"	40	66	44	40	100	0
39c	4-23	"	30	70	26	30	100	0
39a-1	3-23	"	30	80	22	24	80	3
39a-2	3-23	"	50	80	22	50	100	0
39a-3	3-23	"	60	80	22	60	100	25
40a	2-15	1-1	40	66	44	30	75	10
	2-21	1-1	10	68	45	9	90	50
40b	3-21	1-1	25	78	15	25	100	0
40c	4-23	1-1	20	70	26	20	100	10
50	2-16	1-2	25	70	26	25	100	100

Experiment number 40b was on carnations. It showed a hundred percent control of the insects, with no burning of the plant foliage. However, in all cases where coleus were used foliage burning took place even though the material was diluted and soap added, (experiments 40a,40c, and 50). This was undoubtedly due to the action of the oil and the soap. Therefore, it seems that Isco when used straight, as recommended by the manufacturers, is effective on mealybugs. While this material kills equally well in slight dilutions it will not emulsify in water alone; soap, therefore, must be added. As the addition of soap gives burning results and is necessary when water is used, Isco cannot be recommended in any

dilution.

Kaloil:- A self-spreading complete pyrethrum spray, containing seventy-six and five-tenths percent oxidized petroleum hydrocarbons (thirty-six to forty degrees Baume) sulfonated, fourteen and seventy-five hundredths percent unreacted petroleum hydrocarbons (forty-five to fifty degrees Baume), and eight and seventy-five hundredths percent inert material. In all the tests made with Kaloil there was no evidence of kill where only one spray was used; two applications gave only a partial control. This is noted in the following table.

Table VIII. SHOWING THE EFFECT OF KALOIL ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
37a	4-26	1-100	25	70	31	0	0	0
37a-1	2-19	1-100	100	80	24	70	70	0
	2-26	1-100	30	98	18	24	80	0
37a-2	2-19	1-100	120	80	24	96	80	0
	2-26	1-100	24	98	18	20	83.3	0
37a-3	3-12	1-100	60	88	21	54	90	0
	3-23	1-100	6	80	22	0	0	0
37a-4	3-12	1-100	60	88	21	60	100	0
37a-5	3-12	1-100	72	88	21	32	44.4	0
	3-23	1-100	40	80	22	36	90	1
37a-6	3-12	1-100	75	88	21	60	80	0
	3-23	1-100	15	80	22	13	86.6	1
37a-7	3-12	1-100	100	88	21	90	90	0
	3-23	1-100	10	80	22	10	100	0
37b	4-26	1-150	25	70	31	0	0	2
37b-1	3-22	1-150	50	90	23	0	0	1
37b-2	3-22	1-150	30	90	23	0	0	5
37c	2-15	1-200	100	66	44	0	0	0
	2-21	1-200	100	68	45	10	10	0
37c-1	3-22	1-200	80	90	23	40	50	10
37d	4-26	1-300	25	70	31	0	0	0
37d-1	3-22	1-300	60	90	23	6	10	5
37d-2	3-22	1-300	100	90	23	15	15	5
38a	2-15	1-400	15	66	44	0	0	0
	2-21	1-400	15	68	45	7	46.6	0
38a-1	3-22	1-400	40	90	23	4	10	0
	3-27	1-400	36	88	21	3	8.3	0
38a-2	3-22	1-400	50	90	23	0	0	1
	3-27	1-400	50	88	21	0	0	25
38b	4-26	1-400	30	70	31	0	0	0

The above experiments show that Kaloil, when used at the rate of one part to one hundred of water, was fairly effective in the control of the mealybug if the temperature of the room was 80°F or above at the time of the application.

Lemon Oil:-An oil that contains six percent dry soap; five-tenths percent potassium carbonate; three and five-tenths percent vegetable oil; five percent turpentine and eighty-five percent water. When used at the recommended rate Lemon Oil is a satisfactory material for combating mealybugs, but is rather expensive. The recommended dilution is one part to sixteen parts of water, but even one part to twenty parts of water gives a spray which is quite effective. Eighteen experiments were conducted. The results from the dilution in Experiment No. 118 is rather a puzzle, repetition of this experiment failed to give the same results.

Table IX. SHOWING THE EFFECT OF LEMON OIL ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
117b	4-8	1-16	30	60	30	30	100	0
117b-1	4-22	1-16	25	70	20	19	76	0
117a-1	2-19	1-16	80	80	24	65	81.2	0
	2-26	1-16	15	98	18	15	100	0
117a-2	2-19	1-16	60	80	24	60	100	0
119a	4-8	1-20	50	60	30	50	100	0
119b	4-22	1-20	62	70	20	55	88.7	0
119a-1	2-19	1-20	150	80	24	126	84	0
	2-26	1-20	24	98	18	19	79.1	0
120	4-8	1-24	50	60	30	0	0	0
	4-14	1-24	50	67	20	35	70	0
120a	3-22	1-24	120	90	23	0	0	0
	3-27	1-24	120	88	21	0	0	0
120b	3-22	1-24	40	90	23	4	10	0
	3-27	1-24	36	88	21	3	8.3	0
121	4-8	1-28	100	60	30	10	10	0
	4-14	1-28	90	65	20	81	90	0
121a	3-22	1-28	150	90	23	126	84	0
121b	3-22	1-28	60	90	23	30	50	0
122	4-8	1-30	45	60	30	0	0	0
	4-14	1-30	45	67	20	0	0	0
122a	3-22	1-30	40	90	23	0	0	0
	3-27	1-30	40	88	21	0	0	0
122b	3-22	1-30	50	90	23	0	0	0
	3-27	1-30	50	88	21	0	0	2
118	4-8	1-32	200	62	28	180	90	0
	4-14	1-32	20	65	22	18	90	0
118a	3-22	1-32	50	90	23	0	0	0
	3-27	1-32	50	88	21	0	0	0

Lemon Oil in most cases killed ninety to one hundred percent of the mealybugs when used at the rate of one part to sixteen or twenty parts of water. Above this it was not at all effective, however, in Experiment 118, using Lemon Oil at a dilution of one part to thirty-two parts of water ninety percent control was obtained. This experiment was repeated twice, but the above percent of kill was never again obtained. The discrepency was probably due to differences in greenhouse conditions.

Lethane 384:- In consistency this is the thinnest of the three Lethane insecticides used; a lighter oil than either Lethane 420 or Lethane 440. It contains 50% by volume of beta-butoxy beta-thicyano diethyl ether which is its principle toxic agent, standardized with petroleum distillate. It was necessary to use soap in these experiments as an emulsifier. It was found proportionately less effective against mealybugs than the other two brands used. For that reason, only four experiments were performed with it. When used at a dilution of less than one part to four hundred parts of water, burning of the plants resulted. It, therefore, cannot be recommended for the control of mealybugs.

Table X. SHOWING THE EFFECT OF LETHANE 384 ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
111a	3-22	1-100	50	68	56	50	100	100
80	3-1	1-200	50	84	21	0	0	2
80a	3-22	1-200	60	90	23	60	100	0
80b	3-22	1-200	60	90	23	60	100	0
111b	4-8	1-300	200	60	30	150	75	2
	4-14	1-300	50	65	20	45	90	2
111b-1	2-20	1-300	150	60	15	105	70	0
	2-26	1-300	45	98	18	42	93.3	0
111b-2	3-12	1-300	100	88	21	80	80	0
	3-22	1-300	20	80	19	17	85	2
111c	4-9	1-400	55	68	18	0	0	0
	4-15	1-400	55	65	30	0	0	0
111c-1	3-22	1-400	40	90	23	25	62.5	0
	3-27	1-400	15	88	21	12	80	0
111c-2	3-22	1-400	50	90	23	25	50	0
	3-27	1-400	25	88	21	20	80	0

When used at the dilution of one part to three hundred parts of water, Lethane 384 was quite effective in killing mealybugs, but even at that dilution it burned coleus enough to make it impractical for common use on these plants.

Lethane 420:-A aliphatic thiocyanate contact spray somewhat heavier than Lethane 384 which is considerably more effective in controlling mealybugs. It consists of 50% by volume of the aliphatic thiocyanate mentioned in connection with Lethane 384, plus 50% emulsifier wetting agent and diluent. (Experiment 1c was on Ivy).

Table XI. SHOWING THE EFFECT OF LETHANE 420 ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
1a	1-18	1-100	10	68	46	10	100	0
1b	1-20	1-100	80	70	47	40	50	0
	1-28	1-100	40	70	45	32	80	2
	2-4	1-100 (3d)	8	78	40	8	100	5
1c	3-1	1-100	20	84	21	5	25	1
	3-6	1-100	15	72	36	12	80	3
	3-12	1-100 (3d)	3	82	30	3	100	6
27	2-6	1-400	100	78	40	20	20	0
	2-12	1-400	80	76	34	72	90	5
28a	2-6	1-800	100	78	42	50	50	0
28b	4-14	1-800	30	70	20	0	0	0
	4-20	1-800	30	68	15	15	50	[illegible]

Of the insecticides tried by themselves, the Lethanes showed more promise than any other, considering the amount they were diluted. However, in only one case, Experiment 1, did Lethane 420 kill all the insects with one application.

When applied at the rate of one part to four hundred parts water, three applications were necessary to obtain the desired results. A slight burning, not over five to ten percent in any case, followed the second and third sprays.

Lethane 440:-A thiocyanate contact spray, consisting of 25% by volume of aliphatic thiocyanate and 75% emulsifier wetting agent and diluent. Its insecticidal value is claimed to be greater than that of Lethane 420. (Experiment 113a was on carnations).

Table XII. SHOWING THE EFFECT OF LETHANE 440 ON MEALYBUGS

Exp. No.	Date of Spray 1939	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
17a	1-29	1-200	200	60	45	180	90	0
	2-6	1-200	20	78	40	18	90	2
17b	4-26	1-200	25	70	31	0	0	2
17a-1	3-22	1-200	40	90	23	30	75	0
17a-2	3-22	1-200	64	90	23	49	76.5	0
17c	4-26	1-300	50	70	31	0	0	0
17c-1	3-22	1-300	45	90	23	0	0	0
	3-27	1-300	45	88	21	38	84.4	0
17c-2	3-22	1-300	40	90	23	0	0	0
	3-27	1-300	40	88	31	40	100	8
1a	4-8	1-400	30	60	30	0	0	2
	4-14	1-400	30	68	20	0	0	5
1a-1	3-22	1-400	50	90	23	5	10	0
	3-27	1-400	45	88	21	26	57.7	2
1a-2	3-22	1-400	50	90	23	5	10	0
	3-27	1-400	45	88	21	22	48.8	0
1b	4-20	1-400	30	68	15	15	50	0
	4-26	1-400	15	70	31	8	53.3	0
113a	3-22	1-400	100	70	50	100	100	10
113b	4-26	1-400	25	70	31	0	0	0

Lethane 440 was not used stronger than one part to two hundred parts of water. At this dilution ninety-five percent of the insects were killed with the second application, but this was accompanied by a two percent foliage burning. The dilutions of one part to three and four hundred parts water were ineffective even after a second application. Because of variations in the results when used at the rate of one part to four hundred parts of water, no conclusions were drawn. However, this dilution was too strong for use even on carnations, but did not injure coleus. This is somewhat contradictory to results from other insecticides used, as the burning results were generally the reverse. It seems unlikely that this material would give satisfactory, if any, control for insects in general.

Loro:-A medium heavy oil, containing ninety percent active ingredients and ten percent water.

Table XIII. SHOWING THE EFFECT OF LORO ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
6a	1-19	1-300	100	70	47	80	80	0
	1-28	1-300	20	70	45	20	100	2
6a-1	3-22	1-300	150	90	23	150	100	2
6a-2	3-22	1-300	60	90	23	54	90	2
	3-27	1-300	6	40	88	6	100	30
6b	4-8	1-300	25	60	30	25	100	2
6c	4-22	1-300	45	70	20	45	100	30
7a	1-19	1-300	120	70	48	108	90	0
	1-28	1-300	12	70	45	12	100	5
7b	4-9	1-300	100	60	27	90	90	2
	4-14	1-300	10	67	20	10	100	5
7c	4-11	1-400	60	68	18	30	50	3
	4-18	1-400	30	70	15	30	100	2

Loro gave excellent results for mealybug control even when used at a dilution up to one part to four hundred parts of water, but in all cases there was slight burning, but not enough to injure the plant seriously. Soap used with this product (Experiments 7a, 7b, 7c) did not increase the burning as it did in cases when used with other insecticides, but just as high a percentage of kill was obtained without it, consequently it is not necessary to add soap to this product.

Melrosine: A thick, dark insecticide containing eighty-five percent water, the active ingredients are apparently a secret compound. It is recommended to be used at a dilution of one part to twenty-five parts of

of water. It is particularly recommended for rose insects, especially the rose weevil. In the first experiment it gave a hundred percent kill after the second application, but low insect population on the plants and other factors, might have influenced the experiment, as in the other experiments where the insects were numerous, only the nymphs were killed; the adults were not affected in any way. Experiments 61b and 61c were on carnations.

Table XIV. SHOWING THE EFFECT OF MELROSINE ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
61a	2-24	1-25	50	71	47	10	20	0
	3-2	1-25	40	88	14	40	100	0
61a-1	3-22	1-25	45	90	23	15	33.33	2
	3-27	1-25	25	88	21	17	68	0
61b	3-27	1-25	100	84	24	0	0	0
61c	3-22	1-25	100	76	46	50	50	0
	3-30	1-25	50	75	43	25	50	0

Multicide: A light oil, containing a combination of pyrethrins totaling 1.8% by weight; pine oil, potassium, soap, etc. It gave such a low percentage of kill even at comparatively low dilutions, that it cannot be recommended as a control for this pest.

Table XV. SHOWING THE EFFECT OF MULTICIDE ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
95	3-12	1-50	50	82	30	40	80	0
96a	3-12	1-100	50	82	30	40	80	0
96a-1	3-22	1-100	60	80	22	30	50	0
	3-27	1-100	30	88	23	15	50	0
96a-2	3-22	1-100	30	80	22	15	50	0
	3-27	1-100	15	88	23	7	46.6	0
96b	3-27	1-100	66	72	28	55	83.3	0
97a	3-12	1-200	58	80	28	58	100	0
97a-1	3-23	1-200	45	80	22	22	48.8	0
	3-27	1-200	22	88	23	11	50	0
97a-2	3-23	1-200	72	80	22	36	50	0
97b	3-23	1-200	150	66	48	75	50	0
	3-30	1-200	75	72	38	37	49.3	0
98	3-12	1-300	25	80	28	0	0	0
	3-18	1-300	25	62	32	0	0	0
99	3-12	1-400	30	80	26	0	0	0
	3-18	1-400	30	62	31	0	0	0
100	3-12	1-500	100	80	25	0	0	0
	3-18	1-500	100	63	30	0	0	0

Dilutions of one part to fifty and one part to one hundred parts of water, effected eighty to ninety per-cent control without burning of coleus foliage. One part to two hundred parts of water gave a hundred per-cent control on 60 insects. It is doubtful if this percentage would prove out with a greater number of insects. When tried on carnations with a hundred and fifty insects, only the nymphs were killed. Dilutions

above one part to 300 parts of water possessed no insecticidal value on mealybugs.

Nico-Fume: A liquid containing forty percent free nicotine and sixty percent inert ingredients. This preparation is intended primarily for fumigation, but mixes readily with water and may be used as a spray.

Table XVI. SHOWING THE EFFECT OF NICO-FUME ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
17	1-28	1-100	50	70	45	25	50	0
	2-6	1-100	25	78	40	12	48	0
17a	2-20	1-100	125	60	17	62	49.6	0
	2-26	1-100	63	98	18	36	57.1	0
17a-1	3-22	1-100	100	90	23	90	90	0
	3-27	1-100	10	88	21	10	100	0
17a-2	3-22	1-100	120	90	23	120	100	0
8a	4-11	1-150	25	65	20	0	0	10
8b	4-11	1-150	30	65	20	0	0	10
8c	1-20	1-200	25	70	47	0	0	0

As a contact spray for mealy-bugs Nico-Fume shows promise of being effective when used in a warm room. At temperatures below 80° dilutions of one part to one hundred parts of water killed only half the insects even with two applications. Dilutions of one part to one hundred and fifty parts of water at temperature of 65°F killed none of the insects, and burned at least ten percent of the foliage.

Nicona: A very thick oil emulsion having a tar consistency with nicotine incorporated, made especially

for orchard use. It mixes well in water, forming a milky liquid. The manufacturers recommend it to be used at the rate of from one to three parts in one hundred parts of water. It was used at lower dilutions in this series of experiments. Carnations were used in Experiments 91b and 93c.

Table XVII. SHOWING THE EFFECT OF NICONA ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
94a	3-12	1-30	25	80	35	25	100	0
94b	4-23	1-30	30	72	32	30	100	0
91a	3-12	1-50	35	75	40	35	100	0
91b	3-21	1-50	30	72	16	24	80	Severe
92	3-12	1-100	110	75	38	22	20	0
93a	3-21	1-200	200	72	16	50	25	0
	3-30	1-200	150	71	41	36	24	0
93b	4-26	1-200	44	70	31	44	100	0

Nicona diluted to one part to thirty parts of water, gave a hundred percent control with only one application without injuring the foliage of coleus. At the rate of one part to fifty parts of water, the control varied from eighty to a hundred percent. The hundred percent control obtained with Nicona at the rate of one part to two hundred parts of water was, no doubt, due to outside factors , as those mentioned above in other experiments, such as greenhouse conditions , temperature and humidity.

Nik-Emo: A refined oil emulsion containing one and

five-tenths percent free nicotine, eighteen and five-tenths percent unsulfonated residue, and eighty percent selected hydrocarbon oils, mixing readily with water. This material was among the best tested in these experiments as is shown in the following table.

Table XVIII. SHOWING THE EFFECT OF NIK-EMO ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
3a	1-18	1-100	75	75	46	60	80	0
	1-28	1-100	15	70	45	14	93.3	3
3a-1	2-20	1-100	120	60	24	90	75	0
	2-26	1-100	30	98	18	25	83.3	0
3b	4-8	1-100	100	60	30	90	90	0
	4-14	1-100	10	67	20	9	90	0
3c	4-15	1-100	45	65	30	45	100	0
3d	4-15	1-100	100	65	30	100	100	0

Nik-Emo diluted one part to a hundred parts of water gave one of the best controls of all the insecticides used. One hundred percent effectiveness did not always follow the first spraying, but the percentage was sufficient to recommend its use. No other dilutions were tried because this particular one showed enough foliage burning, especially on second application to make lower dilutions inadvisable.

Non-Po Concentrate: A preparation containing thirty-five percent active ingredients, with a minimum of 8% Derris and rotenone, five percent inorganic salts, thirty percent inerts, and thirty percent water. It

was totally ineffective against the mealybugs at a dilution of one part to a hundred parts of water, and at lower dilutions, it burned the plant and still was ineffective in insect control.

Table XIX. SHOWING THE EFFECT OF NON-PO CONCENTRATE ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
5	1-19	1-100	50	47	50	0	0	0
	1-28	1-100	50	70	45	0	0	0
12	1-21	1-75	30	74	38	0	0	0
	2-1	1-75	30	50	45	0	0	0

Penetrol: A standardized uniform miscible oil compound containing oxidized petroleum hydrocarbons sulphonated (32°-40° Baume) 90% and inert ingredients 10%. Soap was used in Experiment 23.

Table XX. SHOWING THE EFFECT OF PENETROL ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
2	1-18	1-100	20	68	46	0	0	0
	1-28	1-100	20	70	46	0	0	0
23	2-6	1-400	10	78	40	0	0	0
	2-12	1-400	10	70	40	0	0	0

When Penetrol gave no percentage of control even after the second application, which burned the plants somewhat, it seemed inadvisable to try it at any other dilutions.

Pyr-A-Mid: A pyrethrum insecticide containing two and five hundredths percent pyrethrum extractive and nine-

ty-seven and ninety-five hundredths percent inert ingredients. For the control of mealybugs a dilution of one part to two hundred parts of water is recommended. Three experiments were tried as follows:

Table XXI. SHOWING THE EFFECT OF PYR-A-MID ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
10a	4-27	1-100	10	68	20	0	0	2
10b	1-20	1-200	50	70	48	0	0	0
10c	4-26	1-200	100	70	31	0	0	0

Pyr-a-mid was not effective on the mealybugs when used at the recommended dilution, and burned the plant slightly. Greater dilutions were not tried.

Pyrocide 20: A pyrethrum spray containing two and fifteen hundredths grains of pyrethrum per hundred cubic centimeters of fluid. Such a low percentage of control was obtained even with the second application at a dilution of one part to a hundred parts of water that no further experiments were attempted.

Table XXII. SHOWING THE EFFECT OF PYROCIDE ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
19	1-29	1-100	40	60	45	2	5	0
	2-6	1-100	38	78	40	1	2.6	0

Red Arrow: An oily rotenone product containing approximately 48% mixture of various oils, 1.66% rotenone, 10% coconut oil soap and 40.34% inert ingredients. This

preparation is primarily intended for garden spraying. The recommended dilution is one part to two hundred parts of water. The results obtained with this compound were as follows:

Table XXIII. SHOWING THE EFFECT OF RED ARROW ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
26a	1-30	1-50	30	70	48	0	0	0
	2-6	1-50	30	78	40	30	100	Tipburn
26b	4-26	1-100	50	70	31	50	100	2
26b-1	2-20	1-100	125	60	19	85	68	2
	2-26	1-100	40	98	18	33	82.5	4
26c	4-26	1-100	25	70	31	0	0	4
16	1-28	1-200	50	70	45	10	20	5
	2-6	1-200	40	78	40	10	25	6

The above experiments indicate that Red Arrow as a control for mealybugs is extremely unsatisfactory. In spite of the fact that one part to fifty parts of water gave a hundred percent insect kill the tipburn that accompanied it would not warrant its use. One part to a hundred parts of water, still caused plant burning and the control was only partial. At the recommended rate the percentage of kill was too low to recommend its use.

Sheps Spray: A moderately heavy oil containing as active ingredients Aliphatic thiocyanate and rotenone bland and inert ingredients not exceeding 20%. Recommended dilution is one part to 50 parts water.

Table XXIV. SHOWING THE EFFECT OF SHEPS SPRAY ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
18	1-29	1-50	25	60	45	25	100	50
11a	4-11	1-100	75	70	28	0	0	0
	4-18	1-100	75	72	15	11	14.6	10
11a-1	2-20	1-100	80	60	24	64	80	0
	2-26	1-100	16	98	18	14	87.5	0
11a-2	2-20	1-100	68	60	24	43	63.2	0
	2-26	1-100	15	98	18	14	93.3	0
11a-3	2-20	1-100	100	60	24	90	90	0
	2-26	1-100	10	98	18	9	90	0
11b	1-20	1-150	45	70	48	5	1.1	0
	1-28	1-150	40	70	45	2	1.5	0
11c	4-11	1-150	30	68	20	0	0	0
	4-18	1-150	30	72	15	0	0	0

At the recommended dilution of one part to fifty parts of water plant burning was so severe as to make its use prohibitive. Dilution of one part to one hundred parts of water produced such variable results that it could not be depended upon. It furthermore resulted in most cases in a fifteen percent leaf-drop. At this dilution its use is out of the question. When used at the rate of one part to one hundred and fifty parts of water, there was no foliage burning, but the control varied from zero to only five percent even after the second spray. Sheps Spray could not be recommended as a control for mealybugs, at any dilution.

Spraylite: An insecticide recommended for general use. No analysis of the ingredients were given in the

folder which it carried. It, too, is useless in greenhouses and cannot be recommended.

Table XXV. SHOWING THE EFFECT OF SPRAYLITE ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead (Nymphs)	Percent Burning
70	3-9	1-100	100	78	26	25	25	0
	3-13	1-100	75	70	38	14	18.7	0
71	2-27	1-150	70	78	32	0	0	0
	3-9	1-150	70	88	25	17	24.3	0
72	2-27	1-120	30	80	32	0	0	0
	3-9	1-120	30	86	25	0	0	0
73	2-27	1-400	50	80	42	0	0	0
	3-9	1-400	50	85	25	10	20	0

Spraylite used at any dilution is slightly effective against the nymphs, but not the adults.

Volck: A light-colored oil spray containing as active ingredients petroleum oils comprising 83% and inert ingredients 17%. It showed promise of being a fairly good control for mealybugs at the dilution of one part to one hundred parts of water. The results, however, varied somewhat, but a control was obtained with this dilution at the first or at least the second application. Experiment 108b was on carnations.

Table XXVI. SHOWING THE EFFECT OF VOLCK ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
106	3-17	1-50	100	90	15	100	100	25
107a	3-17	1-75	100	90	15	20	20	0
	3-24	1-75	80	75	40	40	50	0
107b	4-22	1-75	35	70	20	0	0	0
	4-27	1-75	35	68	35	35	100	0
108a	3-17	1-100	20	88	15	20	100	0
108b	3-24	1-100	50	71	35	0	0	0
	3-30	1-100	50	72	40	50	100	0
108c	4-12	1-100	25	68	30	0	0	0
	4-18	1-100	25	72	15	17	68	0
108d	4-12	1-100	15	68	30	0	0	0
	4-18	1-100	15	72	15	12	80	0
108e	4-22	1-100	15	70	20	15	100	2

Volck, diluted to one part to seventy-five or one hundred parts of water does not burn the foliage and gives a good control. When used one part to one hundred parts of water, eighty to a hundred percent control was obtained by the second application. Therefore, Volck is a more promising material for mealybug control than most of the other insecticides used.

Zenke's Spray: An oil emulsion with the active ingredients pyrethrum, ortho-di-chloro benzine, pine oil, and kerosene. A few experiments were tried with this material, but it was not effective in the control of mealybugs. In only two cases was a partial control effected.

Table XXVII. SHOWING THE EFFECT OF ZENKE'S SPRAY ON MEALYBUGS

Exp. No.	Date of Spray (1939)	Dilution	No. of Insects Treated	Temperature	Humidity	No. Dead	Percent Dead	Percent Burning
49	2-16	1-50	58	70	44	0	0	0
	2-22	1-50	58	70	48	11	18.9	0
49a	3-23	1-50	60	80	22	0	0	0
	3-27	1-50	60	88	21	30	50	0
47a	2-16	1-100	25	70	46	0	0	0
	2-22	1-100	25	70	48	0	0	0
47a-1	3-23	1-100	100	80	22	0	0	0
	3-27	1-100	100	88	21	20	20	0
47b	2-15	1-150	84	68	44	16	19.4	0
	2-21	1-150	68	68	45	14	20.6	0
48	2-16	1-200	30	70	46	0	0	0
	2-22	1-200	30	70	48	0	0	0

Table of Percent of Control Obtained from the Various Insecticides

Insecticide	Active Ingredient	Percent of Active Ingredient in Insecticide	Percent of Control with 1st or 1st and 2nd sprays
Dibug	Pyrethrum	Unknown	42%-81%
Isco	"	Unknown	96%
Kaloil	"	Unknown	70%-90%
Red Arrow Spray	"	18%	70%
Pyr-A-Mid	"	2.05%	0
Pyrocide	"	2.15 gr. per 100 cc.	5%
Zenke's Spray	"	Unknown	15%
Non-Po Concentrate	Derris	Unknown	0
Derrisol	"	5%	54%-72%
Shep's Spray	Rotenone	Unknown	64%-75%
Nico-Fume	Nicotine	1.5%	71%
Nik-Emo	Nicotine	1.5%	89%-92%
Black Leaf 40	Nicotine Sulphate	40%	51%-62%
Lemon Oil	Turpentine	3.5%	95%
Lethane	Thiocyanate	25% to 50%	60%-90%
Volck	Petroleum Oils	80%	90%(2nd Spray)

DISCUSSION OF RESULTS

The facts presented by this group of experiments will be discussed under four headings:(1) General, (2) Insecticides Effective against the Mealybug, (3) Insecticides Ineffective against the Mealybugs, and (4) Effective Combinations of Insecticides.

GENERAL

From the work done with various insecticides, it has been shown that several of them which were supposed to be effective in controlling mealybugs were not at all satisfactory. All preparations will not be discussed; only a few specific ones will be cited. For instance, in the directions accompanying Spraylite, mealybugs were supposed to be killed by it when used at the rate of one part to a hundred and twenty-eight parts of water, but when using it at a dilution of one part to one hundred parts of water, it killed none of the adults and only a few nymphs, even with the second application. Pyr-A-Mid was supposed to be effective when used one part to two hundred parts of water; this dilution gave no control whatsoever nor were the insects killed when sprayed with it at a dilution of one part to one hundred parts of water.

A few insecticides were effective in controlling this pest at the dilutions recommended by the manufacturers; Nik-Emo and Nicona are two that gave satisfactory

control at the prescribed dilutions. Other insecticides were effective at much lower dilutions than those recommended, and did not burn the plant. An example of this was Loro. The directions accompanying it recommended it to be used at a rate of one part to six hundred or eight hundred parts of water for resistant insects such as the mealybugs. The best results achieved with it were obtained when it was used at the rate of one part to three hundred parts of water. This spray gave an eighty to a hundred percent control with the first spray, with only slight plant burning.

In the control of the mealybug it is not sufficient to wash the waxy covering off the body. The spray must attack and have an injurious effect on the insect after the covering is removed. In all the experiments conducted, the pressure used in spraying was sufficient to remove the waxy secretions from the insect, and in practically all cases where the insect was not killed the waxy materials were soon replaced.

INSECTICIDES EFFECTIVE AGAINST THE MEALYBUG:

Of the insecticides tried in this group of experiments, a little less than half of them showed promise of a high percentage of mealybug control with the first or second application. The most effective were: Derrisol, Dibug, Isco, Lemon Oil, Lethane 420, Lethane 440, Loro, Multicide, Nicona, Nik-Emo and Volck.

The following table gives the best insecticides used with recommended dilutions and the percentage of control obtained with them:

Insecticide	Dilution	Percent of Control	No. of Sprays	Percent Burning
Derrisol	1-500	100	1	0
Dibug	1-100	5-100	2	0
Isco	Straight	90-100	1	0
Lemon Oil	1-16;1-20	90-100	1	0
Lethane 420	1-100	100	1 to 3	0-5
Lethane 440	1-200	95	2	2
Loro	1-200	80-100	1 to 2	2-3
Multicide	1-100;1-200	80-100	1	0
Nicona	1-30;1-50	100	1	0
Nik-Emo	1-100	80-100	1	0
Volck	1-100	100	2	0-2

INSECTICIDES INEFFECTIVE AGAINST THE MEALYBUG:

The insecticides which did not have any effect on the control of the mealybug outnumbered those which were effective. A list of ineffective ones follows: Aresket, Black Leaf 40, Cubor, Evergreen, Kaloil, Lethane 384, Melrosine, Nico-Fume, Non-Po Concentrate, Pyr-A-Mid, Penetrol, Pyrocide 20, Red Arrow, Sheps Spray, Spraylite, and Zenke's Spray.

SUMMARY

From a hundred and fifty experiments performed with twenty-seven different insecticides, the following eleven were found to be the most effective in controlling the mealybugs when used singly: Derrisol, Dibug, Isco, Lemon Oil, Lethane 420, Lethane 440, Loro, Multicide, Nicona, Nik-Emo and Volck. Pyrethrum, derris and some nicotine products were more effective than the thiocyanates.

Sixteen commercial brands of sprays which were recommended to give good control measures for insects, gave little or no control for mealybugs. They are as follows: Aresket, Black Leaf 40, Cubor, Evergreen Spray, Kaloil, Lethane 384, Melrosine, Nico-Fume, Non-Po Concentrate, Pyr-A-Mid, Penetrol, Pyrocide 20, Red Arrow, Sheps Spray,

and Zenke's Spray.

With the exception of Lemon Oil which has a turpentine base, the insecticides containing pyrethrum were the most effective as control measures for mealybugs. The percentage of control obtained from the use of different pyrethrum sprays varied greatly. This variance will be discussed upon the basis of the amount of pyrethrum in the spray. Very little information was available as to the constituents of these insecticides.

Dibug, composed of a pyrethrum extractive in sprayene was 42% effective with the first application and 81% effective with the second.

Isco, a light oil with a pyrethrum base, was 96% effective with the spraying apparatus available. It should be tested with a sprayer which would give a much more finely atomized spray than the sprayer used in these experiments.

Information about the percentage of pyrethrum in Kaloil was not available. However, this insecticide was 70% effective with the first application and the second was ninety percent effective in the control of mealybugs.

Red Arrow Spray, containing 18% pyrethrum extract was 70% effective with the first application.

The other pyrethrum preparations were much less effective. Pyr-A-Mid, an insecticide containing 2.05% pyrethrum was entirely ineffective.

Pyrocide, containing 2.15 grains of pyrethrum per

100 cc of fluid, gave only a five percent control of the insects.

Zenke's Spray, in which the amount of pyrethrum is unknown, killed 15% of the insects with the second application which of course would not be enough to make the insecticide worth recommending as a control for mealybugs.

From the above it is quite evident that the higher concentrations of Pyrethrum were more effective than those of the lower percents. The former gave from 18% to 96% effectiveness while the latter gave no kill to speak of.

Derrisol, an insecticide containing 5% Derris, gave 54% control with the first spray, and 72% control with the second application. Non-po Concentrate, another derris-bearing insecticide was entirely unsatisfactory. Information as to the percentage of derris in Non-po Concentrate was unavailable.

Shep's Spray contains rotenone and thiocyanate as active ingredients. The first application killed 64% of the insects, and the second killed 75%.

Nico-Fume and Nik-Emo each contain 1.5% free nicotine. Nico-Fume was 71% effective with two applications, while the first application of Nik-Emo was 89% effective and the second 92% effective.

Black Leaf 40 contains 40% nicotine sulphate; the first application killed 51% of the insects and the second 62%. This indicates that the free nicotine was more effective than the nicotine sulphate in the control of mealybugs.

Lemon Oil, containing 3.5% turpentine was 95% effective in controlling the insects.

Lethane, containing 25% to 50% thiocyanate in petroleum distillate, gave from 60% to 90% control with the first and second applications respectively.

Volck, containing 80% petroleum oils, was ineffective with the first application, but the second killed an average of 90% of the insects. This would be considered to be an effective control measure for mealybugs.

The following bibliography is an attempt to bring together, as far as possible, what has been published on the greenhouse mealybugs. Although a great deal of time has been spent consulting such entomological papers, indeces, periodicals, and other sources of information as are available in the library of the Colorado State College and the Gillette library it is believed that a number of interesting and valuable articles have escaped my notice, therefore the bibliography is by no means exhaustive. References prefixed with an asterisk have not been consulted and where citations are made to various publications they are so noted in the text by bearing the corresponding number prefixing the specific reference.

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