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BULLETIN NO. 640 JANUARY, 1934

New York State Agricultural Experiment Station

Geneva, N. Y.

MAY 5 1934

NON-ARSENICAL DUSTS FOR CAULIFLOWER WORM CONTROL IN WESTERN NEW YORK

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PUBLISHED BY THE STATION
UNDER AUTHORITY OF CORNELL UNIVERSITY

ABSTRACT

Results are given of experiments dealing with the control of the three common species of cauliflower insects, namely the imported cabbage worm (*Pieris rapae* Linn.), the cabbage looper (*Autographa brassicae* Riley), and the diamond back moth (*Plutella maculipennis* Curtis) by the use of arsenicals, derris, pyrethrum, and hellebore.

Analyses of samples of cauliflower from plats receiving various treatments of calcium arsenate indicate that there is little possibility of using this material effectively with the existing arsenical tolerance specifications.

Ground derris root diluted with talc to contain 1 per cent and 0.5 per cent rotenone gave the most satisfactory control of the caterpillars. Promising results were also obtained with pyrethrum dusts, but these preparations were, in general, not equal to derris. Pyrethrum extract, hellebore, and calcium arsenate were inferior to derris dusts, pyrethrum dusts, and lead arsenate.

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NON-ARSENICAL DUSTS FOR CAULIFLOWER WORM CONTROL IN WESTERN NEW YORK

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INTRODUCTION

During the 1933 season studies were made concerning the merits of derris, pyrethrum, and, to a lesser extent, of hellebore, against the three species of caterpillars commonly attacking cauliflower. These investigations were started largely in view of the need of a non-arsenical insecticide for cauliflower on account of the restrictions of the Federal Food and Drug Administration concerning arsenical residues.

Since calcium arsenate has been commonly used in the past for dusting cauliflower, the investigations were first concerned with determining whether this material had a place in the dusting schedule in view of the legal tolerance for arsenical residues. In carrying out these studies certain facts were determined which it is believed are of sufficient importance to be of practical value to cauliflower growers.

The experiments discussed here are undoubtedly of a preliminary nature and it is felt that further investigations are desirable, particularly to determine the relative efficiencies of derris, pyrethrum, and derris-pyrethrum mixtures. These two materials appear to have considerable value in the cauliflower dusting schedule in western New York. They have also been used successfully on cabbage. It appears unlikely at present, however, that derris or pyrethrum will replace the arsenicals for use on this crop, chiefly because of cost and from the fact that there is little danger of the occurrence of excessive residues on the marketed head where the usual arsenical control programs are followed.

ARSENICAL RESIDUE STUDIES [1]

In order to obtain some idea of the possibility of using calcium arsenate on cauliflower without building up a residue in excess of the tolerance, an experiment was carried out on the farm of Henry Marquart at Orchard Park, N. Y., in 1933. This experiment was laid out to determine the amount of arsenical residue remaining on various parts of the plant from single applications made at various periods in the growth of the vegetable up to harvest time and combinations of applications up to a maximum of five. The plats consisted of 45 plants, or approximately 1/215 acre. The dust, consisting of 25 per cent calcium arsenate in hydrated lime, was applied with a rotary hand duster at the rate of about 30 pounds per acre. The first application was made on August 10 with four subsequent applications at approximately 10-day intervals up to September 26. On the date of the last application the first "tying" was being made in the field. A sample comprising five trimmed heads was taken from each plat on October 18. These samples were analyzed for arsenical residues, and the results are shown in Table 1.

TABLE 1.— THE RESULTS OF ARSENICAL ANALYSES OF CAULIFLOWER SAMPLES FROM PLATS RECEIVING DIFFERENT NUMBERS OF CALCIUM ARSENATE TREATMENTS, ORCHARD PARK, N. Y., 1933.

PLAT NO.	APPLICATIONS *	AMOUNT OF RAINFALL FROM APPLICATION TO HARVEST, INCHES †	GRAINS OF ARSENIOUS OXIDE PER POUND ‡			
			Stump	Leaves	Curd	Entire trimmed head, estimated
1....	1	3.67	0.001	.....	.....	0.0001
2....	1, 2, 3	3.67	0.006	0.001	.....	0.0013
3....	1, 2 3, 4	3.67	0.046	0.008	0.006	0.0128
4....	1, 2, 3, 4, 5	3.67	0.632	0.053	0.004	0.1192
5....	2	2.99	0.003	.....	.....	0.0004
6....	2, 3	2.99	0.022	0.008	.....	0.0067
7....	2, 3, 4, 5	2.99	0.193	0.052	0.007	0.0542
8....	3	1.93	0.020	0.007	.....	0.0060
9....	3, 4, 5	1.93	0.221	0.027	0.004	0.0464
10....	4	1.65	0.047	0.005	0.001	0.0106
11....	4, 5	1.65	0.340	0.050	0.005	0.0746
12....	5	1.22	0.209	0.039	0.002	0.0489

* The applications were made Aug. 10, Aug. 20, Sept. 1, Sept. 15, and Sept. 26, respectively.
† The rainfall records are taken from the Federal Weather Bureau Station at Buffalo. The precipitation for August at that Station was 0.67 inch below normal; for September, 1.94 inches below normal; and for October, 1.67 inches below normal.
‡ The legal tolerance is 0.01 grain of arsenious oxide per pound of product.

[1] The writers are indebted to G. W. Pearce of the Division of Chemistry of this Station, who has made the analyses reported here.

The stump, leaves, and curd were analyzed separately for each plat, altho, as will be noted, the leaves and curd were omitted in the case of some plats. The reason for this was that there seemed little possibility that an excess of residue would remain on these parts of the plant when treated a month or more before harvest. In removing the leaves from the stump a short stub was left so that the residue contained in the axil of the leaf would not be disturbed. The grains of arsenious oxide per pound of product are expressed on the basis of the weight of the stump, the leaves, and the curd as well as on the basis of the entire trimmed head. The situation is somewhat complicated owing to the fact that, while most consumers utilize only the curd or flower for food, it is reported that in some metropolitan areas the leaves and stump may also be consumed. For this reason pure food officials have held that the occurrence of a residue on the stump and leaves is a sufficient cause for exclusion from sale.

Altho some inconsistencies appear in the data, it is quite apparent that large amounts of residue may be found on the plant at harvest in cases where more than one application is made or where even one application is made late in the growth of the plant. Of the three parts of the plant considered, the stump or butt contained the most residue. This is due to the collection of large amounts of the material in the pocket formed by the axils of the leaves. The leaves also, in some cases, contained residue in excess of the tolerance, but in general the amounts were slight as compared with the stump. The curd, in all instances, showed only a relatively small amount of residue, even in the case of the sample in which the stump residue was 62 times above the tolerance.

Based on the legal tolerance of 0.01 grain of arsenious oxide per pound of product, it would appear that the only plats escaping an excess of residue were those receiving either the first or second application. These treatments were made on August 10 and August 20, which in the latter case, was a little over 1 month before the first "tying" was made in the field and approximately 2 months before the sample was harvested. In view of this it would appear that under weather conditions such as prevailed in 1933, there would be little opportunity of using an arsenical on cauliflower and remaining within the margin of safety from the standpoint of arsenical residues except where the treatment was made very early in the growth of the plant. Furthermore, it seems unlikely that an application made

6 weeks to 2 months before harvest would have much value in protecting the plant unless supplemented by later treatments of non-arsenical materials.

On Long Island, in 1932, growers having cauliflower containing residues in excess of the tolerance were able to reduce it sufficiently to move the crop by "close trimming" the heads. This was unsatisfactory, however, since it reduced the weight and tended to spoil the appearance of the product.

DESCRIPTION OF MATERIALS TESTED

The problem of finding some material which would be effective against cauliflower worms and at the same time would not leave objectionable residues on the plant at harvest was in general limited to three materials of vegetable origin, namely, rotenone, pyrethrum, and hellebore. That these materials have insecticidal qualities has been known for many years. Their use in this country, however, has been largely confined to the manufacture of household sprays and dusts, fly sprays, insecticides used in greenhouses, and in the home garden. A brief description of these materials follows:

Hellebore.—This material consists of the dry and powdered roots of two plants, namely, *Veratrum album* and *V. viride.* The former is an European species and it is from this that white hellebore is derived, while the latter is the American hellebore and is commonly called "swamp hellebore," "Indian poke," and "itch weed." The powdered root of this species is greyish brown in color. Hellebore apparently contains certain alkaloids which are poisonous to insects, altho probably less toxic than the arsenicals. The poisonous principle in hellebore is rather volatile, losing its strength rapidly when left exposed to the air. For this reason it has been recommended for use on ripening fruits or vegetables since the use of an arsenical in such circumstances might prove objectionable to the consumer.

Pyrethrum.—This material, known as "Persian insect powder," "Dalmatian insect powder," and by various other names, consists of the ground flower heads of certain species of the genus Chrysanthemum. Pyrethrum has been used as an insecticide for a great many years and was introduced into Europe for this purpose around the beginning of the 18th century. According to Glassford[2] there were formerly two varieties of pyrethrum on the market; the red or

[2] Glassford, J. The economics of pyrethrum. *Jour. Econ. Ent.*, 23, *874–877. 1930.*

Persian (*Chrysanthemum roseum*) and the Dalmatian or yellow (*C. cinerariaefolium*). The former has now completely disappeared and the Dalmatian species is the one commonly grown for insecticidal purposes. Glassford also states that Japan furnishes about six-sevenths of the world's production and that the United States uses about 70 per cent.

The active principle in pyrethrum consists of two compounds which have been designated under the names of pyrethrin I and pyrethrin II, the former being much more toxic to insects than the latter. The total pyrethrin content in the dried flowers varies from 0.3 to 1.20 per cent, depending on the growth and climatic conditions. The flowers may be ground up finely and used as a base for dusts, or the active principle may be extracted by solvents. A concentrated extract is used in the preparation of household sprays, fly sprays, plant sprays, and others. The material acts as a contact insecticide, shows a high rate of toxicity against certain insects, and possesses the additional merit of not injuring plants and of being harmless to humans.

Rotenone.—This material is found in the roots of a large number of so-called fish poison plants in the tropics, belonging to the legume family. There are several genera and a large number of species said to contain this material, but, generally speaking, it is from only two species that the material is produced commercially at present, *viz., Derris elliptica,* from which derris is obtained, and *Lonchocarpus nicou,* commonly called "cubé root." The former plant is a native of the East Indies, while the latter is abundant in South and Central America. Devil's shoe string (*Cracca virginiana*), a native of North America, also contains rotenone, but the content is said to be low.

In addition to rotenone, these plants also contain certain other constituents which are reported to be more or less toxic to insects. Davidson,[3] using aqueous suspensions of the four principal constituents of derris, i.e., rotenone, deguelin, tephrosin, and toxicarol, showed that when sprayed on aphids, thrips, white fly larvae, and red spider mites, the relative insecticidal value of these materials was in the order given and that both rotenone and deguelin were more toxic than nicotine. The rotenone content of these plants varies considerably and may range from less than 1 per cent to as much as 11 per cent.

[3] Davidson, W. M. The relative value as contact insecticides of some constituents of derris. *Jour. Econ. Ent.,* **23**, *877–879. 1930.*

Rotenone is marketed in the form of a liquid extract with a definite rotenone content for use in sprays. It is also used in the form of the powdered root with a definite rotenone content as a stock for insecticide dusts. Rotenone is very poisonous to cold-blooded animals, including many insects, but appears to be relatively harmless to warm-blooded animals, including man, when taken orally in small amounts.

Buckingham[4] finds that pure rotenone produced no visible effects on dogs, cats, pigs, or sheep when administered in small amounts by mouth (for dogs up to 1 grain per pound of body weight). However, it does produce a numbness of the lips, tongue, and throat of the operator when one is exposed to the dust. This usually disappears in about 2 hours.

EARLIER OBSERVATIONS ON ROTENONE AND PYRETHRUM

According to the earlier literature, the results from the use of rotenone and pyrethrum against cabbage worms are rather conflicting, possibly owing to the variability in the strengths of the materials used. For instance, Austin[5] found that aqueous and alcoholic extracts of pyrethrum gave rather inferior results against the larvae of the large white cabbage butterfly (*Pontia brassicae*) and the diamond back moth larvae (*Plutella maculipennis*). Fryer and others[6] found that an alcoholic extract of pyrethrum used at 1 and 2 per cent killed all the larvae of *Pieris brassicae*. Weaker dilutions were less effective. Jarvis[7] found that a proprietary derris preparation used at the rate of 2 pounds to 40 gallons of water was more effective against the larvae of the diamond back moth than a nicotine sulfate and arsenate of lead mixture. Morgan[8] showed that sprays containing white oil emulsion, nicotine sulfate and derris preparations were ineffective against the larvae of the diamond back moth. Kelsall

[4] Buckingham, D. E. Action of rotenone upon mammals when taken by mouth, preliminary report. *Ind. and Eng. Chem.*, **22**, *1133–1134. 1930.*

[5] Austin, M. D. Pyrethrum experiments, 1928. *Jour. S. E. Agr. Coll., Wye, Kent., No. 26, 124–135. 1929.*

[6] Fryer, J. C. F., Tattersfield, F., and Gimingham, C. T. English-grown pyrethrum as an insecticide, I. *Ann. Appl. Biol.*, **15**, *423–445. 1928.*

[7] Jarvis, H. Cabbage moth control by non-arsenical sprays. *Queensland Agr. Jour.*, **36**, *399–403. 1931.*

[8] Morgan, W. L. Preliminary experiments in cabbage moth control. *Agr. Gaz. N. S. W.*, **40**, *761–766. 1929.*

and others,[9] in a series of experiments in which derris was tested against a number of insects, showed that when this material was used at the rate of 1, 2, 5, and 10 per cent in hydrated lime against cabbage worms a high degree of control was secured. In another experiment derris was used as a spray at the rate of 0.62, 1.25, 2.5 and 5 pounds in 100 gallons of water to which had been added 3 pints of mineral oil emulsion. This spray gave better control of cabbage worms than arsenate of lead either at the rate of 2.5 or 5 pounds in 100 gallons of the oil-water mixture.

White,[10] reporting on a series of experiments conducted at Chadbourn, N. C., Charleston, S. C., Baton Rouge, La., and Columbus, Ohio, in which derris, pyrethrum, hellebore, and various arsenicals were tested against cabbage worms, drew the following conclusions: Derris either undiluted or diluted with equal parts of tobacco dust or sulfur proved to be the most toxic material used. It also appeared to have some residual effect which pyrethrum did not have. Pyrethrum either undiluted or mixed with equal parts of tobacco dust proved more effective than the arsenicals and nearly as effective as derris. Hellebore was inferior to derris and pyrethrum but compared favorably with the arsenicals. Davidson[11] showed that dusts containing 1 per cent and 2 per cent rotenone both killed 100 per cent of the larvae of the imported cabbage worm.

SOURCE OF MATERIALS USED

Powell's finely ground pyrethrum powder.—This pyrethrum dust was supplied by the John Powell Company, New York City. It was adjusted to contain approximately 1 per cent pyrethrins. It was used undiluted and diluted with various amounts of talc.

Powell's pyrethrum "A" dust.—This is a so-called "activated" pyrethrum dust and was furnished by the John Powell Company. It contained 0.5 per cent pyrethrins and was used both undiluted and diluted with equal parts of talc.

Powell's pyrethrum "C" dust.—This is also an activated pyrethrum dust and was furnished by the John Powell Company. It contained 0.135 per cent pyrethrins and was used undiluted in our experiments.

[9] Kelsall, A., Spittall, J. P., Gorham, R. P., and Walker, G. P. Derris as an insecticide. *Ann. Rept. Ent. Soc. Ont.*, **56**, *24–40. 1925.*

[10] White, W. H. Progress report of experiments on the control of cabbage worms. *United States Bur. Ent., E-309, Aug. 19, 1933.* (Mimeographed.)

[11] Davidson, W. M. Rotenone as a contact insecticide. *Jour. Econ. Ent.*, **23**, *868–874. 1930.*

Powdered derris root.—This material was purchased from the McCormick Company, Baltimore, Md. It contained 4 per cent rotenone and was diluted with various amounts of talc.

Derris-pyrethrum mixture.—This is a derris-pyrethrum mixture made up of 50 per cent of a powdered derris containing 5 per cent rotenone and 50 per cent of a pyrethrum containing 1 per cent pyrethrins. This material was secured from S. B. Penick, New York City.

Derox.—This is a derris dust containing 0.55 per cent rotenone. It was purchased from the Bowker Chemical Company, New York City.

Pyrethrum extract.—This is the Evergreen 20 manufactured by McLaughlin, Gormley, and King, Minneapolis, Minn. It is guaranteed to contain 2.15 grams pyrethrins per 100 cc.

Hellebore.—This material was manufactured by the S. B. Penick Company, New York City, and was used both diluted and undiluted in our experiments.

SEASONAL ACTIVITIES OF THE INSECTS

The three common species of caterpillars attacking cruciferous crops are the imported cabbage worm (*Pieris rapae*), the cabbage looper (*Autographa brassicae*), and the diamond back moth (*Plutella maculipennis*). Of these three species, the imported cabbage worm caused the most damage in 1933. The larvae of the diamond back moth were very abundant, but their feeding seemed to be confined to the loose leaves and they did not bore into the head, in the case of cabbage, which is characteristic of the other two species. The imported cabbage worm and the diamond back moth appeared in the field rather early in July and were most destructive during August and September, altho there was considerable activity up to the first week in November. The cabbage looper was less abundant than the other two species earlier in the season, but increased considerably during September.

FIELD EXPERIMENTS

Altho these experiments were conducted primarily to find some material to be used on cauliflower to control worms, two of the experiments discussed here were carried out on cabbage. This was mainly due to the heavier infestation on this crop. In the case of experiment 1 (Table 2), the plats were 1/60 acre, or approximately

TABLE 2.— THE RESULTS OF TESTS OF VARIOUS MATERIALS AGAINST CABBAGE WORMS ON EARLY CABBAGE, CHURCHVILLE, N. Y., 1933.

MATERIAL	PLAT	ACTIVE PRINCIPLE, PER CENT	NUMBER LARVAE PER PLAT*	REDUCTION IN LARVAE, PER CENT	CLASSIFICATION OF WORM INJURY TO HEADS AT HARVEST, PER CENT			
					Clean	Slight	Medium	Heavy
Pyrethrum powder (A dust)	Treated	0.5	105	63.8	75.9	16.6	7.4	0.0
	Check	.....	290	.....	43.1	17.2	31.0	8.6
Pyrethrum powder (C dust)	Treated	0.135	50	82.8	69.0	28.6	2.4	0.0
	Check	.....	290	.....	43.1	17.2	31.0	8.6
Pyrethrum powder (finely ground), 1 lb.; talc, 1 lb	Treated	0.5	55	81.0	69.1	23.4	6.4	0.0
	Check	.....	290	.....	43.1	17.2	31.0	8.6
Pyrethrum powder (finely ground), 1 lb.; talc, 2 lbs	Treated	0.33	100	65.5	54.3	28.3	17.3	0.0
	Check	.....	290	.....	43.1	17.2	31.0	8.6
Powdered derris root, 1 lb.; talc, 3 lbs	Treated	1.0	25	91.0	77.9	16.8	3.2	2.1
	Check	.....	290	.....	43.1	17.2	31.0	8.6
Hellebore, 1 lb.; talc, 1 lb	Treated	.....	140	51.7	43.9	34.1	15.9	4.9
	Check	.....	290	.....	43.1	17.2	31.0	8.6
Hellebore	Treated	.....	115	62.6	60.0	20.0	20.0	0.0
	Check	.....	307	.....	31.0	21.3	35.1	12.5
Pyrethrum extract, 1–300; fish-oil soap 1 oz. per gal	Treated	.....	150	51.2	31.3	40.0	27.5	1.3
	Check	.....	307	.....	31.0	21.3	35.1	12.5
Lead arsenate, 1 lb.; hydrated lime, 3 lbs	Treated	25.0	60	81.5	56.7	32.8	8.9	1.5
	Check	.....	325	.....	18.9	25.3	39.2	16.5
Calcium arsenate, 1 lb.; hydrated lime, 3 lbs	Treated	25.0	190	41.5	36.3	28.8	28.8	6.3
	Check	.....	325	.....	18.9	25.3	39.2	16.5

* The average distribution of the three species of caterpillars in these counts was as follows: Imported cabbage worm, 53.6 per cent; diamond back moth, 38.5 per cent; and the cabbage looper, 7.8 per cent.

TABLE 3.— THE RESULTS OF TESTS OF VARIOUS MATERIALS USED AGAINST CABBAGE WORMS ON LATE CABBAGE AT CHURCHVILLE, N. Y., 1933.

MATERIAL	ACTIVE PRINCIPLE, PER CENT	AVERAGE WORM POPULATION PER PLAT*			REDUCTION IN WORM POPULATION, PER CENT			REDUCTION ALL SPECIES, PER CENT	CLASSIFICATION OF WORM INJURY TO HEADS AT HARVEST, PER CENT			
		Imported cabbage worm	Cabbage looper	Diamond back moth	Imported cabbage worm	Cabbage looper	Diamond back moth		Clean	Slight	Medium	Heavy
Pyrethrum powder (finely ground), 1 lb.; talc, 1 lb.	0.5	12	0	45	93.2	100.0	83.2	92.1	54.2	32.5	9.0	4.2
Pyrethrum powder (finely ground), 1 lb.; talc, 3 lbs.	0.25	42	3	54	78.0	95.0	79.8	84.3	50.3	33.5	15.4	0.6
Pyrethrum powder (finely ground), 1 lb.; talc, 5 lbs.	0.16	42	18	99	78.0	70.0	63.0	70.3	40.6	45.8	11.6	1.9
Derris-pyrethrum powder, 1 lb.; talc, 1 lb.	1.5	0	3	3	100.0	95.0	98.9	97.9	63.7	34.8	1.5	0.0
Derris-pyrethrum powder, 1 lb.; talc, 3 lbs.	0.75	0	3	48	100.0	95.0	82.1	92.4	60.5	23.2	12.9	3.4
Derris-pyrethrum powder, 1 lb.; talc, 5 lbs.	0.5	9	6	24	95.3	90.0	91.0	92.1	62.3	30.7	5.1	1.7
Pyrethrum powder (A dust), 1 lb.; talc, 1 lb.	0.25	28	12	132	85.4	80.0	50.7	72.0	26.2	35.6	31.5	6.7
Pyrethrum powder (C dust)	0.135	3	0	96	98.4	100.0	64.2	87.5	64.6	27.8	6.9	0.6
Pyrethrum extract, 1–300; fish-oil soap, 1 oz. per gal.	.....	102	12	102	46.7	80.0	61.9	62.9	47.4	40.0	11.9	0.7
Calcium arsenate, 1 lb.; hydrated lime, 3 lbs.	25.0	132	21	135	31.0	65.0	49.6	48.5	35.2	28.6	24.8	11.4
Lead arsenate, 1 lb.; hydrated lime, 3 lbs.	25.0	18	6	31	90.6	90.0	88.4	89.7	.....	.....	.....	.....
Powdered derris root, 1 lb.; talc, 3 lbs.	1.0	3	3	21	98.4	95.0	92.2	95.2	64.0	23.6	11.2	1.2
Powdered derris root, 1 lb.; talc, 7 lbs.	0.5	9	6	42	95.3	90.0	84.3	89.9	67.7	29.0	3.7	0.0
Derox	0.55	3	3	39	98.4	95.0	85.4	92.9	59.6	28.0	10.3	2.0
Check, no treatment	.....	191.4	60	267.8	.....	.....	.....	.....	23.9	39.8	26.2	10.0

* Average of counts made 3 days after each application.

TABLE 4.— THE RESULTS OF TESTS OF VARIOUS MATERIALS USED AGAINST CABBAGE WORMS ON CAULIFLOWER AT ORCHARD PARK, N. Y., 1933.

MATERIAL	ACTIVE PRINCIPLE, PER CENT	AVERAGE WORM POPULATION PER PLAT*			REDUCTION IN WORM POPULATION, PER CENT			REDUCTION ALL SPECIES, PER CENT
		Imported cabbage worm	Cabbage looper	Diamond back moth	Imported cabbage worm	Cabbage looper	Diamond back moth	
Pyrethrum powder (finely ground)	1.0	5.0	5.0	28.8	94.1	88.9	77.8	86.9
Pyrethrum powder (finely ground), 1 lb.; talc, 1 lb.	0.5	11.3	6.3	45.0	86.7	86.1	65.4	79.4
Powdered derris root, 1 lb.; talc, 3 lbs.	1.0	0.0	6.3	12.5	100.0	86.1	90.4	92.2
Powdered derris root, 1 lb.; talc, 7 lbs.	0.5	2.5	12.5	41.2	97.1	72.5	68.3	79.3
Derox	0.55	1.3	8.8	23.8	98.5	80.6	81.7	86.9
Pyrethrum powder (C dust)	0.135	6.3	12.5	40.0	92.6	72.5	69.2	78.1
Lead arsenate, 1 lb.; hydrated lime, 3 lbs.	25.0	11.3	11.3	17.5	86.7	75.1	86.5	82.8
Calcium arsenate, 1 lb.; hydrated lime, 3 lbs.	25.0	42.5	23.8	41.3	50.0	47.6	68.2	55.3
Check, no treatment	.....	85.0	45.4	130.0	.....	.....	.....	.....

* The average of counts made 3 days after first application and 10 days later and 3 days after second application and 10 days later.

160 plants. At the time of the first application there was a considerable infestation in this field, consisting for the most part of the imported cabbage worm and the larvae of the diamond back moth. Three applications were made as follows: July 25, August 14, and September 8. In the case of all experiments, the applications were made in the late afternoon and evening. The results from experiment 1 are shown in Table 2.

In experiment 2, the plats were 1/30 acre. This field also showed a rather heavy infestation of the imported cabbage worm and the diamond back moth. Three applications were made as follows: August 9, August 25, and September 9. The results of this experiment are shown in Table 3.

In experiment 3, the plats were 1/60 acre. Applications were made August 16 and September 5. The results of this experiment are shown in Table 4.

The dusts were applied at the rate of 30 pounds per acre with a rotary hand duster. The dust was directed downward and each row was gone over once with no special effort being made to cover the under surfaces of the leaves. The sprays were applied with a small compressed air hand sprayer. Only the upper surfaces of the leaves were covered. The dusts were mixed fresh before each application.

In measuring the efficiency of the various materials against these insects, counts were made of the number of live worms remaining on the plants 3 days after each treatment. The record was usually based on an examination of 25 plants taken at random in each plat. In the case of the experiments on cabbage the heads were examined at harvest and the injury graded under the following categories: "Clean," "slight," "medium," and "heavy." These grades are shown in Fig. 1.

DISCUSSION OF RESULTS

In these experiments, pyrethrum dusts, pyrethrum extract, derris, a derris-pyrethrum mixture, hellebore, calcium arsenate, and lead arsenate were compared at different strengths on cabbage and cauliflower to determine their efficiency in the control of cauliflower worms. Rotenone, the active principle in derris root, gave excellent control of these insects in all experiments where it was used. The powdered derris root was diluted in talc in amounts to give 0.5 per cent and 1 per cent rotenone, and both of these mixtures appeared, in general, about equal in effectiveness. The derris-pyrethrum

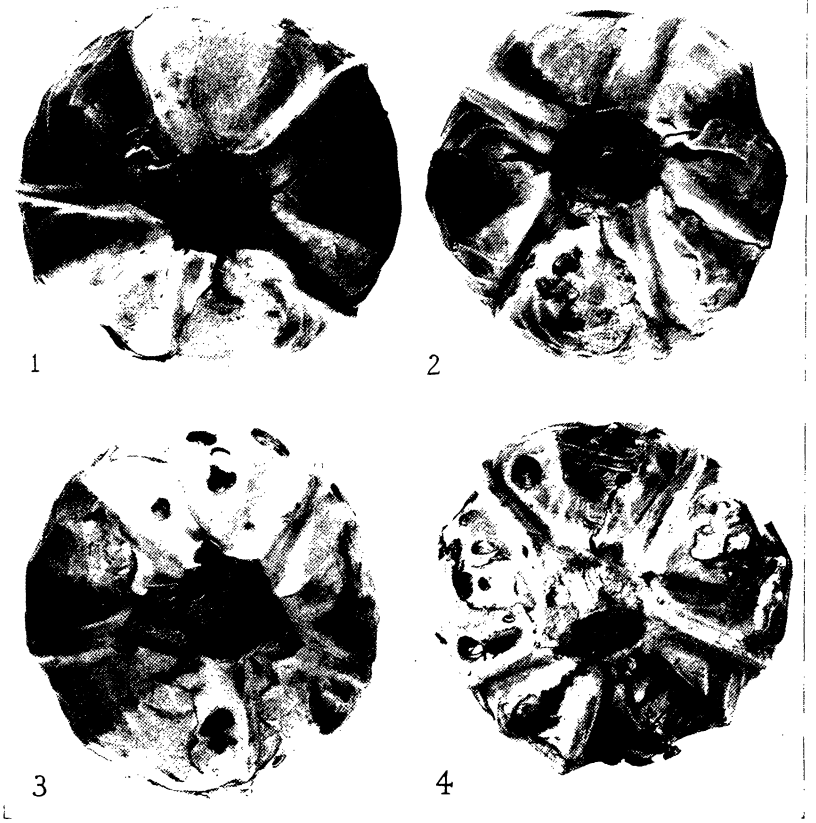

FIG. 1.—CLASSIFICATION OF WORM INJURY TO CABBAGE AS USED IN OBTAINING DATA ON THE EFFICIENCY OF MATERIALS TESTED IN EXPERIMENTS 1 AND 2. 1, clean; 2, slight; 3, medium; 4, heavy.

mixture at the dilutions used was very toxic to cabbage worms; but judging from the appearance of the plants and the actual worm counts, it did not appear to be superior to derris when used alone. Derox, another dust containing rotenone, was about equal in effectiveness to the other dusts containing this material. In general, rotenone had far superior insecticidal qualities against these caterpillars when compared with calcium arsenate and appeared about equal to or possibly slightly better than lead arsenate.

Pyrethrum dusts also gave good results, altho this material is

definitely not as effective as rotenone at the strengths tested. The finely ground pyrethrum powder, when used undiluted or when diluted with equal parts of talc, gave satisfactory protection, but at great dilutions it seemed to lose much of its toxicity. Good results were also obtained with the activated pyrethrum dusts when used undiluted. Pyrethrum extract tested in two experiments with fish-oil soap as a spreader gave rather inferior results and was not as effective as the pyrethrum dusts. This material was more rapid in its action against cabbage worms than rotenone, altho the latter material appeared to have a more decided residual effect and gave protection to the plants over a longer period than did pyrethrum.

Hellebore dust, both undiluted and diluted with equal parts of talc, did not appear very toxic to the worms, altho it compared favorably with calcium arsenate.

Of the three species of caterpillars concerned, the imported cabbage worm was the easiest to control, while the diamond back larvae appeared to be the most difficult. In general, the cabbage looper was not abundant enough to determine definitely what effect the materials had on it. It appeared, however, that the degree of control secured against this species was somewhat less than that secured against the imported cabbage worm.

SUMMARY

In view of the present situation concerning arsenical residues, particularly as it effects cauliflower, the need of some non-poisonous substitute for arsenic is much desired. While it might be possible in some seasons to use an arsenical to a limited extent on this crop, a general recommendation would be difficult to make if the harvested crop is to meet the legal specifications in this respect.

The data discussed in this bulletin are the result of one season's work and it must be recognized that recommendations based on it are only tentative. To meet the situation as it exists at present, it is concluded from these tests that the best single treatment is ground derris root, the diluted dust to contain 0.5 per cent rotenone, the active principle. While pyrethrum dusts possess merit, preference at present is given to derris principally because where pyrethrum is used at strengths to give results equal to derris the cost, at present prices, is higher, and in some instances the results have not been as consistent.

DIRECTIONS FOR USING DERRIS

Derris dusts containing 0.5 per cent rotenone can be purchased commercially. The dusts may also be purchased in the form of the ground derris root containing 4 or 5 per cent rotenone, and this dust can then be mixed with talc to give the required strength. The amounts of each material to be used in diluting can be determined from the guaranteed rotenone content of the ground root. In general, it will probably be more satisfactory to purchase the material already mixed unless the grower has good facilities for dust mixing. Owing to the fact that derris deteriorates rapidly on exposure to light and air, containers should be kept tightly closed at all times.

On cauliflower the dust should be used at the rate of 25 or 30 pounds per acre and can be applied with a power or traction duster or with a good rotary hand duster. In gardens or small plantings the material may be placed in a cheesecloth sack and sifted over the plants. During the season of 1933, with a moderate infestation, two applications about 3 weeks apart gave adequate protection to cauliflower. However, the number and time of applications will have to be left to the discretion of the grower and will depend on the severity of the infestation and the time the plants are set in the field.

Derris dust containing 0.5 per cent rotenone retailed during the season of 1933 for 12 to 14 cents per pound. The ground derris root containing 4 or 5 per cent rotenone retails at 43 to 50 cents per pound f.o.b. New York City. The pyrethrum powder (finely ground) containing approximately 1 per cent pyrethrins retails at 40 to 45 cents per pound, depending on the supply.

In view of the increasing interest in derris as an insecticide, it is probable that this material will be obtainable in 1934 thru local dealers in insecticides and fungicides.