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BUREAU OF ENTOMOLOGY AND PLANT QUARANTINEA REVIEW OF THE INSECTICIDAL USES OF POTENONE AND
POTENOIDS FROM DERRIS, LONCHOCARPUS (CUBE AND
TIMBO), TEPHROSIA, AND RELATED PLANTS

PART VI: COLEOPTERA

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INTRODUCTION

This is the sixth in a series of papers designed to review all available information on the insecticidal uses of rotenone and the rotenoids. Part I reviewed tests with derris, cube, timbo, Tephrosia, Mundulea, and their constituents on members of the Collembola, Orthoptera, Dermaptera, Odonata, Isoptera, Corrodentia, and Mallophaga. Apparently no tests with the rotenone plants on Thysanura, Ephemeroptera, or Plecoptera have been recorded. Part II reviewed the tests that have been made on Thysanoptera; Part III, the tests on Homoptera; Part IV, the tests on Hemiptera; Part V, the tests on Anoplura; and Part VI, the present paper, reviews the tests and recommendations for use on Coleoptera.

COLEOPTERA

Anobiidae

Lasioderma serricornis (F.), the cigarette beetle

Not affected by derris.--Van der Laan (252) in 1936.

Reed and Hookom (324) in 1937 reported rotenone dust ineffective against adult cigarette beetles. Pyrethrum dust was slightly more effective, but not satisfactory.

The adult is definitely susceptible to derris.--Crawford-Benson (90) in 1938.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (308) in its annual report for 1938 reported that pyrethrum-dust mixtures containing a high percentage of pyrethrins were slightly more effective than the dust mixtures containing rotenone, but in no instance did the pyrethrum compounds give a percentage of kill that would be satisfactory in practical operations against adults of the cigarette beetle in tobacco warehouses of the open type.

(Sitodrepa) Stegobium paniceum (L.), the drug store weevil

The adult is susceptible to derris but the results are unreliable and the insect is therefore not a suitable laboratory test insect for evaluating derris preparations.--Craufurd-Benson (90) in 1938.

Anthribidae

Araecerus fasciculatus (Deg.), the coffee-bean weevil

The adult is not susceptible to derris.--Craufurd-Benson (90) in 1938.

Bostrichidae

Dinoderus bifoveolatus Woll.

Feeds on derris roots in storage.--Corbett (86) in 1931; Federated Malay States Department of Agriculture (121) and Miller (286) in 1934; Muesebeck, in a letter to R. C. Roark in 1937.

Dinoderus minutus (F.)

Feeds on derris roots in storage.--Federated Malay States Department of Agriculture (128, 124) in 1933 and 1934; Miller (285) in 1934.

Rhizopertha dominica (F.), the lesser grain borer or Australian wheat weevil

The adult is definitely susceptible to derris.--Craufurd-Benson (90) in 1938.

Rhizopertha sp.

Tephrosia candida seeds and Derris elliptica roots applied as dusts were not effective.--Chatta and Marayanan (29) in 1938.

Sinoxylon anale Lesne

Feeds on derris roots in storage.--Federated Malay States Department of Agriculture in 1926 (119), in 1931 (120), in 1932 (121), in 1933 (122), and in 1934 (124); Corbett (86) in 1931; Spoon and Fovaux (353) in 1933; Miller (285) and Sakai (331) in 1934; Muesebeck, in a letter to G. A. Thompson, Jr., Kingston, F. I., and the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (395) in 1937.

Sinoxylon conigerum Gerst.

Feeds on derris roots in storage.--United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (392) in 1936.

Sinoxylon malaccanum Lesne

Feeds on derris roots in storage.--Corbett (86) in 1931; Federated Malay States Department of Agriculture (120) in 1931 and (124) in 1934; and Miller (285) in 1934.

Sinoxylon rugicauda Lesne

Feeds on derris roots in storage.--Federated Malay States Department of Agriculture (124) and Miller (285) in 1934.

Sinoxylon sp.

Feeds on derris roots in storage.--Cahn (64) in 1935.

Xylopsocus capucinus (F.)

Feeds on derris roots in storage.--Corbett (86) in 1931; Federated Malay States Department of Agriculture (123) in 1933 and (124) in 1934; and Miller (285) in 1934.

Xylothrips flavipes (Ill.)

Feeds on derris roots in storage.--Federated Malay States Department of Agriculture (124) and Miller (285) in 1934.

Bostrichidae (unidentified species)

Two species of Bostrichidae feed on derris roots in storage.--Gater (162) in 1925.

Bruchidae

Bruchus pisorum (L.), the pea weevil

Kuwayama and Endo (251) in 1935 reported that derris-soap and Neeton^{2/} soap sprays proved to be the most effective against the pea weevil. It was recommended to spray these solutions three or more times during the young pod stage in July.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, in its annual report for 1936 (393) reported that experiments indicated that dust mixtures containing rotenone may be useful in the control of the pea weevil, particularly in crops of high-quality peas.

An anonymous (1) writer on August 19, 1937, called attention to the use of rotenone dusts to control the pea weevil in the Pacific Northwest.

The rotenone method of attacking pea weevils takes advantage of their habit of congregating on the first pea to bloom. To lay the foundation for the attack, growers plant narrow border trap crops which will bloom earlier than the main field. The border is dusted just preceding the appearance of blooms in the main field. The weevils congregate on the peas in bloom to feed and deposit their eggs.

2/

Derris extract in fish oil.

Two methods are used in applying the rotenone dust. In large-scale commercial pea growing it is applied with a power duster that covers about 30 feet at a swath. In small garden plantings the dust is applied directly to the rows of peas with a hand dust gun. The first dusting on garden plantings is made just after the peas come into bloom and an application is made in each of 3 weeks thereafter. In large field plantings the dust is applied at the rate of 20 pounds to the acre. For a garden planting the entomologists advise dusting at the rate of about 1.05 ounces of dust to 100 linear feet of peas.

Dr. Wakeland reports that in the cannery pea districts of Washington and Oregon about 30,000 acres of peas were protected by border dusting. One grower protected 4,000 acres of peas with the dust.

Brindley (49) in 1937 reported that rotenone dusts gave promise in control of the pea weevil. As a result of large-scale field tests during 1936, dust mixtures containing 1.0 or 0.5 percent rotenone, with finely ground diatomaceous earth, tobacco dust, or sulfur as diluents, reduced the infestation more than 99 percent, on an average, in green peas harvested for canning and in dry peas harvested for seed or processing, as compared with the pea weevil infestation in untreated plots. These dust mixtures gave results superior to treatments with undiluted cryolite, calcium arsenate-sulfur (1:5), or Paris green-lime (1:5). Five treatments were applied to these experimental plots at a dosage of 20 pounds per acre per application, with the exception of the plot treated with the dust mixture containing 0.5 percent of rotenone in diatomaceous earth, which received 40 pounds per acre per application. In the untreated plots, on an average, approximately 43 percent of the peas were infested by the pea weevil.

Brindley, Chamberlin, and Associates (52) in 1937 reported that dust mixtures containing rotenone have given excellent control of the pea weevil in recent large-scale field tests in Idaho, Washington, and Oregon. Talc appears superior to diatomaceous earth as a diluent. In the Dayton, Wash., area many tons of rotenone-dust mixtures have been applied to the weevil-infested peafields. In most instances a dust mixture containing 1 percent of rotenone has been applied to strips 20 to 30 feet wide around the edges of the field, where the hibernating weevils have congregated. Under favorable weather conditions, most of the infestations in the treated fields have been reduced more than 95 percent and in some instances the weevil population has been reduced 99 percent. From one to three applications to those field borders have been necessary, depending on the movement of the weevils into the fields after such fields have been dusted.

Howard and Mason (198) in 1937, in discussing the best rotenone content of dusts for general use on the truck farm or in the garden, stated that it may be necessary to use a 1-percent dust in the control of the pea weevil.

Experiments by the Bureau of Entomology and Plant Quarantine, in cooperation with the Idaho Agricultural Experiment Station (211), in 1937 reported that successful control of the pea weevil may be expected from the use of derris dust. Peas dusted with derris and tobacco dust were 99.62 percent free from the weevil in the green-pea stage and 98.77 percent free in the dry-pea stage. Other effective insecticides were cryolite and derris dust with diatomaceous earth, and derris dust with sulfur. Calcium arsenate was the least effective of any of the dusts used.

The Oregon Agricultural Experiment Station (310) in 1937 reported that a method of controlling the pea weevil by the application of rotenone dusts had been discovered.

Ballard (25) in 1938 reported that the control of the pea weevil in commercial-scale plantings was achieved the past year by growers of 22,000 acres of peas in Umatilla County, Oreg. This was done by applying a talc dust containing 0.75 percent of rotenone by means of a hood-type duster.

Brindley (50) in 1938 reported that laboratory tests against *B. pisorum* at the Moscow, Idaho, laboratory gave the following results: (1) Distinct differences were shown to exist between the mortality obtained with dust mixtures containing 1, 0.75, and 0.5 percent of rotenone, respectively. Much less difference was noted in the toxicity of dusts containing 1 percent and 0.75 percent than between those containing 0.75 and 0.5 percent of this ingredient. (2) A cube-dust mixture with diatomaceous earth as a carrier did not give so high a mortality as did cube with talc as a carrier. (3) The addition of 2 percent of peanut oil, 1 percent of sodium oleyl sulfate, and 0.5 percent of water to cube in talc did not increase its toxicity. (4) A dust containing 0.005 percent of sulfur nitride was nontoxic to the weevils. (5) The addition of 0.225 percent of pyrethrins to a cube dust in talc, containing 0.5 percent of rotenone, markedly increased the toxicity of the dust. (6) Additional data were accumulated to indicate that at least a part of the toxic effect of rotenone-containing dusts to the pea weevil is due to its contact properties.

Chamberlin and Gray (78) in 1938 reported that the pea weevil in Oregon can be best controlled by the use of dust mixtures containing 0.75 percent of rotenone. From one to three applications to the infested fields are necessary, the first being made when the peas are in bloom and before the pods have set. Dusts should be applied at the rate of 20 to 25 pounds per acre.

Hinman and Fisher (187) in 1938 reported that during the summer of 1937 a dust containing 1 percent of rotenone, applied at the rate of 25 pounds per acre, satisfactorily controlled the pea weevil in Oregon and Washington. The use of hoods on the large dusting machines increased the efficiency of the dust, which should contain not less than 0.75 percent of rotenone.

The Idaho Agricultural Experiment Station (215) in 1938 reported that rotenone-bearing dusts applied when pods began to form and at intervals when the population was increasing, continued to give a high percentage of control of adults.

The New York State Agricultural Experiment Station (303) in 1939 reported that rotenone dusts showed promise in controlling the pea weevil in the field.

The Pea Weevil Conference (313), held in Spokane, Wash., in 1938, recommended rotenone dust for the control of the pea weevil in canning and garden peas. Talc is a good diluent; the rotenone content should not be less than 0.75 percent; and 20 to 25 pounds should be applied per acre by an efficient dusting machine. One to three applications starting within a few days of blooming are necessary.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (396) in 1938 recommended dusts containing not less than 0.75 percent of rotenone for the control of the pea weevil infesting garden peas and also peas grown for canning, for the green-pea market, and for seed. Either derris or cube may be used as the source of rotenone; and talc or some similar inert carrier may be used as a diluent. Applications of from 20 to 25 pounds of the dust mixture per acre, if applied with an efficient dusting machine, should give satisfactory results. In heavy infestations, as in some border-strip plantings, the use of an additional 5 pounds of the dust mixture per acre should give greater assurance of control. The first application should be made within a few days after the peas start to bloom and before any pods have formed; otherwise the weevils may lay eggs on the young pods. Additional weevil populations may fly into some of the fields; in these cases one or two additional applications may be necessary. The date of these later applications depends on the time the weevil population increases in the field. In most instances a 6- to 10-day interval between applications has been satisfactory.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (398) in 1938 reported that biological and control investigations on the pea weevil as a pest of processed and dry peas were continued in the Northwest in cooperation with the States of Washington, Oregon, and Idaho and interested growers, with gratifying results. The large-scale field experiments in the Blue Mountain area of eastern Washington and Oregon, in which dust mixtures containing rotenone were applied, yielded favorable results, as in 1937. Comparative treatments showed that the use of hoods on large dusting machines increased the efficiency of these dust mixtures. No appreciable differences could be detected in the percentage of pea weevil control obtained with dust mixtures containing 1 percent, as compared with those containing 0.75 percent of rotenone, when the quantities of the dust mixture applied per unit area were practically equivalent. The results, however, indicated that under unfavorable climatic conditions or other restricting factors the dust mixtures containing less than 0.75 percent of rotenone might not give a satisfactory degree of control. In large acreages, the practice of treating border strips was followed to protect the rest of the field. In some instances "spot dusting" was practiced to reduce infestation.

In the western Oregon and Washington pea-growing area where the pea-fields are in smaller units, the entire field was treated and weevil infestation was reduced to a minimum.

Brindley (51) in February 1939, reported the results of tests to control the pea weevil. Laboratory tests were conducted in 1934 with four insecticides--calcium arsenate, barium fluosilicate, a dust containing 0.45 percent of pyrethrins, and a dust containing 1 percent of rotenone in the form of powdered derris root. Adult weevils were placed on blossoms picked from plots that had been treated with these materials at the rate of 20 pounds per acre, dusted weevils were placed on untreated blooms, and weevils forced to walk a distance of 2 inches across a glass surface dusted with each of the materials were placed on undusted blooms. One application of calcium arsenate or barium fluosilicate, even though thoroughly applied, did not kill all the weevils in 24 hours, whereas the application of derris and pyrethrum dust killed all the weevils. When the materials were applied directly to the weevils, practically the same results were recorded.

Brindley and Linduska (53) of the Moscow, Idaho, laboratory, reported in February 1939, that experiments with dust mixtures containing rotenone against B. pisorum on garden plots in 1938 showed that the addition of various conditioners to the dust mixtures only slightly increased their efficiency, as compared with dust mixtures composed solely of finely ground derris or cube root with talc or diatomaceous earth as a diluent. The results of these experiments may be summarized as follows: (1) Dust mixtures containing 1 percent of rotenone with talc as the diluent, which is now being used commonly by the growers, gave a control of 95.6 percent when applied to plots harvested as green peas and 94.6 percent in plots harvested as dry peas, as compared with comparable untreated plots. (2) A dust mixture containing 1 percent of rotenone with diatomaceous earth as a diluent, also being used commonly by the growers, gave a control of 98.9 percent in the green-pea plots and 95.8 percent in dry peas. (3) A dust mixture containing 1 percent of rotenone with talc as a diluent, plus 1 percent of lampblack by weight, gave a control of 100 percent in the green-pea plots and 90.4 percent in dry peas. (4) A dust mixture containing 1 percent of rotenone plus 2 percent of peanut oil, 1 percent of sodium oleyl sulfate as a wetting agent, and 0.5 percent of water gave a control of 100 percent on green peas and 96.1 percent on dry peas. (5) A mixture containing equal parts by weight of a dust mixture containing 1 percent of rotenone with talc as the diluent and a dust mixture containing 0.45 percent of total pyrethrins with diatomaceous earth as the diluent gave a control of 99.6 percent on green peas and 89.2 percent on dry peas.

Haude (181) in 1939 recommended cube or derris dust (0.75 to 1 percent rotenone) at 20 to 25 pounds per acre, applied under a hood for control of the pea weevil.

Hinman, Fisher, and Brindley (188) reported in 1939 that a survey of the Blue Mountain area of Washington and Oregon revealed that more than four times as much dust mixture containing rotenone was used against the pea weevil in this area in 1938 as in 1937.

In 1937 approximately 47.5 tons of dust mixtures containing rotenone, costing approximately \$10,925, were used to protect approximately 38,000 acres of peas. In 1938, with an acreage of approximately 34,000 acres, a total of 211.5 tons of dust mixtures containing rotenone, costing approximately \$37,780, were used. The general results of the control campaigns for the 2 years were nearly the same, as in 1937 716 acres of peas, constituting 1.9 percent of the total acreage, were discarded on account of the pea-weevil damage, whereas in 1938 386 acres, or 1.1 percent of the total acreage, were discarded on account of pea weevil damage.

The Idaho Agricultural Experiment Station (216) in 1939 reported that dusts containing 1 percent and 0.75 percent of rotenone gave good control of the pea weevil when applied at the rate of 20 to 40 pounds per acre. Experiments on garden plots indicated that control to the extent of 97.02 percent in peas of table size could be accomplished with rotenone-bearing dusts.

An anonymous writer (5) in 1940 described the use of rotenone dust against the pea weevil in the Washington-Oregon canning-pea section. Approved practice now is to use a dust containing 1 percent of rotenone at the rate of 20 pounds per acre between the appearance of the first blooms and the first pods, usually 2 or 3 days. Cost for materials has been around \$1.50 per acre. Records of weevil damage were as follows:

Year	Acreage in peas	Acreage left uncut because of weevil damage
1935	12,000	Not recorded
1936	28,900	6 percent
1937	38,000	1.0 percent
1938	34,000	1.1 percent
1939	32,000	0.7 percent

Rotenone dust was first tried in the field in 1935, and in 1937 big-scale dusting with power machines was used. Various dusters are pictured and described.

Bruchus rufimanus Boh., the broadbean weevil

Liebster (259) in 1940 reported that pyrethrum and derris dusts were effective against this species.

Callosobruchus chinensis (L.)

Tephrosia candida seeds and Derris elliptica roots, applied as dusts to Bruchus chinensis L. [Callosobruchus chinensis (L.)], according to H. S. Barber, as stated by Muesebeck], in stored pulses gave from 60- to 100-percent mortality in 24 to 72 hours.--Bhatta and Narayanan (29) in 1938.

Chrysobothris femorata (Oliv.) the flatheaded apple tree borer

Johnson and Fenton (229) in 1939 reported the results of toxicity tests made in Oklahoma in 1937 on cage-emerged adults of the flatheaded apple tree borer. Derris (5 percent of rotenone) at 2 pounds per 100 gallons + casein spreader killed 100 percent in 5 days. Lead arsenate must be used at the rate of 8 pounds per 100 gallons to ensure 100-percent mortality in 5 days.

Cryptodactylus gracilis Schoenf.

Matsubara (281) in 1937 recommended spraying with Neoton (derris extract in fish oil) for the control of this buprestid, which is widely distributed on chestnut in Japan.

Byturidae

Byturus tomentosus (Deg.), a raspberry and loganberry beetle

The East Malling Research Station of Kent, England (107) in 1930 reported that a derris-root preparation had been tried for the control of the raspberry and loganberry beetle, but so far without success. In 1930 this station (108) reported that the proprietary derris-root preparation used in previous trials without conclusive results was again used and showed considerable promise. Further trials are being planned on a statistical basis.

In 1931 the East Malling Research Station (109) reviewed its work on the loganberry beetle. In spraying tests made in 1928 for the control of B. tomentosus lead arsenate paste at 4 pounds per 100 imperial gallons of water reduced the infestation from 37.3 to 15.0 percent; and a proprietary derris root preparation at 2 pounds to 40 imperial gallons of water reduced the infestation from 36.5 to 19.2 percent. In 1929 a pyrethrum extract and the derris preparation (2 pounds to 40 imperial gallons of water) did not materially reduce the infestation, whereas lead arsenate at 5 pounds plus 2 pounds of gelatin to 100 imperial gallons of water gave almost complete control. None of the sprays had any appreciable effect on the adult beetles, which were in the flowers at the time of spraying. In 1930 the derris preparation reduced the infestation to 3.7 percent. The failure of derris to control in the tests in 1929 may have been due to variation in the composition of different samples or to the use of old stock. Arsenical residue on sprayed berries bars the use of lead arsenate.

In 1932 this station (107) called attention to Steer's (357) paper on the control of the raspberry and loganberry beetle by means of derris. The proportion of marketable loganberries in a badly infested plantation was increased from 23.8 to 77.7 percent by two sprayings with derris and soap. The average number of loganberries per pound of ripe fruit over the whole of the picking season worked out at 176 on unsprayed and 127 on sprayed plots.

Kearns and Swarbrick (240) of the Agricultural and Horticultural Research Station of the University of Bristol, at Long Ashton, England, in 1932 reported that derris-soap spray (rotenone 0.004 percent) was superior to derris extract in rape oil emulsified in water (rape oil 1 percent, rotenone content undetermined) for the control of larvae of the loganberry beetle.

Steer (356) in 1932 reported favorable results on the control of the raspberry and loganberry beetle in England by means of derris. This beetle was formerly controlled by three applications of lead arsenate given when one-third, two-thirds, and all the blossoms were fully open. On account of arsenical residue on the ripe fruit when the young berries were sprayed with lead arsenate, this insecticide was abandoned in favor of derris. In 1928 a single application of derris spray reduced the infestation considerably. In 1929 indifferent results were obtained because the derris used had been in stock for a long time. In 1931 two sprayings of derris reduced the average infestation of loganberries from 66.3 to 14.6 percent and of raspberries from 78.3 to 5.6 percent. On loganberries this treatment nearly doubled the total weight of the crop and increased the proportion of marketable fruit in a badly infested plantation from 23.8 to 77.7 percent. This meant an increase in marketable fruit at the rate of over 2 tons (from 8.3 to 51.8 cwt.) per acre. The average number of loganberries per pound of ripe fruit over the whole of the picking season worked out at 176 on unsprayed and 127 on sprayed plots. A derris preparation containing soap was used at the rate of 5 pounds per 100 imperial gallons of water and the spray was applied at the rate of 500 gallons per acre per application.

The Agricultural and Horticultural Research Station of the University of Bristol (54), England, at Long Ashton, in 1933 stated that efficient control of the raspberry and loganberry beetle is obtained with derris-soap suspensions.

Hus (209) in 1933 stated that derris preparations used as sprays kill newly emerged larvae of the raspberry beetle.

Kearns and Walton (242) in 1933 reported experiments with pyrethrum and derris washes and dusts for the control of the loganberry and raspberry beetle. Tests are recorded with a derris wash (2-1/2 or 5 pounds of derris powder containing 1.72 percent rotenone and 10 pounds spraying soap per 100 imperial gallons), derris emulsion (derris extract in rape oil), and derris dust (containing 10 percent derris and 0.18 percent rotenone). The proprietary derris emulsion gave very poor results against *Byturus*. Two applications of a derris wash containing less than 0.004 percent of rotenone gave a high control of the larvae. The first application was made 10 days after about one-third of the flower buds had opened and a second application 10 days after the full flowering period. No further increase in control resulted by using a wash of a higher concentration than 0.004 percent of rotenone. In seasons in which the beetles cluster in large numbers on the unopened and just-opening flower buds, the application of a derris dust (containing 0.18 percent rotenone) is effective in killing large numbers of them. The dusting should be followed by at least one application of a derris wash, to kill the larvae.

Kearns and Walton (243) in 1933 further compared the relative efficiency of pyrethrum and derris for the control of *B. tementosus*. A plot of raspberries of the variety Lloyd George was adjacent to the Baumforth 'A' raspberries. One portion was sprayed twice with the 1.0-percent-pyrethrum emulsion and another portion with a derris-soap wash at periods calculated to kill the larvae.

The pyrethrum plot had 22.6 percent and the derris plot 5.5 percent of the berries infested.

Petherbridge and Thomas (316) in 1933 reported that in 1931 a good control of the raspberry beetle in England had been obtained with a proprietary preparation of soft soap and powdered derris used at the rate of 1 pound of derris to 60 imperial gallons of water. This was applied when the eggs began to hatch and again 4 days later. In 1932 a derris powder (2.2 percent of rotenone) at the rate of 1 pound in 50 imperial gallons of water, plus a proprietary spreader for the first application and 5 pounds of soft soap for the second, was used in the Isle of Ely. The percentage of damaged raspberries from this plot was 4.9, as compared with 4.6 from the plot sprayed with soft soap, 5 pounds, and nicotine sulfate, 10 ounces, in 40 imperial gallons of water, and 84.8 percent from the unsprayed plot. In Essex in the same year two sprayings with soft soap and derris powder gave satisfactory control of the raspberry beetle. Four sprayings gave still greater control, but not sufficient to make more than two sprayings an economic proposition. On loganberries two sprayings of soft soap and derris with a power sprayer gave a fairly good control (13.3 percent damaged berries) of this beetle. Two dustings with a derris dust gave a better control (4.5 percent damaged berries) than two sprayings (13 percent damaged berries). The authors concluded that dusting with a derris dust (containing 0.2 percent of rotenone) is the most satisfactory means known at present of reducing the damage done to loganberries by the raspberry beetle.

Spron (352) in 1933 reported that an aqueous suspension of pure rotenone gave excellent results.

Steer (358) in 1933 reported further experiments on the control of *B. tomentosus*. Tests were made with a very finely ground derris powder containing 5.87 percent of rotenone. The sprays were made to contain 13-3/4 ounces of this powder per 100 imperial gallons (rotenone content 0.005 percent) or double this strength. The dust was composed of 1.6 percent of this derris powder and 98.4 percent of china clay, making a rotenone content of 0.09 percent. Three applications of a derris dust, about 100 pounds per acre, reduced the infestation per 100 berries from 75.5 to 12.5. Two sprayings with derris powder (rotenone content of spray = 0.01 percent) plus soft soap, 5 pounds per 100 imperial gallons, reduced the infestation per 100 berries from 78.8 to 0.4. A proprietary derris and soap preparation used with success in previous seasons reduced the infestation to 0.9. According to Steer, an estimation of the rotenone content appears to be the most satisfactory method of assessing the value of a sample of derris, and such estimations have been used as a means of standardization in the trials described. Steer concluded that a spray containing sufficient finely ground derris to give a rotenone content of 0.005 percent, and 5 pounds of soft soap per 100 gallons, gave excellent results against larvae on both raspberries and loganberries, whether used according to the double-spraying or the new single-spraying method. Besides reducing the percentage of fruits infested, it had an enormous beneficial effect on the yield and quality of the crop. A derris dust containing 0.09 percent of rotenone again gave a serviceable measure of control on raspberries but was somewhat inferior to any of the wet sprays used. Preliminary trials showed that the pest can be controlled on cultivated varieties of blackberries by means of derris.

The East Malling Research Station (111) of Kent, England, in 1934 stated that a single application of a derris spray of known rotenone content is adequate for control of the raspberry and loganberry beetle.

Steer (359) in 1934 reported experiments on the control of the raspberry and loganberry beetle in Kent, England. Tests were made with derris (2.71 percent of crude rotenone or 2.32 percent of recrystallized rotenone) as a spray and as a dust, and cube (6.26 percent of crude rotenone and 5.27 percent of recrystallized rotenone) as a spray. In the sprays 2 pounds of derris or 1 pound of cube, plus 5 pounds soft soap, was used per 100 imperial gallons. The dust was made by mixing 3.7 percent of derris and 96.3 percent of china clay. The conclusions are as follows:

Derris dusting. Good results have been obtained by dusting three times with a derris dust of 0.09 percent rotenone content applied to kill the beetle larvae. This method of control is somewhat less effective than a single wet spraying given when the larvae begin to attack the fruit, it is more costly, and the dust is very apt to leave an unsightly (though harmless) deposit on the earlier berries. On the other hand, a dust is quickly and easily applied and for this reason recommends itself to many growers.

An attempt to kill the adults, and to prevent egg laying and subsequent fruit damage, by means of a single application of dust was not successful. This experiment cannot, however, be regarded as conclusive in view of the good results obtained by Petherbridge and Thomas, who dusted loganberries in a similar manner. To get adequate control by means of a dust applied sufficiently early to avoid leaving a deposit on the fruit, and intended for the adult beetles rather than the larvae, it may be necessary to dust very heavily and to use a dust of higher rotenone content than that hitherto used in our experiments.

Wet spraying with derris. From the results of field spraying trials carried out to date at East Malling, it is clear that one application of derris and soap is adequate for either raspberries or loganberries. This should be given when the larvae begin to damage the berries.

The results obtained on blackberries suggest that the very early varieties can be given exactly the same treatment as loganberries.

At the concentrations used no differences can be detected between the performances of derris and of cube either at any one time during the picking season or for the whole period.

Roark (327) in 1938, in comparing the insecticidal values of derris and cube, referred to this report by Steer.

The Wageningen Plantenziektenkundigen Dienst (403) in 1934 reported that an aqueous suspension of rotenone (1:10,000) is effective against adults and larvae of the raspberry beetle.

Amos, Beard, Moore, and Painter (10) in 1935 stated that a proprietary derris powder, 2 pounds plus soft soap, 5 pounds per 100 imperial gallons, was sprayed on raspberries on June 26, 1934, against B. tomentosus, as part of the routine spraying program for that year.

Steer (102) in 1935 reported that finely ground derris (crude rotenone = 3.63 percent or recrystallized rotenone = 2.92 percent) was applied as a spray, 2 pounds to 100 imperial gallons of water, and as a dust diluted with china clay. A single spraying of derris and soap gave inadequate control of the larvae on raspberries. A single application of a derris dust, applied late in May to control the adult stage of the raspberry and loganberry beetle, failed to give satisfactory results on raspberries, even when the rate of dusting was about 3 cwt. per acre and the crude rotenone content of the dust as high as 0.36 percent. On loganberries, derris gave as good results when incorporated in a spray of lime-sulfur and sulfite lye, or of colloidal copper and sulfite lye, as when used with soft soap. A small-scale trial on Himalaya berry confirmed last season's finding that a single application of derris and soap can satisfactorily control the pest on cultivated blackberries.

Gray and Brooks (166) in 1935 reported spraying trials against the raspberry beetle in England. A liquid derris wash gave better control than barium fluosilicate or nicotine. Two applications were sufficient, one during the opening of the buds, the other during petal fall. Applications consisting of a combination of dusts and a wash gave consistently inferior results. Derris dust was applied when the buds were opening and when fully open, and a derris wash when the petals were falling.

Harris (179), of the East Malling Research Station in England, reported in 1936 that a spray of 2 pounds of finely ground derris root and 5 pounds of soap in 100 imperial gallons of water caused a 90-percent reduction in injury by the raspberry beetle.

B. tomentosus is sensitive to derris dust. This is one of the first insects in the Netherlands to be successfully controlled with derris.-- DeBussy et al. (61) in 1936.

Carroll (67) in 1936 reported the results of tests in the Irish Free State with derris against the raspberry beetle. Sprays of derris powder plus coconut oil soap, or of derris preparations containing a spreader when diluted to a rotenone content of 0.005 percent and applied twice (first, about 2 weeks after flowering had begun and second, 10 days later), resulted in 99 percent of the berries being free from larvae.

Fryer (149) in 1936 reported on insect pests of crops in England and Wales for 1932-34 and methods for their control. The success obtained in earlier experiments on the control of the raspberry beetle by means of derris sprays and dusts has been confirmed by further work; and the treatment of raspberries, loganberries, and cultivated blackberries with derris preparations has become a routine method in fruitgrowing areas.

The destruction of the raspberry beetle by derris in the Netherlands was general practice in 1936, according to the Koloniaal Instituut of Amsterdam (12, 13).

One of the principal uses of derris in the Netherlands is for the control of the raspberry beetle.-- Van der Laan (243) in 1936.

Steer (360) in 1936 published a summary of the use of derris as an insecticide in England. For many years, usually under various proprietary names, derris root has been used in England, not only as a spray for fruit trees, hops, and garden crops but as an ingredient of cattle and sheep washes and domestic-insect powders. There are four forms in common use: (1) The finely ground root, for use with soap or other wetter; (2) the ground root ready mixed with dried soap or other wetter and requiring merely the addition of water; (3) an extract of the root, usually in an emulsified form, ready for dilution with water; and (4) the ground root mixed with a suitable "carrier" or "filler," such as china clay, and intended for application as a dusting powder. Derris powder costs from 50 to 62 cents per pound. Dusting powders containing 0.2 percent of rotenone usually cost about 7 cents per pound. Derris is compatible with any of the sprays in common use, such as bordeaux mixture and lime-sulfur. At East Malling Research Station derris was first used experimentally in 1928 to control the larvae of the raspberry beetle. Against the raspberry beetle a single spraying of derris and soap gives perfectly satisfactory results. Many growers prefer to attack the adult stage of the pest by means of derris dusts and so prevent egg laying and subsequent fruit damage. Good results are obtained by dusting during the flowering period, but several applications of the dust seem to be required.

Derris gives good results. --Anonymous (2) in 1937.

Kearns and Marsh (238) in 1937 recommended derris dust for the control of adults of the raspberry beetle and derris dust or spray for the larvae. The derris dust should contain not less than 0.13 percent, and the spray not less than 0.004 percent of crystalline rotenone. Many samples of derris root contain 1.5 percent of crystalline rotenone, and with a root of this concentration it is necessary to use 2-1/2 pounds of derris root per 100 imperial gallons of water. The application after petal fall is the more important, and a spray is preferable to a dust, as it also provides a control of aphids. For loganberry and blackberry a program similar to that for raspberry is recommended.

Warwick (410) in June 1938, reported that two dustings with derris are usually adequate to control the raspberry and loganberry beetle.

Shaw (337) in January 1939, wrote that the mixed derris-copper-oxychloride wash was likely to become recognized in Great Britain as the standard combined treatment for the raspberry beetle and cane spot.

Byturus unicolor Say, a raspberry fruitworm

Caffrey (63) in April 1935, recommended derris sprays and dusts for the control of B. unicolor. If sprays are used, the first spray applied just before the blossoms open should consist of a mixture of 4 pounds of lead arsenate powder and 4 pounds of hydrated lime to 100 gallons of water.

Two weeks later apply a derris-root spray containing 0.01 percent of rotenone, made up according to the following formula: 100 gallons of water, 27 ounces of derris root powder containing 5 percent of rotenone, and 1 pint of a good grade of neutral mineral oil or pine oil or sulfonated castor oil. This derris spray should be repeated 2 weeks later. Although dusts have not been so successful as sprays in controlling the raspberry fruitworm, dusts may be used if desired. Time of application of the dust mixtures should be the same as for the sprays. The first dust application should consist of lead arsenate powder mixed thoroughly with an equal weight of hydrated lime and applied at the rate of 35 pounds per acre. The second and third dust applications should consist of a mixture made up of 2 pounds of derris-root powder, containing approximately 5 percent of rotenone, and 98 pounds of tobacco dust, talc, or clay as a diluent.

Crumb (89) in 1935 reported results of tests at Puyallup, Wash., with insecticides against the raspberry fruitworm on Marlborough and Cuthbert raspberries, loganberries, and youngberries. Best results were obtained by applying a spray consisting of 4 pounds of lead arsenate and 4 pounds of hydrated lime to 100 gallons of water at the peak of beetle emergence, approximately 2 or 3 weeks prior to blossoming, followed by a second application of the same spray just before blossoming, with a third application of a derris-root-powder spray, containing 0.01 percent of rotenone, 2 weeks after blossoming. The omission of the first or second lead arsenate spray decreased the percentage of control. In general, sprays gave better results than dusts. The application of a derris-root spray containing 0.01 percent of rotenone in the third spray gave results superior to those obtained with a nicotine sulfate spray (40 percent of nicotine) 1: 400.

The United States Bureau of Entomology and Plant Quarantine (393) in 1936 reported that large-scale tests directed against the raspberry fruitworm in the Puyallup Valley, Wash., showed that two sprays of lead arsenate applied to the plants prior to blooming, followed immediately after the blooming period by one spray containing derris root, gave a satisfactory commercial control and produced fruit free of arsenical residues.

Crumb (94) in 1938 reported that applications of ground derris or cube root, either as a spray or as a dust, will give satisfactory control of the raspberry fruitworm, if the work is done properly. In general, however, sprays have given better results than dusts. Three applications of spray containing finely ground derris or cube root powder are necessary for the best results. The first spray should be applied 10 days after blossoming begins, the second 7 days after the first, and the third 7 days after the second. If only two sprays are used, the first should be applied 15 days after blossoming begins and the second 10 days later. The last spray, if applied later than recommended, may leave an unsightly residue on the harvested fruit, particularly if derris or cube root low in rotenone is used, thus making it necessary to use a large quantity of the material. The derris or cube powder should be made into a paste with a small quantity of water before being added to the water in the spray tank. The time of application of the dusts should be the same as that recommended for sprays, and 35 pounds per acre should be used for each application. The diluted spray should contain about 0.01 percent of rotenone; the dust, 0.5 percent of rotenone. Very finely ground talc, bentonite clay, and tobacco dust

are suitable for use as carriers. Lime should not be used for this purpose, because it greatly reduces the effectiveness of these insecticides.

Hanson and Webster (178) in 1938 recommended derris or cube dust (0.5 percent of rotenone) or spray (0.01 percent of rotenone) for the control of the raspberry or loganberry fruitworm, B. unicolor. Three applications should be made, the first 10 days after blossoms appear and the others at 10-day intervals thereafter.

At the New York County Agents Training School (299) held in Ithaca, N. Y., on December 19, 1938, it was reported that rotenone gave very good results against the raspberry fruitworm. Reports from Washington State indicate that good results were obtained with three rotenone sprays, the first 10 days after bloom and the last two at 7-day intervals. Under Hudson Valley, N. Y., conditions the applications would have to be made much earlier than this.

The United States Bureau of Entomology and Plant Quarantine (398) in 1938 reported that continued insecticide tests against the raspberry fruitworm in the Puyallup Valley, Wash., showed that satisfactory control of this pest could be obtained with three timely applications of sprays or dust mixtures containing rotenone, and that in general the sprays were superior to the dust mixtures in controlling the fruitworm.

Landis and Baker (255) in 1939 reported that of 50 Puyallup Valley raspberry growers who were questioned, 46 used insecticides containing rotenone in combating B. unicolor in 1938. Of the growers who used dust mixtures containing rotenone, 63.6 percent made one application, 27.3 made two, and 9.1 percent made three. Of the growers who used sprays containing rotenone, slightly more than half made one application and none made more than two. Judging from all available information satisfactory control of the raspberry fruitworm was obtained with two applications of the sprays or two or three applications of the dust mixtures, timed and applied properly. These results coincided in general with the results obtained in experimental plots, which indicated that sprays containing 0.01 percent of rotenone were slightly better than dust mixtures containing 0.5 percent of rotenone, and that three applications of these insecticides were superior to two.

Byturus sp.

The Wageningen Plantenziektenkundigen Dienst (402) in 1933 reported that rotenone suspended in water 1:5,000 and derris powder at a concentration equivalent to rotenone at 1:2,500 gave very good results against Byturus on raspberry.

Cantharidæ

Cantharis (Telephorus) sp.

Killed by one application of derris dust containing 0.5 percent of rotenone and 1.2 percent of other extractives.--DeBussche et al. (61) in 1936.

Zabrus tenebrioides (Goeze) ~~≠~~ Z. zibbus F.)

Resistant to a dust containing 2 percent of rotenone.--Anonymous (2) in 1937.

Cerambycidae

Gracilia minuta F.

Sensitive to derris dust.--DeBussy et al. (61) in 1936

Perissus laetus Lameere

Feeds on derris roots in storage.--Federated Malay States Department of Agriculture (124) and Miller (285) in 1934.

Pterolophia melanura Pasc.

Feeds on derris roots in storage.--Federated Malay States Department of Agriculture (124) and Miller (285) in 1934.

Chrysomelidae

Altica ampelophaga Guér.

Chevalier and Laffond (81) in 1938 reported that the toxicities of dusts containing different amounts of derris, cube, or rotenone were tested on adults of Rhaphidopalpa foveicollis Lucas on melon, and on larvae and adults of (~~Haltica~~) Altica ampelophaga Guér. on grapevines in Algeria. Determinations were made of the contents of rotenone and other extractives in 13 commercial dusts containing cube or derris alone or with a diluent. Experiments were arranged to test the toxicity of rotenone (using talc impregnated with a solution of pure rotenone), of derris diluted with talc, and of commercial dusts of known composition. Each powder was tested on 10 larvae and 10 adults in 3 ways--by rolling the insects in the dust, by dusting them from a distance of 15 centimeters, and by placing them on powdered foliage. Control insects were treated similarly with pure talc. Mortality varied directly with the content of active material. A dust containing 0.25 or 0.5 percent of rotenone appeared to be effective, although commercial products usually contain more. Dusts containing plant material were more effective than talc with the same rotenone content, which showed the insecticidal value of the other extractives. The rate of action of the insecticides appeared to be practically independent of the method of application. There was considerable difference in the toxicities of some of the commercial products with nearly the same rotenone content.

Altica ignita Ill., a strawberry flea beetle

Fenton (127) in 1936 referred to work at Dickinson, Tex., by Roney, who found that a dust containing rotenone (0.5 percent) and also pyrethrum and sulfur controlled this beetle.

CORRECTION

E-603. A REVIEW OF THE INSECTICIDAL USES OF ROTEHONE AND ROTENONDS FROM DERRIS, LONCHOCARPUS (CUBE AND TIMBO), TEPHROSIA, AND RELATED PLANTS. PART VI: COLEOPTERA.

The paragraphs that follow were accidentally omitted from the original edition of the circular. This sheet should be inserted (as page 18a) between pages 18 and 19.

Altica oleracea (L.), a flea beetle

This pest on cauliflower was killed by a product containing 12 percent of powdered Lonchocarpus nicou root (of 6 percent rotenone content) and 88 percent of talcum, according to Etablissements Rotenia in 1938, in a letter to R. C. Roark.

Altica pagana Blackburn, a metallic flea beetle

Evans (116) in 1937 reported that the metallic flea beetle in Tasmania can be controlled by the application of derris dusts, several brands of which are now on the market. These dusts can be used right up to the time the fruit is picked, unlike lead arsenate, which can be used with safety on plants only prior to fruit development. Derris dust will not only kill the beetles and grubs on treated plants but will protect the plants for a period from further attack.

Altica spp.

Hamp (175) in 1937 reported that flea beetles of the genera Chaetonnema, Psylliodes, and Altica are among the worst pests of hops in Bavaria, especially in warm, sunny situations. In spring the injury to the shoots, usually most severe in May, retards their growth, weakens the plants, and reduces the crop. The second summer attack impairs the appearance and quality of the inflorescences. The beetles were particularly abundant in 1928, in 1934 (which was extremely hot and dry), and in 1935. Some varieties of hops are more attacked than others; e.g., those that grow rapidly when young overcome the effect of the injury most readily. Since 1926 45 different insecticides have been tested in 31 experiments. Hand dusters and knapsack sprayers were used. On an average, 60 minutes were required to dust 7,000 hop vines and 70 minutes to spray them with 22 gallons of spray. The effect was best judged after an interval of 72 hours. In the dusting tests, derris insecticides invariably proved absolutely reliable and were distinguished by rapid and effective action. Pyrethrum was always less efficient, and though good results were obtained with 22 pounds per 1,000 vines, it is not advocated. Nicotine acted quickly, but required a high air humidity, and many beetles recovered. Arsenicals acted slowly but were effective if the weather was continuously fine. The silicic acid powder, Naaki, was merely a repellent. In the spraying tests, derris and nicotine had good killing power, while that of pyrethrum was poor. Dusts, however, are more satisfactory, prompt application being essential.

Aphthona sp.

Sensitive to derris dust.--DeBussy et al. (61) and van der Laan (252) in 1936.

Aspidomorpha miliaris (F.)

The larvae of this beetle were used as test insects for determining the insecticidal value of specimens of derris by Corbett, entomologist of the Federated Malay States Department of Agriculture (124) in 1933. They were also used by the Federated Malay States Department of Agriculture (125) in 1934 in testing the insecticidal value of Derris elliptica and D. malaccensis.

Miller (286), of the Federated Malay States Department of Agriculture, in 1935 reported results of spraying and immersion tests against A. miliaris which indicated that the insecticidal properties of the three kinds of derris tested were about the same. He concluded that the rotenone content is not necessarily a reliable index to the toxic value of derris root. Rotenone, deguelin, and toxicarol were only moderately toxic to the insects used in the tests. The aqueous solutions of derris root or crushed, freshly harvested roots were toxic to larvae of A. miliaris without actual contact, indicating that derris may yield a volatile toxic substance. Fluids obtained from derris by steam distillation were also toxic to larvae of the same species when immersed therein, killing 12 percent of A. miliaris. The indications are that derris may affect the nervous system of insects through the integument, and may also act as a repellent.

About 24,000 of these beetles were used, and they proved to be entirely suitable because of their adaptability to laboratory conditions.

Brontispa longissima Gestro

These hispids living on coconut proved in laboratory tests to be readily killed by derris. Wetting with derris powder suspensions having rotenone content of 1:10,000 to 1:20,000 was effective on both adults and larvae. Control by means of derris would probably be more difficult in practice, because the insects live concealed in the unopened leaves. These leaves should be opened as far as possible and the derris powder sprayed or dusted into the heart of the cluster.--Van der Vecht (401) in 1936.

Cassida sp., a tortoise beetle

Both adults and larvae of a species of Cassida on beets were resistant to derris.--Anonymous (2) in 1937.

(Aulacophora) Ceratia flavomarginata Duviv.

(401) in 1936

Frequently a serious pest of cucurbits. Van der Vecht reported that the beetles are extraordinarily sensitive to derris. In the laboratory conclusive results were obtained by spraying with derris powder in water, rotenone content 1:2,000, 1:3,000, and 1:5,000. All treated beetles (in lots of 20) were paralyzed after a short time and were dead within 1 to 2 days.

Also, spraying with suspensions with rotenone content of 1:10,000, 1:20,000, and 1:30,000 was frequently conclusive. All the beetles were paralyzed within a few hours; however, death usually occurred later, after 2 to 6 days, and in case of treatment with the 2 last-named liquids, 1 to 2 of the 20 beetles reacted to contact even after 6 days. All the insects were paralyzed by spraying with suspensions with rotenone content of 1:40,000 and 1:56,000, but at every test 2 of the 20 beetles recovered, the other 18 dying after 2 to 5 days. In field spraying tests made in triplicate on about 50 to 100 beetles each time, with derris-powder suspensions in water (rotenone content 1:20,000) 100 percent always died. If more dilute spray liquids were used, a few beetles always remained alive. Van der Vecht recommends a suspension with a rotenone content of 1:10,000 to 1:20,000; that is, 1 to 2 gm. per liter of a powder with about 5-percent rotenone content.

Dusting with derris powder diluted with talc also proved effective against the beetles. The insects were paralyzed within a few hours and all died within 24 hours after dusting with powders that contained 0.25 to 0.5 percent of rotenone. Even by dusting with a mixture of equal parts of talc and a derris powder containing less than 0.3 percent of rotenone and only 6 percent of ether extract, the beetles were still paralyzed; in a few instances, however, 4 or 5 days elapsed before they died. Dusting with talc powder plus 5 percent of ether extract without rotenone was also effective, the treated insects being paralyzed in 1/2 hour and dead in 18 hours. Van der Vecht recommends for dusting: High-grade powders to be diluted to 0.5 percent rotenone content; low-grade to 0.25 percent.

The question whether spraying or dusting is more profitable is difficult to answer in this case. In general, less material is used in spraying than in dusting, but perhaps the treatment would have to be repeated more frequently since the after effect of spraying is very poor. In the laboratory, beetles confined for 2 days on leaves that had been sprayed with a strong derris-powder suspension (rotenone 1:1,600) showed only slight mortality (5 of the 20 beetles). The insects took almost no food; thus the sprayed leaves, in general, seem to have had a repellent effect. After the beetles had received fresh food they again fed normally. The after effect of the dusting was much greater than that of the spraying; dusted leaves were not only attacked but a considerable percentage (about 60 to 80 percent) of the beetles that settled down on them died. This advantage over spraying, however, is important only in times with little rainfall and in cases where the chances of reinfestation are great.

Finally, it has been concluded that it is desirable to begin the treatment early, to protect the plants during the difficult early stages; before all, the spraying or dusting must be regularly repeated in the beginning. The results that can be obtained were shown in a Luffa planting of the Agricultural Institute. At first this was treated with derris twice a week, later once a week; then treatments were begun when the little plants were 2 weeks old. While the untreated Luffa were continually severely attacked and showed completely riddled leaves and for this reason grew slowly, the leaves treated with derris remained practically whole and the growth was faster.

Cerotoma trifurcata (Forst.), the bean leaf beetle

Brannon (37) in 1936 reported that in preliminary tests derris sprays containing 0.015 percent of rotenone were shown to be effective against C. trifurcata, which had been abnormally abundant in the Norfolk section during May. The treatment applied to the infested snap beans was the same as that recommended for the control of the Mexican bean beetle. Before treatment of these beans, the foliage injury caused by the bean leaf beetle was estimated at from 60 to 75 percent. Eleven days after treatment the foliage injury on the treated plots was estimated at from 5 to 15 percent, whereas on the untreated plots it ranged from 35 to 40 percent.

Fenton (127) in 1936 recommended the same treatment for this beetle as for the Mexican bean beetle, that is, rotenone dusts and sprays.

Nettles (294) in January 1939 recommended derris extract for the control of the bean leaf beetle in South Carolina.

Haule (181) in 1939 recommended a dust (0.5 percent of rotenone) or a spray (3 pounds of cube or derris of 4 percent rotenone content per 100 gallons) for the control of this insect.

Brannon (47) in 1939 reported that a spray containing cube root, pyrethrum, and sulfonated castor oil, and a dust mixture composed of cube plus pyrethrum flowers, with sulfur as a diluent, and containing 0.5 percent of rotenone, were highly toxic to the bean leaf beetle on the spring crop of snap beans at Norfolk, Va.

Sulfur was much more effective than talc as a diluent for cube-root powder in the control of this insect.

Chaetocnema aridula (Gyll.), a flea hopper

Ripper (326) in 1936 reported that derris dust gave good results in preliminary trials when applied under a long canopy attached to a "Bean" duster.

Chaetocnema sp.

See Hampp (175) under Altica spp., on page 19.

Chalcinus dorsalis Thumb., the locust leaf miner

Poos (320) in 1940 reported the results of tests of a derris dust (0.75 percent of rotenone) C. dorsalis attacking soybeans. The grower made a heavy application of the dust, and an examination of the area 5 days later indicated that a very large percentage of the adult beetles had either been killed or driven away. The plants had made a remarkable recovery and were rapidly growing out of the injury. The adults showed no tendency later to deposit eggs on the plants, even on those not treated.

Chrysoschus cobaltinus Lec., a blue milkweed beetle

L. G. Smith (344) in 1939 suggested a rotenone dust for the control of this beetle on peach trees or other economic plants.

Chrysomela populi L.

Kearns (237) in 1936 reported on the control of Melasma populi (L.) (Chrysomela populi L.) a pest of basket willows in England. Toxicity tests in the laboratory showed that the beetle is readily killed by a wash containing not less than 0.0025 percent of crystalline rotenone. The larvae, particularly when fully grown, were not so readily killed by a derris wash, and the application of lead arsenate to the foliage proved to be a more certain method of controlling them. The infested bud was sprayed on June 27, 1934, with a combined wash consisting of derris root, 4 pounds of lead arsenate powder, and a proprietary wetter added to 100 gallons of water, the concentration of the wetter being adjusted so that a satisfactory deposit of the lead arsenate was obtained on the foliage. The wash killed by contact action considerable numbers of beetles, and of those that escaped many more were killed by the arsenate. Many of the larvae collected a week after the spraying died, presumably by eating the arsenate on the foliage.

Chrysomela spp., willow leaf beetles

Hamilton (172) in 1937 reported that willow leaf beetles (Line spp. = Chrysomela spp.) on black willow trees were well controlled by a spray of 4 pounds of derris or cube powder (4% of rotenone) and 4 pounds of rosin-residue emulsion per 100 gallons of water. The spray acts as a repellent and contact poison and gave good control of larvae.

The New Jersey Agricultural Experiment Station (293) in 1932 reported that a spray of derris or cube powder plus resin-residue emulsion in water was effective against the larvae of the willow leaf beetle and has some contact and repellent action against the adults.

Glitea metallica Chen

Chen (80) in 1937 reported on the bionomics and control of this beetle, which is a serious pest of citrus in China. The larvae attack the buds, young leaves, flowers, and fruit. Lead arsenate and bordeaux mixture are recommended against the adults, and "tu yu t'eng" [probably derris, according to the Review of Applied Entomology (A) 23:117] against the larvae.

Crioceris asparagi (L.), the asparagus beetle

At the 1934 meeting of the American Association of Economic Entomologists Cory (388) led a discussion of field results with arsenical substitutes for the control of vegetable insects. According to Headlee, (133) in 1935, the asparagus beetle can be controlled by derris dust. In the same year the New Jersey Agricultural Experiment Station (296) reported that derris had proved effective in field demonstrations.

Derris gives good results according to an anonymous (2) Dutch writer in 1937.

Bourne and Boyd (33) in 1937 gave directions for the control of common insect pests in the home garden. Derris or cube dusts should contain 0.5 to 0.75 percent of rotenone. For the control of the asparagus beetle, during the cutting season, leave occasional shoots uncultivated to attract the beetles for feeding and egg laying, and keep the rest of the bed closely cut; or apply nonpoisonous pyrethrum or rotenone sprays or dusts.

Huckett (205) in 1937 recommended derris or cube for the control of the asparagus beetle. Injury may be prevented in beds by spraying or dusting the tips thoroughly with derris mixtures during the cutting season to kill beetles and slugs. As a spray use 5 pounds of derris and 4 pounds of skim milk or Kerosene to 100 gallons of water. As a dust use 15 pounds of derris to 85 pounds of clay or talc. Use powdered derris 10 or 4 to 5 percent rotenone content and 15 to 18 percent total extract content; or, if derris is not available, substitute powdered cube or timbo root of comparable analysis.

Hutson (213) in 1937 recommended derris dust (0.6 percent of rotenone) for the control of this beetle.

Derris powder (4 percent of rotenone) at the rate of 2 pounds per 100 gallons of water, plus about 2 pounds (dry basis) of coconut-oil soap killed 98 percent of the larvae and 83 percent of the adults. -- Manschke (272) in 1937

Derris dusts have given satisfactory results on the asparagus beetle. -- New Jersey Agricultural Experiment Station (297) in 1937.

C. L. Smith (339) in 1937 reported tests of derris sprays against several species of insects. Small-plot tests were made and the derris powder (90 to 95 percent, passing a 200-mesh sieve, rotenone 4 percent) plus a 40-percent coconut-oil soap was applied with a knapsack sprayer. A spray containing derris powder at the rate of 2 pounds per 100 gallons of water plus 4 pounds 11 ounces of soap reduced the population of adult asparagus beetles 83 percent, 24 hours after application.

This pest on asparagus was killed by a product containing 12 percent of powdered Lonchocarpus hircu root (6 percent rotenone content) and 88 percent of talcum according to a letter from Etablissements Rotenia to R. C. Roark in 1938.

Dust weekly during the growing and cutting season with a derris flour (or gypsum, pearl dust, or sulfur) dust containing 2 percent of rotenone.--Gunderson (168) in 1938.

Leiby (258) issued instructions in 1938 for asparagus beetle control with derris spray and derris dust. A satisfactory derris spray is prepared by mixing 3 ounces of derris powder (containing 4 or 5 percent of rotenone) in 4 gallons of water to which should be added as a sticker 2.5 ounces of skim milk powder previously mixed in a small quantity of water. A satisfactory derris dust consists of a mixture of 1 pound of derris (containing 4 or 5 percent of rotenone) and 6 pounds of clay or talc. Better adhesiveness is obtained if the dust is applied when the plants are wet with dew. Dust or spray applications should be made whenever they are thought necessary. They are often most advisable when the second brood of beetles and their slugs appear, which is during July and early in August.

Rotenone spray was recommended by Parks and Pierstorff (312) of the Ohio Extension Service in 1938.

The South Carolina Agricultural Experiment Station (351) in 1938 reported the results of tests of several insecticides on the asparagus beetle in 0.1-acre plots. Against the adults a dust containing 3.5 percent of cube resins, 73 percent of sulfur, and 23.5 percent of diluent ranked first in effectiveness, but was inferior to calcium arsenate against the larvae. Cage experiments were conducted to determine the effectiveness of various concentrations of rotenone against adults. The maximum, minimum, and average mortality of adult asparagus beetles after 48 hours' exposure to plants treated with various dilutions of rotenone derived from cube and applied as a dust are shown in the following table.

Rotenone content (percent)	Mortality		
	Maximum	Average	Minimum
	Percent	Percent	Percent
1.00	96.0	91.5	87.0
1.75	96.0	91.6	78.3
.50	92.0	80.2	65.3
.25	52.0	42.2	34.8
.10	40.0	36.4	21.7

Dilutions were made with walnut-shell flour.

The New York County Agents Training School (300) held at Ithaca, N. Y., reported in 1938 that the derris dusts and sprays recommended by Hockett (205) and Crosby, Chupp, and Leiby (92) have been found most successful. Harvey reports that the best spray contains 4 pounds of derris (4 to 5 percent of rotenone) and 1 pound of powdered skim milk to 100 gallons of water.

In 1939 Crosby, Chupp, and Leiby recommended a spray containing 4 pounds of derris, cube, or tinbo powder (4 to 5 percent of rotenone) and 2 pounds of skim milk or other spreader in 100 gallons of water, or a dust consisting of 15 pounds of derris and 35 pounds of talc.

Haude (181) in 1939 recommended a dust containing 0.75 or 1 percent of rotenone and 25 to 75 percent of sulfur, or a spray of 4 pounds of derris or cube (4 percent of rotenone) per 100 gallons of water. The larva is the most susceptible stage.

Knowlton (247) in 1939 reported on the asparagus beetle in Utah. Rotenone-bearing sprays, at the rate of 3 pounds of 4 percent rotenone-bearing derris or cube powder to 100 gallons of water, with a wetting agent added, gave good control. Satisfactory kills usually resulted when cube and derris dusts containing 1 percent of rotenone were properly applied.

Nettles (294) in 1939 suggested derris dust (0.75 percent of rotenone) for the control of the asparagus beetle in South Carolina.

Crioceris duodecimpunctata (L.), the spotted asparagus beetle.

See Hockett (205), Gunderson (160), Crosby et al. (92), and Haude (178) under Crioceris asaragi (L.) on pages 23 and 25.

Wahl (404) in 1916 recommended a solution of 26 gm. of Katakill in 5 liters of water, for the control of the larvae of this species. [Katakill is a proprietary product containing derris powder and soap.]

Hutson (202) in 1937 recommended derris dust (0.6 percent rotenone).

Crioceris lilii (Scop.)

(61)

Sensitive to derris dust.--DeBusay and van der Loan (252), in 1936.

Cryptocephalus incertus Oliv., a cranberry fire beetle

The Massachusetts Agricultural Experiment Station (277) in 1937 reported tests of insecticides against insects attacking cranberries. Ten pounds of derris powder (4 percent of rotenone) and 3 pounds of fish-oil soap in 100 gallons of water, 400 gallons to an acre, killed 90 percent of the fire beetles. In 1939 this station (279) reported that derris applied in various ways, both in sprays and as dusts, failed to effect a good kill of the beetles. Lead arsenate, 3 pounds per 100 gallons, was very effective.

Diabrotica balteata Lec., the banded cucumber beetle

McKinney (267) in 1935 reported tests with derris dust against cucumber beetles at Phoenix, Ariz. The direct application of a derris-talc dust mixture containing 1 percent of rotenone killed from 86.1 to 99.8 percent of the adult beetles. The beetles were collected by the sweep-net method from wild gourd vines on the desert. They were liberated within a screened enclosure and were treated with the dust mixture after they had settled on the screen. Judging from the results obtained, it seems possible that derris dust mixtures containing approximately 1 percent of rotenone should prove very effective when applied directly to cucumber beetle adults. The species involved in these tests were the striped cucumber beetle (Diabrotica vittata (F.)) the spotted cucumber beetle (D. duodecimpunctata (F.)), and the banded cucumber beetle (D. balteata Lec.).

In 1936 McKinney (268) reported that preliminary cage and field tests at Phoenix indicated that rotenone-containing insecticides are more toxic to the striped cucumber beetle and the banded cucumber beetle than to the spotted cucumber beetle. In the course of experiments cantaloupes, cucumbers, and watermelons infested by the three species of beetles were treated with a dust mixture of derris and cube containing 1 percent of rotenone, with talc as a diluent. It was shown that, under conditions existing in the Salt River Valley of Arizona, talc alone had some repellent effect on the three species of beetles involved. In general the application of this dust mixture kept small watermelon vines in the field free from beetles for at least 4 days.

Diabrotica duodecimpunctata (F.) the spotted cucumber beetle

See McKinney (267) under Diabrotica balteata Lec. on pages 26 and 28.

A suspension of rotenone in water 1:20,000 killed none of the adults on potato in the field.--Davidson (97) in 1930.

Darley (96) in 1931 sprayed adult spotted cucumber beetles, confined in small wire-screen cages, with an aqueous suspension of rotenone made by adding a 2-percent solution in acetone to water. Rotenone at 1:1,000 killed 50 percent in 24 hours, 79 percent in 48 hours, and 91.9 percent in 72 hours. Penetrol was added to each spray at the rate of 1:200.

Rotenone suspended in water 1:125 had no effect on the adults.--Davidson, reported by Campbell (66) in 1932.

At the 1934 meeting of the American Association of Economic Entomologists, Corv (388) led a discussion of field results with arsenical substitutes for the control of vegetable insects. Headlee, of New Jersey, in 1935 published a statement that the spotted cucumber beetle can be controlled by derris dust.

C. L. Smith (339) in 1937 reported that a spray of derris powder (4 percent of rotenone) at 2 pounds per 100 gallons of water plus 1- 7/8 pounds of coconut-oil soap (anhydrous basis) killed 97 percent of spotted cucumber beetles on squash plants confined in cheesecloth cages 24 hours after application. A 1-percent derris dust gave a kill of 88 percent.

Britton (56) in 1938 advised a correspondent to spray with one of the commercial preparations containing rotenone or pyrethrum, neither of which is known to discolor the flowers, for the control of the spotted cucumber beetles on dahlia blossoms.

For control of the second-generation beetles a derris dust (1 percent of rotenone) should be applied at least twice a week for a month.--Gundersen (168) in 1938.

Parks and Pierstorff (312) in 1938 recommended rotenone sprays (4 pounds of 4 percent powder per 100 gallons) or dusts (0.75 percent of rotenone).

Derris-talc dust (0.75 percent of rotenone) will help to reduce the number of beetles.--Crosby, Chang, and Leiby (92) in 1939.

Dust with cube or derris (1 percent of rotenone) at the rate of 15 to 30 pounds per acre. Do not mix with sulfur.--Hauke (181) in 1939.

Diabrotica soror Lec., the western spotted cucumber beetle

Mote and Thompson (290) in 1934 reported that a derris extract proved inferior to pyrethrum extract when tested for the control of this species on canning beans under field conditions in Oregon.

Rockwood (329) in 1936 reported that a derris-infusorial-earth dust (1.25 percent of rotenone) was effective against these beetles on fence posts. The mean temperature for the 3 days following the dusting was 43.5° F., with a maximum of 50° and a minimum of 38°. There were light rains totaling 0.77 inch. Very few living beetles were found on or near the dusted posts. That this dust was lethal to D. soror at low temperatures was shown by a laboratory experiment on January 29, when 20 D. soror beetles, collected on January 20 and fed alfalfa and Austrian peas, were shaken up in a paper carton with a pinch of the dust as used in the field. They were then placed in a clean carton with green food. This carton and similar ones containing undusted beetles were kept in an unheated room (40-50° F.). All but 3 of these beetles died within 21 hours (most of them in 3 hours). The other 3 were able to move their appendages when taken into a warm room. All were dead within 45 hours. None of the 100 undusted beetles died during this period.

The Oregon Agricultural Experiment Station (310) in 1937 reported that the bean leaf beetle or western twelve-spotted cucumber beetle (D. soror) did not occur on beans in the summer of 1934 in sufficient numbers so that additional information on control could be obtained, although a few preliminary tests with a derris dust showed it to be of value in killing the beetles with which it came in contact. In 1935 tests showed that rotenone-bearing dusts diluted to contain less than 1 percent of rotenone did not kill the beetles.

Diabrotica trivittata (Mann.), the western striped cucumber beetle

McKinney (269) in 1936 reported that the application of dust mixtures containing 1 percent of rotenone, derived from derris or cube, with talc as a diluent, proved effective in controlling the western striped

cucumber beetle on cantaloupes in the Salt River Valley of Arizona. Treated plots yielded approximately 1.6 times more fruit than did untreated plots grown under comparable conditions, and the protected plants also produced more fruits earlier in the season, when prices were high.

Dust with cube or derris (1 percent rotenone) at the rate of 15 to 30 pounds per acre. Do not mix with sulfur.--Hauke (181) in 1930.

Diabrotica vittata (F.), the striped cucumber beetle

See McKinney (267) under Diabrotica balteata on page 26.

Cannball (36) in 1932 reviewed unpublished work by Davidson, who found that rotenone suspended in water at 1:250 killed all adults.

Foliafume (a proprietary product containing derris and pyrethrum extractives) at 1:400 killed 80 percent in 48 hours.--Penick and Gorman (314) in 1933.

At the 1934 meeting of the American Association of Economic Entomologists, Cory (388) led a discussion of field results with arsenical substitutes for the control of vegetable insects. According to Headlee (180) in 1935, the striped cucumber beetle can be controlled by derris dust.

Huckett and Hervey (208) in 1935 wrote that derris dust shows considerable promise, because it actually kills many of the beetles.

The Massachusetts Agricultural Experiment Station (275) in 1935 reported that, when both commercial and home-made dusts containing the derris equivalent of 0.4 to 0.6 percent of rotenone and a pyrethrum-sulfur dust with a 0.05 percent pyrethrin content were applied directly to striped cucumber beetles in the laboratory, all were dead or dying within 4 hours after the application. In the field seven applications were made to melons, cucumbers, and summer squash. Fresh applications of dust killed many of the beetles and protected the plants from injury until they were washed off, although the greatest interval between rains during this period was 5 days. Derris-sulfur dust and copper-arsenate-lime dust caused slight injury to melon vines during exceptionally hot weather, and this caused a slight decrease in the yield. Yield records of melons and cucumbers indicated that the application of these dusts did not noticeably interfere with pollination.

Walker and Anderson (407) in 1935 reported promising results in the control of the striped cucumber beetle with a derris-gypsum dust containing 0.5 percent of rotenone. Gypsum gave slightly better results than talc when used as a carrier with derris.

The Wisconsin Agricultural Experiment Station (416) in its annual report for 1935-36 (issued March 1937) reported that derris-talc dust containing 0.48 percent of rotenone controlled the striped cucumber beetle.

Beard (26) in 1937 reported tests against the striped cucumber beetle in Connecticut. Potted squash plants were used for food material and were covered by copper-wire-screen cages. Beetles were introduced into the cages and the insecticides applied through the wire screen. Five insecticides were tried, as follows:

Derris dust: Containing 0.6 percent of rotenone (derris root diluted with clay).

Derris spray: Ground derris root used at a dilution of 1:200 with SS-3 spreader at a dilution of 1:1,600.

Rotenone spray: A commercial product of cube root, containing 2.5 percent of rotenone, used at a dilution of 1:200.

Calcium arsenate: One part diluted with 9 parts of gypsum.

Pyrethrum dust: A concentrated pyrethrum dust containing 2 percent of pyrethrins diluted with talc 1:9.

Beetles were also caged over untreated plants to serve as a check. Twenty-four hours after the insecticides were applied, counts were made to determine the killing powers of the dusts and sprays. The results obtained are as follows:

Treatment	Tests Number	Beetles Number	Beetles Number	Killed Percent
Derris dust	4	70	70	100.0
Derris spray	3	47	46	97.9
Commercial rotenone spray (derived from cube)	3	58	39	67.2
Calcium arsenate	2	40	18	45.0
Pyrethrum dust	1	38	38	100.0
Check	4	87	1	1.1

Derris was also the most effective insecticide when beetles were introduced into the cages 5 days after spraying or dusting. In a block of Hubbard squash, one-half of the plants were treated with derris dust and one-half with cube dust, also containing 0.6 percent of rotenone. The killing action was immediate in both cases. From these tests it may be concluded that Derris dust, containing 0.6 percent of rotenone, is the most effective treatment against the striped cucumber beetle and is to be preferred to the calcium arsenate, which heretofore has been the standard recommendation of this station. Roark (327) in 1938, in comparing the relative effectiveness of Derris and cube, referred to this work of Beard.

Bourne and Boyd (33) of the Massachusetts Extension Service, in 1937, recommended that when beetles first appear a dust containing at least 0.5 percent of rotenone be applied.

Hamilton (172) in 1938 reported that striped cucumber beetles on cucumbers were controlled 100 percent by a spray of 4 pounds of derris or cube powder (4 percent of rotenone) and 4 pounds of rosin-residue emulsion per 100 gallons of water. The spray acts as a contact poison or as a repellent. No beetles were observed later than 2 weeks after spraying.

In laboratory tests derris-gypsum dust containing 0.2 percent of rotenone killed 100 percent in 1 day. A dust containing 0.04 percent of rotenone killed 20 percent and a dust containing 0.1 percent killed 80 percent in 1 day. Field experiments showed this insect to be very susceptible to derris dust.--Kelsall and Stultz (245) in 1937.

C. L. Smith (339) in 1937 reported that a spray of derris powder (4 percent of rotenone) at 2 pounds per 100 gallons of water plus 1-7/8 pounds of coconut-oil soap (anhydrous basis) killed 97 percent of striped cucumber beetles on squash plants confined in cheesecloth cages 24 hours after application. A 1-percent-derris dust gave 88-percent kill.

Ultrawet (a proprietary wetting agent consisting of water-soluble sodium sulfonates of petroleum hydrocarbons) did not improve the control of the striped cucumber beetle provided by cube dusts (0.75 percent of rotenone) or sprays (3 pounds per 100 gallons of water).--Walker (406) in 1938.

Dunlap and Turner (106) in 1938 recommended a dust containing 0.6 or 0.75 percent of rotenone applied three or four times weekly at the rate of 15 pounds per acre.

For the second-generation beetles a derris dust (1 percent of rotenone) should be applied at least twice a week for a month.--Gunderson (168) in 1938.

Howard (192) in 1938 reported that in preliminary tests against *Diabrotica vittata* excellent control was obtained with a dust mixture containing 0.4 percent of rotenone, with talc as a diluent. Applications of the undiluted finely ground root of the gourd *Cucurbita foetidissima* H. B. K. were not so effective against the cucumber beetle as the dust mixtures containing derris, but showed some possibilities. The derris dust mixture was effective for several days and exhibited considerable protection from striped cucumber beetles for 6 and 10 days after application, even though heavy rains occurred and the plants made rapid growth. Indications from these experiments were that in commercial practice the derris-dust mixture should be applied every few days. Sulfur nitride is not so effective as a derris-talc-dust mixture containing 0.4 percent of rotenone.

The Massachusetts Agricultural Experiment Station (278) in 1938 reported that a spray of wettable cube powder containing 3.65 percent of rotenone, and used at the rate of 4 pounds in 100 gallons of water, reduced the number of beetles 90 percent, as compared with the untreated plants, and was the most effective treatment. Cube-clay dust containing 0.6 percent of rotenone ranked next in effectiveness, with an 85-percent reduction in beetle population. Yield records corresponded with the striped beetle control, and the plants treated with cube-clay dust yielded 2.03 harvested fruits per vine, as compared with 1.35 fruits on the untreated vines.

Rotenone sprays or dusts (0.75 percent of rotenone) were recommended by Parks and Pierstorff (312) in 1938.

A dust prepared with talc as a diluent and containing 0.75 percent of rotenone has given satisfactory control of the striped cucumber beetle and may be used instead of the gypsum or talc-calcium arsenate mixture if desired.--Crosby, Chapp, and Leiby (92) in 1939.

Dust with cube or derris (1 percent rotenone) at the rate of 15 to 30 pounds per acre. Do not mix with sulfur.--Haude (181) in 1939.

G. D. Jones (232) reported in 1939 that rotenone dusts had given promising results for the control of striped cucumber beetle in Missouri.

The Massachusetts Agricultural Experiment Station (279) in 1939 reported tests to control the striped cucumber beetle. Records of the effectiveness of insecticides were taken by counting the number of beetles present just before spraying or dusting and again 24 hours after treatment. Cube-clay dust containing 0.75 percent of rotenone reduced the beetles 93.8 percent throughout the period and gave the best protection. Cube-clay dust (.06 percent of rotenone), copper oxychloride-lime dust 1:14 (DuPont), copper-rotenone dust (0.8 percent of rotenone), and calcium arsenate-lime dust 1:14 all gave 90 to 92 percent of protection. Micronized rotenone-sulfur dust (0.75 percent rotenone and 20 percent sulfur) was the least effective of the dusts used. Wettable cube and derris sprays (4 pounds in 100 gallons) gave 83.4 and 84.4 percent protection and were slightly inferior to the dusts. The effectiveness of all the treatments is within the range of experimental error, indicating that the calcium arsenate-lime dust, which is the cheapest, was the most practical under 1938 conditions.

Beard (27) in 1940 wrote that for the control of this species a derris dust containing 0.6 percent of rotenone is to be recommended over other treatments, because this material serves not only as a repellent but as both a stomach and a contact poison.

Diabrotica spp., cucumber beetles

Howard, Mason, and Davidson (200) in 1935 reported that derris had been tested against cucumber beetles, but in every instance the infestation was too light to afford conclusions.

Derris was effective in field demonstrations.--New Jersey Agricultural Experiment Station (296) in 1935.

Davis (99) in 1936 reported results by Gould, of the Purdue University Agricultural Experiment Station, with copper compounds, arsenicals, fluorine compounds, nicotine, and derris against the cucumber beetle and wilt. The best material (a mixture of calcium arsenate and copper oxychloride), derris, and no treatment compared as follows:

Treatment	Wilt	Yield	Cost of Material
	Percent	per acre Bushels	per acre Dollars
Calcium arsenate 2 lbs. copper oxychloride 3 lbs., water 50 gal.	3.6	1,147	\$8.64
Derris dust (0.75 per- cent rotenone)	15.5	820	88.88
Check	30.0	39 ^a	----

Howard and Mason (198) in 1937 referred to the work of other investigators who have found that derris and cube are very effective in the control of cucumber beetles.

Derris dusts have given satisfactory results on cucumber beetles.-- New Jersey Agricultural Experiment Station (297) in 1937.

The New York County Agents' Training School (300) in 1938 made the following recommendation for the control of cucumber beetles: Use 1 percent of rotenone if arsenate-lime dust is not satisfactory. It kills and is also a good repellent, but more expensive. Treat the whole field at once.

Epitrix cucumeris (Harr.), the potato flea beetle

See reports on the control of Epitrix parvula (F.) by Chamberlin and Madden (77); and the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine annual reports for 1937 (394) and 1938 (398) on pages 32, 38, 41, 42, and 43 respectively.

Anderson and Walker (15) in 1934 reported the results of field tests on the Eastern Shore of Virginia for the control of the potato flea beetle with calcium arsenate-bordeaux spray (2-4-6-50) plus derris dust (1:7; with derris dust (1:3) and also (1:7); and with concentrated derris extract (1:400). Some striking results were obtained with derris products, both spray and dust, when used on a small scale. Kills of better than 90 percent were obtained with caged beetles treated with a derris dust containing 0.5 percent of rotenone, or with a concentrated derris extract with 5 gm. of rotenone per 100 cc., diluted 1:400. When these materials were used in the field good kills were also observed, but permanent protection was not given and the beetles migrated in from surrounding unsprayed plats, causing considerable injury.

Lacroix (254) in 1935 reported on tests in Connecticut in the summer of 1934 with pyrethrum dust, 8 pounds per acre, Gubor dust (0.5 percent of rotenone) 8 pounds per acre, and barium fluosilicate 6 pounds per acre, for the control of the potato flea beetle, with only one application of each material. Pyrethrum and rotenone were both toxic to the potato flea beetle, but their potency was lost within a few days after exposure to the atmosphere. These tests indicated that during a rainy season, in which several applications of dust are necessary, any of the three dusts would undoubtedly give good control.

The Massachusetts Agricultural Experiment Station (275) in 1935 reported that against flea beetles all the rotenone products (Cubor, Kubatox, and Red Arrow) gave excellent protection. They appeared to exert a considerable repellent effect, in addition to their direct killing action. The sprays were slightly superior to the dusts. The pyrethrum dust was effective for a short time after application, but appeared to have very little residual effect. Excellent yields were obtained in all the plots, particularly in those where rotenone compounds had been applied. The yield record of the different plots is as follows:

Material (Bordeaux 5-5-50 added in all applications)	Yield per acre Bushels
Cubor spray (rotenone)	647.99
Cubor dust (rotenone)	579.00
Kubatox spray (rotenone)	573.75
Kubatox dust (rotenone)	601.38
Pyrethrum dust	439.57
Calcium arsenate-arsenite mixture	519.12
Bordeaux mixture only	560.30

Walker and Anderson (408) in 1935 reported that very high kills of the potato flea beetle were obtained with derris dusts containing 0.5 percent of rotenone, but only slight increases in yield were obtained by dusting heavily infested potato plants with as many as six applications at 7 - 10-day intervals.

Herman and Hockey (185) in 1936 reported Cubor 75 dust (0.75 percent of rotenone) and derris-gypsum dust (0.4 percent of rotenone) effective against potato flea beetles on tomato plants.

The Massachusetts Agricultural Experiment Station (276) in 1936 reported field tests against potato flea beetles with the rotenone preparations Cubor, Kubatox, and Derrisol. All were combined with a 5-5-50 Bordeaux mixture, and 14 applications were made at 7-day intervals, from June 13 to September 11. All tests were conducted on the standard variety, Green Mountain. The plants in the unsprayed check plots were badly riddled by flea beetles and browned by leafhoppers, and were practically all dead by the last of July. The plants in the sprayed plots were thrifty and green until killed by frost on October 9. The unsprayed checks yielded 179 bushels per acre, whereas the average yield in the sprayed plots was over 430 bushels per acre. Laboratory tests on the effect of the various sprays upon flea beetles gave the following results:

Material	Mortality	
	40 hours	62 hours
	Percent	Percent
Bordeaux mixture 5-5-50	4	80
Kubatox + bordeaux 5-5-50	33	100
Cubor + bordeaux 5-5-50	38	100
Derrisol + bordeaux 5-5-50	78	95
Calcium arsenate + bordeaux 5-5-50	30	75
Barium fluosilicate + bordeaux 5-5-50	28	55

Weekly records of flea beetle damage were made in each plot throughout the season. Results are tabulated as follows:

Material	Punctures per leaf cluster, average for season
	Number
Bordeaux mixture 5-5-50	143
Kubatox + bordeaux 5-5-50	151
Cubor + bordeaux 5-5-50	110
Derrisol + bordeaux 5-5-50	101
Calcium arsenate + bordeaux 5-5-50	82
Barium fluosilicate + bordeaux 5-5-50	135

The yield record in the various plots was as follows:

Material	Yield per acre
	Bushels
Bordeaux mixture 5-5-50	474.56
Kubatox + bordeaux 5-5-50	505.48
Cubor + bordeaux 5-5-50	416.76
Calcium arsenate + bordeaux 5-5-50	404.21
Derrisol + bordeaux 5-5-50	392.56
Barium fluosilicate + bordeaux 5-5-50	381.35

Anderson and Walker (17) in 1937 reported tests made in 1932 and 1933 for the control of the potato flea beetle. Derris products as sprays and dusts killed a high percentage of the beetles present at the time of application, but gave only temporary protection, as other beetles soon reinfested the treated plots.

In laboratory tests derris-gypsum dusts containing 1.0, 0.5, and 0.2 percent of rotenone, respectively, killed 100 percent in 45 minutes. In field experiments derris dusts were also very effective.--Kelsall and Stultz (242) in 1937.

The Massachusetts Agricultural Experiment Station (277) in 1937 again reported on the control of flea beetles on potatoes. In the plots devoted to field tests of different insecticides on the standard variety Green Mountain, 11 applications of bordeaux mixture were made from June 10 to August 24. Insecticides were added to 5-5-50 bordeaux in 5 applications from July 15 to August 14. The treatments were duplicated on 1/100-acre plots. Bordeaux mixture itself is an effective repellent for flea beetles, yet, each additional material produced increased control. The ranking effectiveness of the spray mixtures, measured by successive counts of leaf punctures, was as follows:

1. Bordeaux plus Calrite (a brand of calcium arsenate)
2. Bordeaux plus Cubor (rotenone)
3. Bordeaux plus Niapron (rotenone)
4. Bordeaux plus Kubatox (rotenone and pyrethrum)
5. Bordeaux plus nicotine tannate
6. Bordeaux alone

The protracted drought during July and the early part of August was not favorable for high yields--a duplication of the conditions that prevailed in 1935 with similar results. The yield in the experimental plots was as follows:

<u>Material</u>	<u>Yield per acre</u> <u>Bushel</u>
Bordeaux 5-5-50	439.1
Nicotine tannate $\frac{1}{2}$	464.4
Derris (rotenone) $\frac{1}{2}$	463.7
Cuber (rotenone) $\frac{1}{2}$	457.3
Niazon (rotenone) $\frac{1}{2}$	456.8
Kubatox (rotenone-pyrethrum) $\frac{1}{2}$	422.7
Calcium arsenate $\frac{1}{2}$	420.8

$\frac{1}{2}$ Combined with bordeaux mixture 5-5-50

With flea beetles the outstanding insect pest, and in the absence of potato diseases, the higher yield in the nicotine-tannate and rotenone plots is believed to be due largely to the protection furnished against incipient attacks of leafhoppers and potato aphids, and reflected the superior appearance of the plants in these plots throughout the growing season.

Morrill and Lacroix (288) in 1937 reported tests to control the potato flea beetle on shade and field-grown tobacco in the Connecticut Valley. The following dusts containing rotenone were tested:

1. One part of cube powder (4 percent of rotenone) plus 3 parts of sterile tobacco dust (finely ground and certified to be a by-product in the manufacture of nicotine sulfate), applied at the rate of 4 to 10 pounds per acre.
2. Two parts of cube powder (4 percent of rotenone) plus 3 parts of barium fluosilicate, applied at the rate of 4 to 8 pounds per acre.
3. Dust containing 1 percent of rotenone, applied at the rate of 12 pounds per acre.
4. One part of cube powder (1 percent of rotenone) plus 1 part of barium fluosilicate, applied at the rate of 15 pounds per acre.
5. Proprietary dust containing 0.55 percent of rotenone, applied at the rate of 12 pounds per acre.
6. Proprietary dust containing 0.83 percent of rotenone, applied at the rate of 8 pounds per acre.

All the above-named treatments, and also cryolite, gave a distinct improvement over the untreated check. The mixture of cube-root powder and tobacco dust showed the highest number of dead beetles and the next to the least total leaf injury. The mixture of barium fluosilicate and cube-root powder was somewhat more effective, if judged by the number of live beetles and the total leaf injury. This superiority is not believed to be sufficient to justify the increased cost of the mixture, as each material was used at nearly the same strength as when applied alone.

C. L. Smith (339) in 1937 reported that derris powder (4 percent of rotenone) 2 pounds per 100 gallons of water plus 2.5 pounds of coconut oil soap (anhydrous basis) reduced the population of potato flea beetles on tomato plants 98 percent after 24 hours. McCormick's dust (0.75 percent of rotenone) reduced the population 87 percent.

Walker (406) in 1937 reported that Ultrawet at 1:1000 enhanced the control of the potato flea beetle when added to derris-clay dust (0.75 percent of rotenone) from 59.3 to 82.2-percent reduction, and at 1:1,600, it raised the effectiveness of cube spray, 3 pounds per 100 gallons of water, from 49.6 to 76.8-percent reduction.

The Connecticut Agricultural Experiment Station (85) in 1938 reported the results of tests to control the potato flea beetle on Irish Cobbler potatoes. Results indicated (1) that cube dust (0.75 percent of rotenone) was more effective than cube spray, 1 pound pure ground cube root (4 percent of rotenone) in 25 gallons of water; (2) that cube dust 0.75 percent of rotenone was more effective than barium fluosilicate dust 1 part barium fluosilicate and 4 parts hydrated lime; and (3) that the addition of a petroleum-sulfonate spreader, Ultrawet, to cube dust at the rate of 1 part in 1,000 parts of dust increased the effectiveness and reduced the amount of feeding by flea beetles.

Dunlap and Turner (106) in 1938 recommended a dust containing 0.75 percent of rotenone at the rate of 20 pounds per acre for the control of flea beetles on eggplant and the potato flea beetle on tomatoes.

The Massachusetts Agricultural Experiment Station (278) in 1938 reported on the results of experiments for the control of flea beetles on potatoes. In the experimental plots different insecticides were tested on the standard late-season variety, Green Mountain. Twelve applications of bordeaux mixture were made between June 10 and August 27. Two rotenone compounds, nicotine tannate, a pyrethrum extract, and calcium arsenate were tested in combination with 5-5-50 and 5-3-50 bordeaux mixture in the applications from July 9 to August 12. The rankings of the different material on the basis of flea beetle control was as follows:

With 5-5-50 bordeaux		With 5-3-50 bordeaux	
Material	Average punctures per leaf cluster	Material	Average punctures per leaf cluster
	Number		Number
Cubor (rotenone)	306	Derris	192
Derris (rotenone)	326	Cubor	231
Calcium arsenate	341	Nicotine tannate	302
Nicotine tannate	433	DX	333
Check (bordeaux only)	488	Calcium arsenate	334
DX (pyrethrum)	520	Check (bordeaux only)	355

In both combinations the rotenones were about equally effective and decidedly ahead of all other treatments. Both were much more effective in the low-calcium bordeaux. Calcium arsenate gave equally good protection in both combinations. Nicotine tannate showed to better advantage with 5-3-50 bordeaux, and the effectiveness of DX, the pyrethrum extract, was greatly increased in this combination. The fact that all the materials gave better control with the 5-3-50 bordeaux would indicate that their action may be somewhat inhibited by the excess lime of the 5-5-50 combination.

Yields were as follows:

Material	With 5-5-50 Bordeaux			With 5-3-50 Bordeaux		
	Yield	Crop		Yield	Crop	
	per acre Bushels	Grade 1 %	Grade 2 %	per acre Bushels	Grade 1 %	Grade 2 %
Check (bordeaux only)	261.7	75	11.5	257.5	67	18.5
Calcium arsenate	396.6	83	8.6	270.8	77.5	10.5
Derris (rotenone)	321.7	82.3	9.1	302.5	82.6	8.0
Cuber (rotenone)	267.5	71.6	13.1	253.4	71.7	15.7
Nicotine tannate	264.1	84.5	6.6	293.4	82.7	7.3
DX (pyrethrum)	245.9	79.3	9.8	270.8	77.8	11.0

All the materials gave higher yields when combined with 5-5-50 bordeaux except nicotine tannate and DX. The yield in the plots of these last two materials reflected the improved control of flea beetles which they effected when combined with 5-3-50 bordeaux. Sprout injury was very severe on the plots sprayed with 5-3-50 bordeaux. This undoubtedly explains the reduced yield.

The Massachusetts Agricultural Experiment Station (279) in 1938 reported that cube and derris powders (each containing 4 percent of rotenone) and a commercial product containing 2 percent of rotenone, used with either 5-5-50 or 5-3-50 bordeaux, gave better control of flea beetles than did bordeaux alone.

Morrill and Lacroix (289) in 1938 reported tests of insecticides made during 1937 at the Windsor, Conn., tobacco substation. The following rotenone preparations were tried against the potato flea beetle: (1) Cube dust containing 1 percent of rotenone plus sterilized tobacco dust as the diluent; (2) cube dust containing 1 percent of rotenone plus a diluent consisting of 75 percent of sterilized tobacco dust and 25 percent of neutral tobacco-colored clay; and (3) dust consisting of barium flubasilicate, 8 parts, and cube root powder containing about 5 percent of rotenone, 2 parts. The dust mixtures were applied in two shade tents, and each was applied on two 1/8-acre plots. An equal number of 1/8-acre plots were left untreated in the shade tents for data on the infestation prevailing when no treatments were applied. Seven applications of each insecticide were made between June 4 and July 16 at intervals of 7 days. The rates of application were 6, 8, and 10 pounds per acre, depending on the size of the plants. The dosage of 10 pounds per acre was used for the last two applications in July, when the tobacco was nearing maturity. Good plant protection was obtained from the application of each of the insecticides listed above. The average of sample counts of insects and damaged leaves showed that none of the dusts was significantly better than the others, but there was a highly significant difference between all the treated plots and the untreated checks. Plots treated with the dusts showed an average of 4.4-percent damage, whereas untreated check plots showed 24.3-percent damage.

Agicide DO-4 (rotenone 0.6 percent) at the rate of 4 pounds per 100 gallons of water (0.003 percent of rotenone in spray) killed from 50 to 100 percent within 96 hours.--Agicide Laboratories (6) in 1939.

Potato flea beetles on eggplants may be held in check with a dust containing 0.75 percent of rotenone.--Crosby, Chapp, and Leiby (92) in 1939.

The Pennsylvania Agricultural Experiment Station (315) in 1939 reported that flea beetle injury to tobacco and potatoes is caused by the potato flea beetle early in the season. The greatest protection against beetle damage to tobacco leaves was afforded by dusting with a mixture of 1 part of ground cube root (4 percent of rotenone) and 3 parts of sterilized tobacco dust (filter dust remaining after nicotine extraction) with 1 part to 800 of a wetting agent, Ultrawet. The material was applied at the rate of 3 to 5 pounds per acre to newly set plants, increasing to 10 to 15 pounds per acre after topping.

Epitrix parvula (F.), the tobacco flea beetle

Chamberlin (68) in 1933 reported that, of various dusts tested against the tobacco flea beetle, derris dust produced the highest mortality within the shortest period of time. Derris caused an immediate and extreme irritation, as evidenced by the insect's convulsive effort following application of the material.

The same author (69) reported in 1934 and also in a typewritten report to the Division of Truck Crop and Garden Insects, of the Bureau, in 1935, that at Quincy, Fla., both derris and cube diluted to a rotenone content of 1 percent by admixture with tobacco dust or kaolin gave good control of the tobacco flea beetle on tobacco in tobacco-plant beds. The infestation was light. Neither poison injured the foliage even when applied undiluted. Derris and cube dusts containing 0.75 percent of rotenone rid newly set field tobacco of overwintered flea beetles. Field tests on maturing tobacco indicated that a dust containing 0.75 percent of rotenone, applied at the rate of 8 to 10 pounds per acre, is effective in controlling flea beetles when the infestation is light. As diluents for derris or cube the following were tried: Georgia clay, talc, celite, and a tobacco dust 60 percent of which passed through a 150-mesh screen. The last is the most suitable for shade-tobacco dusting. Derris applied at the rate of 8 pounds per acre killed 94.8 percent of the flea beetles and cube applied at the rate of 7.5 pounds per acre killed 83.2 percent. Both powders contained 0.75 percent of rotenone.

Stanley and Marcovitch (354) in 1935 reported that derris-root dust containing 0.75 percent of rotenone was found to act quickly on flea beetles, but after the second day beetles appeared again on plants, even though derris was still on the leaves. To determine how long derris retains its toxicity when exposed to climatic conditions, an experiment was performed as follows: Small leaves were removed from tobacco, placed in vials with water, and dusted heavily with derris dust containing 0.75 percent of rotenone. They were then placed in direct sunlight. Each evening at 5 o'clock the leaves were removed to the insectary for protection from rain, and at 7 a.m. they were again placed outside. Each day for 5 days a dusted leaf was removed and placed in a cage with flea beetles, and the kill noted. It was found that derris lost its toxicity rapidly upon exposure, giving 100-percent kill the first day, 55 percent the second, and 20 percent the third.

Data are shown in the following table:

Exposure to weather (days)	Insects used	Percentage kill in days				
		1	2	3	4	5
1.....	25	16	56	84	100	--
2.....	25	10	45	55	55	55
3.....	25	4	4	8	20	20
4.....	25	0	0	12	12	12
5.....	25	0	4	4	4	4

A typical example of control of flea beetle in the field with derris and pyrethrum on June 15, 1934, is shown in the following table:

Material	Dust used per acre	Beetles found		
		Before dusting	June 16	June 19
	Pounds	Number	Number	Number
0.20 percent pyrethrum	25.7	106	114	501
0.50 percent pyrethrum diluted with talc	26.1	131	83	527
Derris (0.75 percent rotenone)	10.3	146	2	204

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (390), in its annual report for 1935 reported that derris powder has shown excellent promise as a control for the tobacco flea beetle, especially in the seedbeds. Similar control was obtained in the field, but the cost of such treatments had not been determined.

White (412) in 1935 recommended derris-tobacco dust (2 percent of rotenone) at the rate of 1 pound per 100 square yards of plant bed for the control of flea beetles on tobacco.

Chamberlin (71) reported in 1936 from Quincy, Fla., that recent laboratory and field experiments designed to determine the loss in toxicity of cube dust as a result of exposure to direct sunlight have shown that the toxic properties of a cube-dust mixture with denicotinized tobacco dust as a diluent decreased rapidly when this dust mixture was subjected to direct sunlight, and measured by its toxicity to the tobacco flea beetle. These experiments also disclosed that the cube-dust mixture containing 1.5 percent of rotenone maintained its toxicity much longer than did a dust mixture containing 0.5 percent of rotenone. A cube-dust mixture containing 1 percent of rotenone killed 74 percent of the tobacco flea beetles after the dust mixture had been exposed to direct sunlight for 24 hours, which was equivalent to approximately 45 hours' exposure under field conditions. In performing these experiments it was not possible to make proper allowance for two important influences which ordinarily occur under normal shade-grown tobacco conditions, namely, the wetting effect of heavy dews and the dense shade which prevails within a crop of maturing shade-grown tobacco. Consequently, it is probable that under actual field conditions cube-dust mixtures will retain their insecticidal efficiency against the tobacco flea beetle for a longer period than was indicated by these experiments.

In 1936 Chamberlin (70) also reported tests made at Quincy in 1934 in which he found that derris and cube, diluted with a fine, nearly neutral, denicotinized tobacco dust to a rotenone content of 0.05 percent were equally effective (85 percent mortality) when dusted on the tobacco flea beetle under cage conditions.

Roark (327) in 1938, in a review of the comparative insecticidal values of derris and cube, referred to this finding by Chamberlin.

Howe (201) in 1936 reported tests made at Clarksville, Tenn., against the tobacco flea beetle, which indicated that a cube-root-dust mixture having a rotenone content of approximately 1.5 percent was the most toxic of the materials tested against the flea beetle on dark-fired tobacco, but that a similar dust mixture containing 2 percent of rotenone was most efficient in the tests with Burley tobacco. In general, however, it appeared that the dust mixture containing 1.5 percent of rotenone was so nearly equal to the mixture containing 2 percent of rotenone that the former dilution is preferable because of its lower cost. The cube-dust mixture proved more effective than a mixture of 50 percent of cryolite and 50 percent of kaolin, or a mixture composed of 7 percent of paris green, 42 percent of lead arsenate, and 50 percent of kaolin. Results indicated very little difference in the relative toxicity to flea beetles on tobacco plant beds between the two last-mentioned dust mixtures.

Experiments in Florida and Tennessee disclosed that a derris or cube-dust mixture containing 1 percent of rotenone was effective in controlling the tobacco flea beetle in the plant bed, as well as on newly set plants and on the growing crop. Tests with different diluents for the derris or cube-root powder indicated that sterilized tobacco dust was the most suitable for this purpose and did not leave unsightly deposits on the harvested plants. The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (393) in 1936.

The South Carolina Agricultural Experiment Station (348) in 1936 reported that at the Pee Dee Experiment Station tests against tobacco flea beetles were made with derris dust (1 percent of rotenone) and cube dusts (0.5 and 1.0 percent of rotenone). The difference in the percentage of reduction of living beetles with the rotenone and the nonrotenone dusts at the end of 72 hours was not sufficiently great to warrant the selection of any of the materials as outstanding. However, the greatest percentages of dead beetles were obtained from the application of dust mixtures derris and cube containing 1 percent of rotenone. There was no significant difference between these two insecticides, although there was a tendency for the cube of 1-percent-rotenone content to lose its effectiveness faster than the derris.

In field tests against the tobacco flea beetle on shade-grown tobacco in Florida, F. S. Chamberlin (72) reported in 1937 that cube dusts containing 1 or 1.5 percent of rotenone were more effective than a cube dust containing 0.5 percent of rotenone. Later (73) he reported a dust containing 1 percent of rotenone and sterilized tobacco as a diluent applied at the rate of 4 to 8 pounds per acre to be effective in controlling the tobacco flea beetle on shade-grown tobacco. Applications made once a week should ordinarily protect the crop sufficiently.

Chamberlin and Madden (77) in 1937 reported on the value of rotenone dusts for the control of flea beetles attacking shade-grown tobacco. In the Georgia and Florida producing region the crop is attacked by the tobacco flea beetle (*Eutrix parvula*) while in the Connecticut Valley the potato flea beetle (*E. cucumeris* (Harr.)) is the attacking species. Because of lower cost, cube has been used instead of derris. The three main advantages of the rotenone-bearing dust mixtures made of cube powder over the insecticides used previously to control flea beetles on shade-grown cigar-wranner tobacco are speed of action, safety to the crop, and absence of objectionable residue, combined with a relatively high toxicity to the insect. The outstanding disadvantage of this material is that its efficiency is of short duration under the conditions imposed in tobacco shades. Cube-dust mixture containing 1 percent of rotenone exerted a 74-percent kill of the flea beetle *E. parvula* after an exposure of 24 hours to sunlight, which was about the equivalent of 2 days of cloudless exposure. The dust mixture containing 1.5 percent of rotenone maintained its toxicity much longer than did the 0.5-percent material. It appears that the effectiveness of cube-dust mixtures containing 1 percent of rotenone is limited to about 3 days under field conditions.

Until additional data are obtained it seems desirable to continue the present recommendations of a dust mixture containing 1 percent of rotenone for the control of flea beetles on shade-grown cigar-wranner tobacco.

Rotenone-dust mixtures appear to kill flea beetles principally because the irritating properties of this insecticide impel the beetles to "clean up" after coming in contact with it. Dosages of this insecticide should therefore be sufficient to give good coverage of the plants. For newly set tobacco plants a dosage of 4 or 5 pounds per acre should be sufficient whereas in the mature crop 8 to 10 pounds per acre is believed to be necessary. Satisfactory diluents are finely ground Georgia clay, kaolin, diatomaceous earth, and tobacco dust.

Jewett (227, 228) in 1937 reported that derris dust (powdered derris root plus infusorial earth) containing 1 percent of rotenone applied at the rate of 1 pound per 100 square yards permitted 27.55 percent of the plants to be injured by the tobacco flea beetle. A dust containing 2 percent of rotenone permitted 27.08 percent injury, as compared with 31.79 in the control (no treatment) and 15.43 for the best insecticide, barium fluosilicate.

Shands et al. (336) in 1937 reported that an effective mortality of tobacco flea beetles can be obtained by the proper application of a dust containing 1 percent of rotenone at any time of the day when the wind velocity does not exceed approximately 4 miles per hour.

The South Carolina Agricultural Experiment Station (349) in 1937 stated that a cube dust containing 1 percent of rotenone was more effective than one containing 0.5 percent of rotenone or a dust containing 36 percent of cryolite when applied at the same rate per acre. For the best results with 1-percent-rotenone dust, the rate of application should range from near 8 pounds per acre when the plants are small to 10 pounds or more for mature plants. Although insect injury was greater to plants treated only at broad emergence than where more frequent applications were made, commercial control was obtained on both series. When more detailed information is available on the habits and life history of the tobacco flea beetle, applications of insecticides can be timed more accurately with regard to broad emergence, with probable increase in the efficiency of the insecticides.

Tobacco flea beetles E. parvula and E. cucumeris, are controlled by cube or derris dusts containing sterilized tobacco dust as the diluent.-- United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (394) in 1937.

White (413) in 1936 and again (414) in 1937 advised that the most satisfactory control of flea beetles attacking tobacco is a derris or cube dust containing 1 percent of rotenone. These dusts are obtained by diluting derris or cube powder to the desired strength with a clay diluent. The following dosages of dust are recommended for each application: For plant beds 1/2 pound per 100 square yards, applications to be repeated every 4 days until control is obtained. For newly set plants, 3 to 5 pounds per acre, applications to be repeated every 4 days until control is obtained. For the growing tobacco crop, 8 to 10 pounds per acre, depending on the size of the plants, applications to be repeated every 7 days until control is obtained.

F. S. Chamberlin (74) in 1938 reported that experiments and observations have indicated that finely ground and sterilized tobacco dust is the most satisfactory diluent for cube or derris when applied to shade-grown tobacco in combating the tobacco flea beetle. The addition of clay to the customary cube- or derris-tobacco-dust mixture used for combating the tobacco flea beetle apparently did not improve its dusting qualities when applied with rotary hand-operated dusters. It appeared that the use of a dust mixture containing 1 percent of rotenone, with 75 percent of tobacco dust and 25 percent of finely ground Georgia clay as a diluent, on shade-grown tobacco under favorable weather conditions at the rate of 6 pounds per acre, did not leave conspicuous residues on the cured tobacco leaves. Heavier applications, however, did leave conspicuous deposits on the cured product. In general, these experiments demonstrated that the addition of finely ground clay to the derris- or cube-tobacco-dust mixture did not result in any appreciable improvement in the finished dust mixture and may cause a permanent white residue to remain on the treated leaves.

Chamberlin (76) later reported in 1938 that results of recent experiments designed to determine the duration of the toxicity of a cube-dust mixture containing 1 percent of rotenone to the tobacco flea beetle on shade-grown tobacco have shown that the toxicity of this dust mixture to the insect decreases very rapidly on shade-grown tobacco. In the presence of the most favorable weather conditions the effectiveness of a light application of the cube-dust mixture is limited to approximately 3 days but apparently the toxic action occurring on the third day after application is relatively slight. Showers evidently remove much of the cube-dust mixture from tobacco foliage and render such applications ineffective. It is believed that this mechanical loss by the action of rain is one of the most important factors limiting the effectiveness of cube-dust mixture for flea beetle control in Florida. Cube-dust mixtures applied to shade-grown tobacco by the "drift" method when the foliage is moist with dew appeared to be more effective against the flea beetle than when applied to dry foliage. The above results were obtained and conclusions drawn from experiments wherein the method of procedure consisted of confining a definite number of tobacco flea beetles with leaf discs cut from the treated foliage at various intervals and determining the percentage of the resulting flea beetle mortality.

Cory (88) in 1938 issued recommendations based on the report of the Tobacco Insect Council, for the control of tobacco insects.

The Tobacco Insect Council (372) in March 1938 issued suggestions for the control of tobacco insects. Dust containing 1 percent of rotenone was recommended for combating the tobacco flea beetle infesting flue-cured, Burley, and dark fire-cured tobaccos, also shade-grown types of cigar tobaccos. For the latter, finely ground, sterilized tobacco dust should be used as the diluent application being made with a rotary hand-operated duster. When the plants are about knee-high a dosage of 4 to 5 pounds per acre is sufficient. Mature tobacco may require 7 to 8 pounds per acre. Applications should be repeated every 4 to 7 days until control is obtained.

At the second annual meeting of the Tobacco Insect Council (373) in July 1938, several speakers mentioned rotenone. W. H. White of the Bureau of Entomology and Plant Quarantine, reported that dust mixtures prepared from either derris or cube have been used during the last two seasons rather effectively and extensively for flea beetle control. He stated also that in attempts to increase the toxicity of cube and derris materials, certain vegetable oils have been incorporated with the powders and extracts. Early tests showed that the addition of these oils served to increase the toxicity of the materials to certain insects. However, further work has indicated that when these oils are used with certain spreading or wetting agents, the effect might be a reduction rather than an increase in the toxicity. H. H. Jewett, of the Kentucky Agricultural Experiment Station, reported that for the control of flea beetles in tobacco-plant beds, dusts containing rotenone are effective only when applied at frequent intervals and are little used for that reason and because of greater cost. These insecticides do not injure tobacco plants in beds if applied properly and in correct amounts. L. B. Scott, of the Bureau of Entomology and Plant Quarantine, Clarksville, Tenn., reported on the use of dips prior to setting tobacco plants. Cube and pyrethrum dusts may be used with safety, but it is not known whether either will be effective against crabs or flea-beetle larvae. W. A. Shands, of the Oxford Laboratory of the Bureau of Entomology and Plant Quarantine, spoke on the possibilities of incorporating insecticides effectively in the spray for downy mildew. The results of two series of tests conducted in the spring of 1938, together with those from similar tests in 1937, showed that the application of the recommended spray containing 0.02 percent of rotenone, for the control of blue mold was not so effective in controlling the tobacco flea beetle in plant beds as was the application of a dust containing 1 percent of rotenone. H. C. Hallock, of Pennsylvania State College, reported that preliminary tests indicated that cube containing 1 percent of rotenone with sterilized tobacco dust as a diluent, will give good results for the control of the flea beetle under Pennsylvania conditions, especially if some sticker such as Ultrawet is used with the material.

The Recommendations Committee of the Tobacco Council suggested the following change in the 1937 recommendations for tobacco insect control: "That rotenone dust for field control of flea beetles on sun-grown tobaccos be recommended with, perhaps, stronger reservations."

The United States Bureau of Entomology and Plant Quarantine (395) in 1938 stated that field-plot tests and large-scale field experiments against *E. parvula* and *E. cucurbitae* in Florida, Tennessee, North Carolina, South Carolina, and Connecticut corroborated the results of tests performed during previous years in indicating that wherever the value of the crop justified the use of this insecticide these pests could be controlled in the plant bed, as well as on newly set plants and on the growing crop, by timely applications of a dust mixture containing rotenone.

Nettles (294) in 1939 recommended derris dust for the control of the tobacco flea beetle on eggplant and cabbage in South Carolina.

The Pennsylvania Agricultural Experiment Station (315) in 1939 reported that flea beetle injury to tobacco and potatoes is caused by the tobacco flea beetle after mid-July. The greatest protection against beetle damage to tobacco leaves was afforded by dusting with a mixture of 1 part of ground cube root (4 percent of rotenone) and 3 parts of sterilized tobacco dust (filter dust remaining after nicotine extraction) with 1 part to 800 of a wetting agent. The material was applied at the rate of 3 to 5 pounds per acre to newly set plants, increased to 10 to 15 pounds per acre after topping.

"Galerucella rubi Tamanuki"

Tamanuki (364) in 1928 recommended derris and soap spray for the control of this insect on the young leaves of strawberry plants in southern Sakhalin.

Galerucella viburni (Payk.)

Sensitive to derris dust.—DeBussy et al. (61) in 1936.

Galerucella xanthomelaena (Schr.), the elm leaf beetle

Hamilton and Gammell (174) in 1934 reported that derris powder applied as a spray gave good control, and the foliage retained considerable toxicity for 6 days.

Hamilton (163) in 1935 reviewed information on nonpoisonous substitutes for arsenicals. Powdered derris is more stable and cheaper than derris extract. Reference was made to Hamilton and Gammell (174) who, in 1934, reported that a dust containing 1 percent of rotenone, diluted 1 pound to 3 gallons of water, gave almost 100-percent control of the elm leaf beetle, and 3 days after having been sprayed 96 percent of the larvae placed upon the sprayed foliage were killed, and 6 days after spraying 58 percent were dead.

Rotenone dust gave excellent control.—Van Gundia (469) in 1936.

Hamilton (172) in 1937 reported that elm leaf beetles on elm trees were not satisfactorily controlled by a spray of 4 pounds of derris or cube powder (4 percent of rotenone) and 4 pounds of rosin-residue emulsion per 100 gallons of water. Five tests were made, two of which were satisfactory. The spray acts as a contact poison and as a repellent. The period of effectiveness is 5 to 7 days. Control seems to depend on time of application.

The New Jersey State Agricultural Experiment Station (298) in 1936 reported that a spray of derris or cube powder plus rosin-residue emulsion in water was effective against the larvae of the elm leaf beetle and has some contact and repellent action against the adults.

The New York State Agricultural Experiment Station (303) in 1938 reported that a rotenone spray is apparently very effective in the control of the elm leaf beetle. It has the advantage of leaving no visible residue on the foliage and also avoids the possibility of staining painted surfaces.

Gambrell (154) in 1940 recorded tests for the control of the elm leaf beetle with cube powder (4 percent of rotenone) at 4 pounds per 100 gallons plus 4 ounces M-181; derris powder (5 percent of rotenone) at 4 pounds per 100 gallons plus 1 pint of soybean oil plus 1 pound of Binderine (Goulac); stabilized derris powder (from the United States Rubber Company) with the same materials; and both regular and stabilized derris powders plus either soybean flour (1 pound) or Grasselli Sticker-Spreader (1/2 pint).

Experiments in 1938 indicated that sprays containing either 4 pounds of cube powder or 6 pounds of lead arsenate to 100 gallons of water were effective when applied after more than half of the eggs had hatched. In 1939 spray mixtures containing either derris (2 or 4 pounds) or lead arsenate (4 or 6 pounds) in 100 gallons of water gave satisfactory control if applied on or after the second week of June. Limited tests with 2.5 percent of rotenone extract, diluted 1:400, effected a high degree of control of both larvae and adults. In field tests no appreciable differences were noted between the effectiveness of regular derris and that of stabilized derris (containing an anti-oxidant), with the possible exception of the influence on the unhatched eggs.

The advantages of derris powder or rotenone extract sprays appear to include the lack of objectionable residue; relative safety to man and pets; and rapidity of kill. The latter point is of particular importance when sprays are applied rather late in the season when many larvae are second or third instars and immediate relief from foliage injury is desired. The main disadvantages are the danger of poisoning fish, cost of the material, and possible lack of adhesion on foliage during heavy rains or wet weather. This latter objection may not prove to be serious, inasmuch as the material should be applied to the under surface of the leaf and also because of the fact that much of its effectiveness apparently results from the contact action of the spray within a short time after application.

Lema oryzae Kuw.

Kuwayama (250) in 1936 gave a detailed historical account of the use of insecticides for the control of this insect on rice in Japan and of experiments made during 1930-34 in Hokkaido. A spray of 6-2/3 ounces of pyrethrum and 5 ounces of soap in 10 gallons of water proved very effective against the eggs, larvae, and adults; and one of nicotine sulfate and soap was more effective than derris.

Lema trilineata (Oliv.), the three-lined potato beetle

The three-lined potato beetle was controlled by a dust application of a 50-50 mixture of derris and hydrated lime.--Kelsall et al. (244) in 1926.

The Wisconsin Agricultural Experiment Station (416) in 1937 reported that derris powder, 3 pounds per 100 gallons of water plus an "oleated resinous soap" as a spreader was almost 100 percent effective in 1936 against the larvae and adults of the three-lined lema attacking potatoes and Japanese lanterns.

Leptinotarsa decemlineata (Say), the Colorado potato beetle

McIntee, Sievers, and Abbott (266) in 1919 reported that derris powder as a stomach poison was tested on a small scale against potato beetle larvae at several strengths, ranging from 1 pound of powder to 16 gallons of water up to 1 pound to 128 gallons, and was found to be very effective. Practically all the larvae were killed within 48 hours and the plants were little eaten. As these spray mixtures might have acted as contact poisons, because the larvae were already on the plants when the latter were sprayed, a second series of tests was arranged to eliminate this factor. The same plants were used and from 20 to 40 larvae were placed on them 1 or 2 days after they had been sprayed. The results obtained were practically the same as in the first series of tests. Very few living larvae were found 3 days later and the plants were little eaten. When applied as a dust, derris was equally efficient against potato beetle larvae. The alcoholic extract of Derris elliptica in the ratio of extract from 1 pound of powder to 50 gallons of water killed 96.6 percent of the larvae and 29.1 percent of the adults.

Brittain (55) in 1924 described insectary feeding tests made in Fiske trays with potato beetle larvae. Arsenate of lead (paste), 2 pounds to 40 imperial gallons, was compared with various contact poisons, namely, nicotine sulfate, fish-oil soap, and derris powder, an attempt being made to use the last both as a contact insecticide and as a stomach poison. To test the contact action of derris the insects were placed in a wire basket and dipped in the solution, then drained and fed on unsprayed leaves.

To test the internal action of derris the leaves were dipped in the solution and fed to the insects. The experiments lasted for a week, daily records being taken. The most notable results of the tests were those obtained in the case of derris, which in all strengths, ranging from 3 pounds to 100 imperial gallons to 1 ounce to 100 imperial gallons, and with both methods, destroyed 100 percent of the insects, including half-grown and fully grown grubs and adults. It seems certain that this material did not act as a stomach poison, because the beetles were found dead in the trays, with no evidence of feeding.

The extreme toxicity of this material to potato beetles is shown by the fact that 1 week after this experiment was concluded a number of last instars were placed upon untreated leaves in a tray. The next morning the insects were found dead in the bottom of the tray without ever having fed on the leaves. This tray had been used in the previous week's test for one of the derris treatments (1 ounce to 100 imperial gallons), and evidently sufficient solution had been taken up by the cheesecloth bottom of the tray to cause the death of the insects. In comparing these results with those of field tests, it appears that the material is much more effective under insectary conditions.

Kopp (248) in 1924, in a review of the use of derris as an insecticide, stated that at the rate of 1 pound to from 1¹/₂ to 100 gallons of water it had given excellent results against this species.

McIndoo and Sievers (265) in 1924, reported that cube and derris dusts, also the cold alcoholic extract of cube with soap, were effective against potato beetle larvae. An alcoholic extract of derris, with soap, was inefficient against the larvae and adults.

Kelsall et al. (244) in 1926 published the results of tests on Colorado potato beetle larvae with derris in 4-lb-40 bordeaux, derris and hydrated lime, and derris alone, which led to the following conclusions: Derris is effective in both spray and dust forms: derris kills more rapidly than the arsenicals; derris is less effective when mixed with hydrated lime, and still less so when mixed with bordeaux. To get the same eventual kill, 1 pound of derris is apparently about equivalent to from 1-1/2 to 3 pounds of calcium arsenate. These workers regarded derris as a contact poison only.

Davidson (97) made tests on potato plants in the field in 1930 and obtained the following results with suspensions of rotenone in water:

Insect stage	Concentration	Mortality
	gm.: cc.	Percent
Adults -----	1:2,000	60.0
Adults -----	1:5,000	12.0
Adults -----	1:10,000	0.0
Eggs -----	1:30,000	100.0
Small larvae -	1:30,000	95.0
Large larvae--	1:10,000	96.5
Large larvae--	1:30,000	92.9

Little (261, 262) in 1931 reported excellent control (96.8 percent kill) of Colorado potato beetle larvae feeding on eggplant in the field, by using root of devil's-shoestrings (Tephrosia virginiana) at 4 pounds per 100 gallons of water.

Campbell (66) in 1932 critically reviewed tests made by Davidson with rotenone on the Colorado potato beetle. Rotenone suspended in water 1:200 sprayed on leaves and fed to the adults as a sandwich killed all; at 1:1,000, feeding was curtailed; beetles on a plant sprayed with rotenone 1:10,000 were not affected. Davidson also made an experiment with rotenone to test its repellent effect against Colorado potato beetles. The insects were given an opportunity during a period of 5 hours to feed on potato-leaf sandwiches containing rotenone. Thereafter they were fed untreated leaf disks for 8 days. The mortality was negligible but it was observed that the beetles ate less of the rotenone sandwiches than of those containing lead arsenate. On the following day the beetles that had taken rotenone ate less untreated foliage than did those that had taken lead arsenate. Davidson, therefore, suspected a repellent action of rotenone, but Campbell believes that no repellent action was demonstrated. The beetles probably ate sublethal doses of rotenone and were affected to the extent that they were unable to feed normally on untreated leaf disks until they had recovered. Undoubtedly the same effect could have been produced with lead arsenate if larger sublethal doses had been taken.

Turner (376) in 1932 reported that in laboratory tests rotenone in mineral oil 1:25,000 killed 78 percent of Colorado potato beetle larvae in 6 days. Lead arsenate at 1-1/2 pounds to 100 gallons killed 100 percent, and 23 percent died on the untreated check. In these tests the larvae were transferred to cut potato shoots after the spray had dried.

At the 1934 meeting of the American Association of Economic Entomologists, Cory (388) led a discussion on field results with arsenical substitutes for the control of vegetable insects. According to Headlee of New Jersey (183) in 1935, the Colorado potato beetle can be controlled by derris dust.

Lapparent (257) in 1934 reported that in France trials with cube and derris powders (5 percent of rotenone) against the Colorado potato beetle gave good results.

The Alabama Polytechnic Institute (8) in 1935 stated that derris dust (0.5 percent of rotenone) is effective in controlling potato beetles when applied at the rate of 10 pounds per acre.

Feytaud (128) in 1935 referred to the use of rotenone powders for combating the Colorado potato beetle in France. The type formula is 5 parts of powdered derris or cube (rotenone not less than 5 percent) and 95 parts of talc or kaolin.

Feytaud and Lapparent (130) in 1935 reported favorable results against the Colorado potato beetle in France with a terpinolene extract of derris (or cube) emulsified in water. These workers prepared terpinolene extracts of derris and cube by macerating 8 gm. of root with 100 gm. of terpinolene for 3 to 5 days. After being filtered and emulsified, this extract killed larvae of the Colorado potato beetle at a dilution of 1:19 with water.

A good emulsion is made by mixing 700 gm. of the terpinolene extract with 300 gm. of sulfated higher fatty alcohol (oleyl, lauryl, cetyl). This is better than sodium resinate. Terpinolene, or essence of pine, is rich in iso-cineol.

Later, Feytaud and Lapparent (131) reported that in laboratory tests against the Colorado potato beetle it was necessary to use the following quantities of a product containing about 16 percent of the extractives of derris, of which 5 percent was rotenone: 100 gm. per hectoliter of water for young larvae, 200 gm. per hectoliter of water for old larvae, 500 gm. per hectoliter of water for adults. Derris extract in terpinolene is made as follows: 15 gm. of powdered derris or cube (rotenone = 5 percent) is macerated for 5 days at a temperature not above 30°C. in 100 gm. of terpinolene, then filtered and kept in a tinted glass flask to escape the action of light. A mixture is made of derris extract in terpinolene, 60 parts; terpineol, 20 parts; sulfated oleyl alcohol, 20 parts. Preferably the last two ingredients are mixed first and the derris extract then added. For use this mixture is added to water to make a 0.5-percent emulsion. Ammonium sulfocinate may also be used as an emulsifier. A 0.5-percent emulsion of this applied to fourth instars of the potato beetle killed 30 percent in 24 hours, 75 percent in 48 hours, and 100 percent in 4 days.

Fryer (148) in 1935 reported that derris had been used against the Colorado potato beetle at Tilbury, England, but that the exact degree of success will not be known for another year.

Derris was effective in field demonstrations.--New Jersey Agricultural Experiment Station (296) in 1935.

Robin (328) in 1935 reported good control of the Colorado potato beetle in France within the following mixture: Derris powder (rotenone 4 percent), 18 percent; pyrethrum powder (pyrethrins 0.6 percent), 25 percent; and clay 57 percent. Excellent results against larvae and adults were obtained when dusted at the rate of not more than 15 kg. per hectare.

In discussing insecticides suitable for combating the Colorado potato beetle in 1936 (28), Feytaud stated that powders containing 5 percent of cube or derris were in use for this purpose.

Fenton (127) in 1936 referred to an unpublished report of the Texas Agricultural Experiment Station, which described tests for the control of the Colorado potato beetle. When 10 pounds of derris (0.5 percent of rotenone), 15 pounds of pyrethrum Powco "A" dust (0.75 percent of pyrethrins), and 75 pounds of 325-mesh sulfur were employed, all insects were killed within 36 hours; when 10 pounds of derris (0.5 percent of rotenone) and 90 pounds of 325-mesh sulfur were employed, 95 percent of the insects were killed within 48 hours; and when 25 pounds of pyrethrum Powco "A" dust (0.125 percent of pyrethrins) and 75 pounds 325-mesh sulfur were employed, all insects were killed within 48 hours.

Feytaud (129) in 1936 recommended rotenone powders for combating the Colorado potato beetle. The derris or cube should contain 5 percent of rotenone and should be diluted with talc or kaolin. The proportion of root powder should be 5 to 20 percent.

Herman and Hockey of Nova Scotia (185) in 1936 reported practically complete control of potato beetles by the application of Cubor 75 dust (0.75 percent of rotenone) or derris-gypsum dust (0.4 percent of rotenone).

Chevalier (83) in 1937 discussed the use of rotenone-bearing roots in France to combat the Colorado potato beetle and other insects. Derris-gypsum dusts in laboratory tests gave results as follows:

Insect Stage	Rotenone content	Mortality in 4 days
	Percent	Percent
Adults	0.5	100
Adults	0.2	80
Adults	0.1	100
Larvae	1.0	100
Larvae	0.2	100

In the field a dust containing 5 percent of derris (equivalent to 0.2 percent of rotenone) was very effective.--Kelsall and Stultz (245) in 1937.

Derris powder (4 percent of rotenone) at the rate of 2 pounds per 100 gallons of water plus about 2 pounds (dry basis) of coconut oil soap killed 98 percent of the larvae and 82 percent of the adults on tomatoes.--Manschke (272) in 1937.

Derris dusts have given satisfactory results on the Colorado potato beetle.--New Jersey Agricultural Experiment Station (297) in 1937.

Smith (339) in 1937 reported that a spray of derris powder (4 percent of rotenone) at 2 pounds per 100 gallons of water plus 1-7/8 pounds of coconut oil soap (anhydrous basis) killed 98 percent of the larvae and 92 percent of the adults of the Colorado potato beetle 24 hours after application.

A preparation called Pirox, in use in France for the control of the Colorado potato beetle, contains derris, sulfur, and copper. Reference is made to various derris mixtures mentioned in the literature for the control of this insect.--Wahl (405) in 1937.

The Colorado potato beetle on potatoes was killed by a product containing 12 percent powdered Lonchocarpus nicon root (of 6 percent rotenone content) and 38 percent of talcum, according to Etablissements Rotonia in 1938. in a letter to R. C. Roark.

The United States Bureau of Entomology and Plant Quarantine, Division of Control Investigations (397) in 1938 issued its third report of tests on the insecticidal value of various compounds. Results of tests with Derris against fourth instars of the Colorado potato beetle were reported as follows:

Material (dust)	Micrograms per sq. cm.	Effect
Derris (rotenone 5.4 percent; total extractives 15.5 percent)	125 or 110	Permitted slight feeding and killed 100 percent in 48 hours.
Derris + talc (rotenone 1 percent)	100	Do.
Derris-talc (rotenone 0.5 percent)	230	Do.
Cube powder (rotenone 4.4 percent; total extractives 20.7 percent)	140	Do.

Agicide DC-4 (rotenone 0.6 percent) at the rate of 4 pounds per 100 gallons of water (0.003 percent rotenone in spray) killed from 50 to 100 percent of the beetles in 96 hours.--Agicide Laboratories (6) in 1939.

Desaynard (101) in 1939 discussed the advantages and limitations of rotenone as an insecticide. A powder containing rotenone, stabilized according to a patented process, retained full toxicity to Colorado potato beetle larvae when exposed to light for 110 hours, whereas the nonstabilized powder dropped to 12 percent of its efficacy in this time.

Feytaud and de Larrarent (132) in 1939 described experiments carried out in France in 1938 to compare the insecticidal value of a cube dust (6 percent rotenone content) used alone or in combination with various diluents, each mixture containing 15 percent of cube. Fourth instars of the potato beetle were used as the test insects. The results showed that the mixtures were practically as toxic as the pure cube, which caused fatal paralysis of the larvae in less than 2 hours, and that calcium carbonate, sulfur, kaolin, carbonated talc, or gypsum were preferable to silica, bentonite, or lime.

To test their durability, the dusts were kept in closed metal boxes for 3 and 13 months or exposed in layers of 2 to 3 mm. to light and changes in temperature and humidity in an insectary for 3, 5, and 15 months. There was no decrease in the toxicity of the dusts kept in metal boxes, with the exception of the mixtures containing bentonite and lime, of which the toxic action on the larvae was delayed for several hours. Of the dusts exposed in the insectary, cube alone and mixtures of it with calcium carbonate, talc, sulfur, carbonated talc, or gypsum retained their full toxicity even after 15 months; whereas the paralyzing effect on the larvae of the dusts containing kaolin and silica was delayed for several hours, and that of the lime mixture for several days. The bentonite mixture showed a very retarded action after exposures of 3 and 5 months, and after 15 months it turned into a solid mass and when broken up did not affect the larvae placed on it.

In experiments in May 1939 a potato plant protected from rain but not from air, light or humidity was dusted with a mixture of derris and talc containing 0.25 percent of rotenone and larvae of Leptinotarsa decemlineata were placed on it the same day or at various intervals. All those placed on it 27 days later, the longest interval tested, died within 24 hours. In further tests in June 1939 a commercially prepared dust containing 0.65 percent of rotenone and stated to be stabilized against the effects of air and bright light was found to be considerably slower in its action than a nonstabilized dust containing only 0.3 percent of rotenone, whether used after having been kept in an air-tight box or after 9 days' exposure to bright sunlight. The addition of a coloring agent to the second dust did not increase its toxicity.

The International Institute of Agriculture (221) in 1939 stated that rotenone preparations are remarkably effective against Colorado potato beetles in the early stages.

Nelson and Howard (293) in 1939 reported that experiments in 1938 in Ohio showed that standard sprays containing lead arsenate at the rate of 4 pounds to 100 gallons of water were far superior to derris sprays containing 0.015 percent of rotenone, phenothiazine, or sulfur nitride (22.9 percent pure), each at the rate of 4 pounds to 100 gallons of water, for the control of the Colorado potato beetle. Two applications of each of these sprays were made. Although slower in action, sulfur nitride compared favorably with phenothiazine and with derris at the expiration of 3 weeks after the second application; however, only lead arsenate gave satisfactory control at the expiration of the 3-week period. The addition of a varnish sticker to the derris spray did not improve the percentage of control.

Sellke (335) in 1939 reported that derris dust, derris spray, derris plus pyrethrum dust, and derris plus pyrethrum spray were effective against the larvae and adults of the Colorado potato beetle in tests in Germany.

Demonstrations in controlling the Colorado potato beetle on tomato with rotenone dusts were so favorable that a number of growers are using that material in place of calcium arsenate.--Maryland University Extension Service (274) in 1940.

Longitarsus suturalis (Marsh)

This flea beetle, found on Crotalaria, is sensitive to derris. Dusting and spraying with the above-mentioned concentrations gave conclusive results. How frequently the treatment should be repeated in practice is still not known. Of 40 beetles, which were fed for 3 days on Crotalaria leaves sprayed with derris powder in water (rotenone 1:2,000), 25 died in 4 days; the other 15 remained alive for a considerable time, so that the action of derris as a stomach poison is insufficient. Therefore, it is essential to contact the beetles with the remedy.--Van der Vecht (401) in 1936.

Longitarsus sp.

A species which perforated the young leaves of patchouly in the "Culture Garden" at Buitenzorg, Java, on being tested by dusting with derris powder (laleur) plus talc 1:3, died in a short time. After the planting was dusted with the powder mixture by a hand duster, only a very few beetles were to be found on the plants the following day. When the dusting was repeated after 1 week the infestation practically disappeared.--Van der Vecht (401) in 1936.

Luperodes praeustus Motsch., a clover leaf beetle

Tamanuki (365) in 1929 recommended spraying with derris to control the larvae of this species.

Nodeonota puncticollis (Say), the rose leaf beetle

Hamilton (172) in 1937 reported that N. puncticollis on bush honeysuckle was controlled 60 percent by a spray of 4 pounds of derris or cube powder (4 percent of rotenone) and 4 pounds of rose-residue emulsion per 100 gallons of water. The spray acts as a repellent. The effective period is 4 to 6 days. Repeated sprays should give satisfactory control.

Paria canella (F.), a strawberry rootworm

Derris dust and derris extract, applied as above-ground treatments were inferior to lead arsenate mixed with bench soil at the rate of 10 pounds per 1000 square feet.--New Jersey Agricultural Experiment Station (296) in 1935.

Britton (56) in 1938 recommended derris dust for the control of the strawberry rootworm feeding on the leaves of strawberry plants.

Parks and Pierstorff (312) in 1938 recommended derris or cube dust (0.5 to 0.75 percent of rotenone) or spray (4 pounds of powder of 4 percent rotenone content per 100 gallons of water) to be applied in May when the beetles are first observed.

Phaedon brassicae Böly

The Institute of Physical and Chemical Research (220) in 1927 reported that Neeton (derris extract in fish oil), 1 pound in 60 imperial gallons of water, killed 100 percent of the adults and 90 percent of the larvae in the field in warm weather, but when the temperature dropped (middle of September in Japan) the mortality of both forms dropped to 60 percent. Neeton, 1 pound in 40 imperial gallons of water, killed 21.6 percent of the eggs.

Phaedon cochleariae (F.), a mustard beetle

Thompson (370) in 1932 reported that one spraying with a derris-soap wash, followed by flooding, was effective in checking the injury by this beetle in one locality in Wales. Another bed of water cross was dusted with derris powder, but on account of the large quantity of material required this method was discontinued and the derris-soap wash was sprayed on six or seven times at intervals of about a week. It was concluded that spraying in this way is thoroughly effective as a control measure.

Edwards (114) in 1938 reported the results of experiments carried out in England in 1935 with derris and pyrethrum insecticides for the control of the mustard beetle. Insecticides tested comprised a derris spray containing 0.004 percent of rotenone with 0.05 percent of sulfonated loral as a spreader, two derris dusts with respective rotenone contents of 0.2 and 0.5 percent, and a pyrethrum emulsion containing 0.01 percent of pyrethrin I. Two applications were made, on June 24 and July 5, respectively, on plots of uniformly heavily infested water cress. Counts were made on July 10, the weather in the interim having been warm and sunny. The treatment reduced the beetle population to an average of 22.4, 13.7, 3.1, and 37.9 percent, respectively, of that on the control plots, which averaged 322 individuals per square foot. The control given by the second derris dust was considered very satisfactory, but several disadvantages would attend an indiscriminate use of derris dusts in the beds. These include the danger of poisoning fish in rivers or ponds to which the dust might be carried, and the practical difficulty of ensuring a thorough application to the lower leaves, where the beetles congregate in dull weather.

These results were confirmed by growers in South Wales and Monmouthshire in 1936, who obtained sufficiently good control with derris dust of not less than 0.2-percent-rotenone content applied at intervals of 10 days in sunny weather.

Phaedon incertus Baly

Nozu and Sonoyama (307) in 1926 recommended spraying with derris mixtures for the control of this chrysomelid feeding on cruciferous vegetables in Japan.

Nakayama, Masaki, and Tabashi (292) in 1933 recommended a spray of about 1 fluid ounce of derris soap [Neeton?] to 1 gallon of water.

Phaedon sp.

Korff and Boning (249) in 1933 stated that a spray containing 0.5 percent of Polvosol (a derris preparation) killed 100 percent of the beetles of Phaedon sp. in 12 hours.

Phyllodecta vitellinae (L.), a brassy willow beetle

A very high kill of willow beetles was obtained with a derris dust of known rotenone content. In dry weather the dust acted as an efficient repellent for several days.--Agricultural and Horticultural Research Station of the University of Bristol (54) in 1933.

Hutchinson and Kearns (210) in 1935 reported on the effectiveness of derris dust for the control of the brassy willow beetle in England. A proprietary dust, consisting of ground derris root and a carrier, with a crystalline rotenone content of 0.18 percent (ether-extraction method) was used. The material was a fine dust and easily distributed by means of a Niagara type of hand blower. A total of 449 beetles were collected from a willow bed, and batches of 50 were lightly shaken in Petri dishes with a small quantity of the derris dust. Immediately after this treatment they were placed in clean dishes. The following day 98 percent were dead. This experiment showed that the dust was highly toxic to the beetles, provided it came into intimate contact with them.

As a result of the above experiment further observations were carried out on a bed of Salix alba vitellina. A block of 35 stools infested with beetles were dusted on May 30 and on the following day the stools and soil were examined. The dust had settled on the bark of the stools and on the soil surface, but very little was evident on the foliage. A total of 751 beetles were counted on the soil surface at the base of the stools, and only 3 living beetles were present on the plants. No dead beetles were observed on an adjoining untreated block of 25 stools on which 450 beetles were counted.

In a second experiment designed to determine the duration of effective toxicity, a stool and its shoots and adjacent soil were lightly dusted, then covered with muslin to form an insect cage, and 128 beetles were introduced. The following day all the beetles were dead. On the same stool, 3 days after the dust application, a second batch of 150 beetles was added to the cage, and of these 127 were dead on the following day.

The failure of pyrethrum dust to control the beetles had suggested that the result was due to the poor adhesion of the carrier, kaolin, to the insects. An experiment was, therefore, carried out using kaolin mixed with the finely ground derris root, to ascertain whether the efficiency of the derris was affected. In order to compare the results with those obtained with the proprietary dust, the kaolin was mixed with the derris root in proportions to give the same content of crystalline rotenone. The results obtained from this experiment showed that the kaolin preparation gave a 100-percent kill of the beetles, despite its poor adhesion, and the results from its use were similar to those obtained with the proprietary dust. Hutchinson

and Kearns concluded from the above experiments that derris is much more toxic to the beetles than pyrethrum when used in dust form, and that a satisfactory control of Phyllodecta vitellinae can be obtained by the use of a derris dust. Under dry-weather conditions the powder after application retained sufficient effective toxicity to kill or to repel wandering beetles for at least 3 days.

Phyllodecta vulgatissima (L.)

Sensitive to derris dust.--DeBussy et al. (61); also Van der Laan (252) in 1936.

Phyllodecta sp., blue and brassy beetles

Kearns (236) in 1935 recommended derris spray and derris dust for the control of insect pests of basket willows. The spray should contain not less than 0.004 percent of crystalline rotenone, and 1/2 pound wetter (best suited for hard waters), per 100 imperial gallons of water. Derris dusts should contain not less than 0.15 percent of crystalline rotenone. Dusts provide a satisfactory control of the adults of the blue and brassy beetle, Phyllodecta sp., and the larvae and adults of the brown beetle. The best results are obtained when the beetles have collected in considerable numbers on the shoots and young leaves in the early spring. At other times of application dusts do not give satisfactory results. Derris may be used in connection with bordeaux mixture.

Phyllotreta albionica Léc., a cabbage flea beetle

Derris dust (3.05 percent of rotenone) was very effective in field tests alone and when diluted with gypsum in the ratios of 90:10 and 70:30.--Kelsall and Stultz (245) in 1937.

Phyllotreta atra (F.)

Petherbridge and Thomas (317) in 1935 reported on the control of flea beetles in seedbeds in England. The species of flea beetles found attacking cabbage plants during the course of the present investigations were the following: Phyllotreta atra (F.), P. consobrina (Curt.), P. cruciferae (Goeze), P. nemorum (L.), P. nigripes (F.), P. punctulata (Marsh), and P. undulata Kutsch. In 1931 best results after the plants were up were obtained with a 4-percent-nicotine dust. Poor results were obtained with heavy derris dust, the dusted beds being as severely attacked as the controls. The dust was also difficult to apply with a rotary blower and injured the plants. In 1934 experiments were made on cauliflowers with 3-percent-nicotine dust, light and medium derris dusts (0.2 percent of rotenone), and other materials. The best control was obtained with a light derris dust applied four times, the plots having only three applications being nearly as good.

In a season when flea beetle damage is very bad, the following procedure was recommended for cabbage seedbeds: (1) Prepare as fine a tilth as possible; (2) apply naphthalene or a derris dust about 4 or 5 days after the seed is sown; (3) dust with a light derris dust as the plants are coming through the ground; (4) subsequently, dust with a

derris dust at intervals of 3 to 5 days, depending on the weather and the extent of the attack--in the event of a severe attack, as many as five applications may be necessary; and (5) keep a very careful watch on the seedbeds. During fine weather they should be examined twice a day. A bed may be free from beetles in the morning and yet be severely attacked by the evening of the same day. It is possible that this method of dusting with derris may be applied to other crops subject to attack by flea beetles. If a light dust is used, about 30 pounds per acre per application should be enough if the plants are in drills about 2 feet 6 inches apart.

Phyllotreta bipustulata (F.)

Fenton (127) in 1936 referred to an unpublished report by Roney, of the Texas Agricultural Experiment Station, who found that a dust composed of 15 pounds of pyrethrum (0.5 percent of pyrethrins), 10 pounds of derris (5 percent of rotenone), and 75 pounds of sulfur successfully controlled these beetles.

Phyllotreta consobrina (Curt.)

P. cruciferae (Goeze)

P. nemorum (L.)

See Fetherbridge and Thomas (317) under Phyllotreta atra (F.), on page 55.

Phyllotreta nigrines (F.)

See Fetherbridge and Thomas (317) under P. atra (F.), on page 56.

Blunck and Meyer (30) in 1932 reported derris powder and Polvo to be effective for combating P. nigrines.

Phyllotreta punctulata (Marsham)

See Fetherbridge and Thomas (317) under P. atra (F.) on page 55.

Phyllotreta sinuata (Redt.)

This flea beetle can be especially injurious to mustard. Dusting with derris mixtures containing 0.5 percent of rotenone, and spraying with suspensions of 1:5,000 rotenone content in the laboratory, killed the insects in a short time. After a field test in a kitchen garden in Batavia, the treated plots were noticeably better than the untreated, but were not entirely free from attack. Probably this is to be ascribed to the regular watering of the plants, by which means the derris powder was washed off; then reinfestation occurred from the control plots.-- Van der Vech (401) in 1936.

Phyllotreta undulata Kutsch

See Fetherbridge and Thomas (317) under P. atra (F.) on page 55.

Blunck and Meyer (30) in 1932 reported derris powder and Polvo to be effective for combating this species.

Phyllotreta vittata (F.), the striped flea beetle

Allen (9) in 1934 reported that a derris dust containing 1 percent of rotenone and equal parts of finely ground tobacco dust, with 300-mesh dusting sulfur as a diluent, is very effective in controlling the striped flea beetle.

Easily killed by derris dust.--Hamilton and Gemmell (174) in 1934.

Killed by a derris-gypsum dust (0.4 percent of rotenone)--Herman and Hockney (185) in 1936.

Okamoto (309) in 1936 reported that a derris insecticide is very effective for the control of this species, which is very common on cruciferous vegetables in Japan.

Agicide DC-4 (rotenone 0.6 percent) at the rate of 4 pounds per 100 gallons of water (0.003 percent of rotenone in spray) killed from 50 to 100 percent within 96 hours.--Agicide Laboratories (6) in 1939.

A 1-percent-rotenone dust may be used for the control of the striped cabbage flea beetle with effective results if the applications are thoroughly made and reasonably frequent. The tendency is to begin the treatments too late, and injury is often severe before even an experienced grower realizes it.--Crosby, Chupp, and Leiby (92) in 1939.

Phyllotreta vittata discedens Weise

The Louisiana Agricultural Experiment Station (263) in 1938 reported that a derris dust containing 1 percent of rotenone has given best results in the control of the striped flea beetle on turnips and mustard. If the dust is applied at weekly intervals as long as beetles are present, this pest can be controlled very effectively.

Phyllotreta sp.

Sensitive to derris dust.--DeBussy et al. (61); also Van der Laan (252) in 1936.

Davies (96) in 1937 referred to experiments by Petherbridge and Thomas (317, 318) in 1935 and 1936 with derris dust against flea beetles. Davies tested derris, derris plus slate dust (1:4), and other materials against turnip flea beetles, Phyllotreta sp., on Swede seedlings. Slate dust (10 percent of seedlings damaged) alone was about as effective as derris (15 percent damaged) in protecting the plants. From 74 to 89 percent of the untreated plants were damaged.

Plagioderma inclusa Stal, a soybean leaf beetle

In the laboratory 30 adults were repeatedly dusted with laleural dust 1:1, and Derris malaccensis plus talc 1:1, and sprayed with derris "X.I." 0.5 percent in water (rotenone 1:2,850), and rotenone emulsion (1:2,000), according to Van der Scheer's procedure. The result was not conclusive as 10 or more beetles of each group were still alive after three days. Better results were obtained by feeding the

the beetles for 3 days with soybean plants previously dusted with mixtures of derris powder and talc. After using laleur plus talc 1:1, the number of beetles that died on successive days were 1, 10, 11, 7, and 2, respectively, of a total of 30 beetles. One-hundred-percent mortality was still obtained, even by dusting with laleur plus talc 1:5, 16 beetles died within 3 days and the other 14 were paralyzed and died with 3 to 6 days after being dusted. Of the untreated beetles, and of those dusted with talc (30 each), only 2 and 3, respectively, died.

As Plagiodera does not occur in the neighborhood of Buitenzorg, Java, two plantings in the Kalasan district were dusted with a dust mixture composed of laleur, Changi, and talc, which contained about 1 percent of rotenone. The dusting was done with a hand duster. The first experiment took place on July 12, 1935, at which time a planting of about 620 square meters was dusted with 1 kg. of powder mixture. The effect of the dusting was checked on July 15. Apparently all the larvae were dead; however, the dusting had had practically no effect on the beetles. The second experiment was made on July 30. At that time a planting of fully 300 square meters was dusted with about 2/3 kg. of the dust mixture. This plot was attacked by adults only. Neither on the second nor on the fifth of August could any reduction in the number of beetles be observed.--Van der Vecht (401) in 1936.

Plesispa reichsei Chap.

All the larvae but none of the beetles were killed by wetting with a derris powder suspension with rotenone content of 1:5,000.--Van der Vecht (401) in 1936.

Podagrica javana (Motsch.), a kapok flea beetle

The beetles (20 in number) when placed on kapok leaves that had been lightly dusted with Changi plus talc 1:3 and laleur plus talc 1:1 did not feed and, apparently by contact with the powder, were more or less paralyzed after a few hours. Half of them were dead after 24 hours, and of the remainder a few continued to react to touch for 4 to 5 days, but they did not recover.--Van der Vecht (401) in 1936.

Podontia affinis Grönd.

The larvae of this species living on "kedondong" in Java were dusted in the laboratory with derris (laleur) plus talc, 1:1. Six of the 10 nearly full-grown larvae fell from the leaves after an hour, while the other 4 moved only sluggishly. All the larvae were dead in 24 hours. There was no mortality on the controls.--Van der Vecht (401) in 1936.

Phylliodes chrysocephala L.

Roebuck (330) in 1937 reported that cabbages in Derbyshire, England, were severely infested by this species during 1935-36. The cabbages attacked by larvae were ploughed in and dusts of derris and barium fluosilicate and sprays of lead arsenate were employed against the adults. The winter of 1936-37 was unfavorable to the pest, so crops were not attacked the following spring.

Psylliodes punctulata Melsh., -- the hop flea beetle

Dorst (164) in 1938 reported on flea beetle injury to sugar beets in central Utah. During the spring of 1937 the hop flea beetle bred in enormous numbers upon Cheirinia repanda (L.) Link, an introduced wild mustard known commonly as western wallflower, on the range land adjacent to the cultivated areas of the Sevier Valley, in central Utah. Preliminary experiments designed to control the flea beetle indicated that a spray made up at the rate of 2 pounds of derris root powder, containing 2 percent of rotenone, in 100 gallons of water killed a large proportion of the resident flea beetle population. This spray, however, gave only temporary protection, as incoming flea beetles soon reinfested the fields. Bordeaux mixture (4-4-50), to which 4 pounds of calcium arsenate was added, applied at the rate of 75 gallons per acre gave satisfactory protection against the flea beetles.

Psylliodes sp.

See Hamp (175) under Altica sp., on pages 19, 22, ...

Rhaphidopalpa femoralis Motsch.

Neaton, 1 pound in 80 imperial gallons of water plus 2 pounds of soap, killed all adults of "Aulacophora femoralis". [This species according to H. S. Barber, as stated by Muesebeck, may be a chrysomelid... if so, the name should be Rhaphidopalpa femoralis Motsch.].--Institute of Physical and Chemical Research (226) in 1927.

Nezu, Sakamoto, and Sonoyama (304) in 1934 reported studies on this species, a serious pest of cucurbits in Japan. Derris sprays are effective against the larvae and the adults.

Mishima (287) in 1936 reported that in Japan a derris dust was effective against the adult beetles on cucurbits. Derris also kills the eggs and stimulates the growth of the plants.

Sawaragi (332) in 1936 recommended sprays containing derris for the control of the larvae of this species in Japan. In the Mie Prefecture they should be applied twice, in mid-June and early in July.

Rhaphidopalpa foveicollis Lucas

See Chevalier and Laffond (81) under Altica annelophana Guér., on page 18.

Systema frontalis (F.), a cranberry flea beetle

Against the cranberry flea beetle, a spray of 10 pounds of derris powder (4 percent of rotenone) and 1 pound of Areskan in 100 gallons of water, applied at the rate of 400 gallons per acre on August 11, gave a satisfactory kill of the beetles.--Massachusetts Agricultural Experiment Station (277) in 1937.

Typophorus viridicyaneus (Crotch), a sweetpotato leaf beetle

Brannon (38) reported in 1936 that cryolite-talc dust (60:40) was more toxic to the sweetpotato leaf beetle adults in field-cage tests than were derris or cube-root mixtures containing 0.5 percent of rotenone or derris-root sprays containing 0.02 percent of rotenone. The same author (41) in 1937 reported that the sweetpotato leaf beetle had developed into a pest of distinct importance in northeastern North Carolina. Results of cage toxicity experiments demonstrated that undiluted calcium arsenate was more toxic to the insect than was a derris- or cube-dust mixture containing 0.5 percent of rotenone or a water suspension of ground derris root containing 0.02 percent of rotenone.

C. L. Smith (339) in 1937 reported the following results against the sweetpotato beetle:

Material	Reduction	
	Larvae	Adults
	Percent	Percent
Derris powder (4 percent rotenone)		
3 lbs + 1-7/8 lbs. coconut-oil soap (anhydrous basis) per 100 gal.	81	89
McCormick's dust, 0.75 percent rotenone	79	89

Brannon (45) in 1938 reported the results of toxicity tests in cages, which indicated that undiluted calcium arsenate, 80 percent barium fluosilicate 1 part with infusorial earth 2 parts by weight, and synthetic cryolite 3 parts with talc 2 parts are highly toxic to the adult sweetpotato leaf beetle. These materials were more toxic than were derris or cube dusts containing 0.5 percent of rotenone, or a water suspension of ground derris root at a dosage equivalent to 4 pounds of derris of 4 percent rotenone content in 100 gallons of water (rotenone content of spray 0.02 percent).

Wallacea palmarum Gestro

According to a communication from P. Dakkus, Buitenzorg Botanical Garden, this species, which lives in the heart of palms was successfully controlled by dusting derris powder (2 percent of rotenone) into the heart of the infested plants. Satisfactory results could probably be obtained with a powder of lower rotenone content.--Van der Vecht (401) in 1936.

Chrysomelidae (unidentified spp.), flea beetles

In 1934 Cory (388) led a discussion of field results with arsenical substitutes for the control of vegetable insects. According to Headlee (123) in 1935, flea beetles in plant beds can be controlled by derris dust.

McCampbell (264) in 1934 recommended derris dust for the control of flea beetles on cabbage.

Derris-sulfur dust (0.5 percent of rotenone) is of some value for combating flea beetles on cabbage.--Alabama Polytechnic Institute (8) in 1935.

Howard, Mason, and Davidson (200) in 1935 reported that a hotbed of eggplant heavily infested with flea beetles was cleaned up by spraying with a commercial product composed of finely ground derris root mixed with a high-grade soap powder. Derris root should not be mixed with soap if residual or lasting effect is desired.

The Kentucky Agricultural Experiment Station (246) in 1935 reported talc to be superior to fuller's earth, bentonite, or tripoli as a diluent for derris used to control flea beetles.

Miles (284) in 1935 reported that two substances were found effective against flea beetles on Brassicac in England. As soon as the seedlings are breaking through the soil, the rows should be dusted with either naphthalene or derris at the rate of 30 to 40 pounds per acre. It can be applied by means of a knapsack duster, and under ordinary circumstances two men can dust an acre in an hour and a half. Two or three dustings may be necessary. While naphthalene is only repellent in its action, derris dust is definitely toxic to the beetles and also repellent.

Derris was effective in field demonstrations against flea beetles.--New Jersey Agricultural Experiment Station (296) in 1935.

A mixture of 2.5 parts of derris, 7.5 parts of sabadilla seeds, and 90 parts of talcum proved useful in exterminating flea beetles.--Schotte and Görnitz (333) in 1935.

The East Malling Research Station, England (110) in 1936 stated that a proprietary derris powder was used in the routine spraying program in 1935 for the control of flea beetles on hops.

Petherbridge and Thomas (318) in 1936 reported the results of further tests with derris in England. In 1935, tests were made at three places in Bedfordshire with three dusts for the control of flea beetles in Brassicac seedbeds. The dusts were (1) Derris dust (rotenone = 0.2 percent); (2) naphthalene-silica (50:50), and (3) a German proprietary dust consisting of finely powdered quartz [Naaki?]. Dusts 1 and 2 were applied at the rate of 65 to 85 pounds per acre and Dust 3 at the rate of 145 pounds per acre. Both Dusts 1 and 2 gave very good control of flea beetles. As a result of these tests, the authors recommend dusting with a derris or naphthalene-silica dust as the plants are coming through the ground and subsequently dusting at intervals, depending on the weather and the extent of attack.

Steer (360) in 1936 wrote that for flea beetles on hops and cruciferous crops derris dust is the preferred insecticide.

The United States Department of Agriculture (381) in 1936 referred to derris and cube as effective against flea beetles destructive to growing tobacco.

White (413) in 1936 issued recommendations for the control of insects attacking certain vegetables, small fruits, and tobacco. Derris dusts indicated that they may aid in the control of flea beetles infesting cabbage and related crops.

Howard and Mason (198) in 1937 wrote that in the hotbed and cold-frames derris or cube will be found useful in controlling attacks of flea beetles on young tomato plants and young eggplants.

Derris dusts have given satisfactory results on flea beetles.--New Jersey Agricultural Experiment Station (297) in 1937.

Hampp and Jehl (176) in 1938 reported experiments on the control of hop flea beetles in 1937 at the hop experiment station at Hull, Germany. The overwintered adults appeared early in May, and the new adults, in smaller numbers, from mid-July on. The tests were made with unstated quantities of derris, derris mixed with pyrethrum, and nicotine. As in all previous tests derris dusts proved absolutely reliable if applied in sufficient quantity and were much superior to pyrethrum, nicotine, or arsenicals, and especially superior to sprays.

Rotenone sprays or dusts were recommended by Parks and Pierstorff of the Ohio Extension Service (312) in 1938 for the control of flea beetles on beet, eggplant, pepper, radish, sweet corn, tomato, and turnip.

Warwick (410) in 1938 reported that the most uniformly reliable method for controlling flea beetle in England is the broadcasting of a good quality of derris dust at the rate of about 1/2 cwt. (56 pounds) per acre.

The Idaho Agricultural Experiment Station (216) in 1939 reported rotenone dusts to be effective against flea beetles.

Chrysomelidae (unidentified sp.), a red melon beetle

An anonymous (4) writer in the Palestine Gazette in 1939 stated that the red melon beetle is extremely sensitive to derris dusts, which can be regarded as the specific poison for chrysomelid beetles, and that it can be easily controlled by two or three applications of derris dust containing 0.75 percent of rotenone, from April to June, inclusive. Against the larvae boring in the root collar of the cucurbits hardly a measure can be advised because they hide underground and their presence becomes evident only after the damage is irreparable. Therefore, the necessity of a quick and full control of the adults is stressed. A 50-50 mixture of pure barium or sodium fluosilicate and derris dust is recommended, provided the whole mixture contains 0.75 percent of rotenone.

Cicindelidae

Cicindela campestris L., a tiger beetle

This insect on roses was mitigated by a product containing 12 percent of powdered Lonchocarpus nicou root (of 6 percent rotenone content) and 88 percent of talcum, according to a letter from Etablissements Rotenia to R.C. Roark in 1938.

Cleridae

Necrobia rufipes (Deg.), the red-legged ham beetle

Not affected by derris.--Van der Laan (252) in 1936.

Coccinellidae

Epilachna borealis (F.), the squash beetle

Rotenone suspended in water, 1:500, prevented feeding by the adults and even at 1:2,000 feeding was curtailed.--Davidson, reported by Campbell (66) in 1932.

Epilachna dodecastigma Muls.

About 40 larvae of different instars were lightly dusted with "laleur" plus talc 1:1 (rotenone 0.5 percent). These larvae, and also the ravenous fourth instars, were paralyzed after a few hours, ceased feeding, and died within 24 hours. An experiment with 15 adults gave corresponding results; pupae that had been dusted with the said powder mixture produced normal beetles.--Van der Vecht (401) in 1936.

Epilachna indica Muls.

Most of the adults and larvae die within 24 hours after being placed on the leaves of Solanum melongena which have been dusted with a mixture of rotenone and tapioca flour.--Federated Malay States Department of Agriculture (126) in 1938. [This report was referred to by the Imperial Institute (218) in 1938.]

Epilachna varivestis (Muls.), the Mexican bean beetle

The West Virginia Department of Agriculture (411) in 1929 stated that Derrisol showed promising results as a repellent and killing agent for adult Mexican bean beetles and as a killing agent for their larvae.

Davidson (97) in 1930 reported the following results with suspensions of rotenone in water. Tests were made on bean plants in the field.

Insect stage	Concentration	Mortality
		Percent
Overwintered adults	1:5,000	100
	1:10,000	85
	1:20,000	0
Fall-brood adults treated in October	1:500	150
	1:250	850
	1:125	100
Small larvae	1:60,000	98.3

In field tests half-grown larvae were all killed with a dust of 1 part of rotenone and 99 parts of diatomaceous earth.

In 1930 the United States Department of Agriculture (380) called attention to its research on rotenone, which was being tested against the Mexican bean beetle and other destructive insects with promising results.

Darley (96) in 1931 sprayed adult Mexican bean beetles confined in small wire-screen cages with an aqueous suspension of rotenone made by adding a 2-percent solution in acetone to water. Rotenone at 1:50,000 was ineffective. Rotenone suspended in water 1:200 sprayed on leaves and fed to the larvae as a sandwich killed all. At 1:5,000 all adults on a sprayed plant were killed and at 1:10,000, 90 percent were killed.--Davidson, reported by Campbell (66) in 1932. Campbell also reviewed work by Howard, who reported the failure of a dust containing 0.15 percent of rotenone to protect beans from Mexican bean beetle attack. Two applications of 20 to 25 pounds per acre gave some temporary protection, but at the close of the experiment, 25 days after the second treatment, the foliage had been destroyed, whereas the magnesium arsenate plots remained green. Howard also used concentrated aqueous suspensions of rotenone in cage tests against the Mexican bean beetle, with disappointing results.

Douglass (105) in 1933 reported the results of tests of insecticides against the Mexican bean beetle in New Mexico. Derris dust and Cubor dust killed more beetles than did arsenicals and barium fluosilicate. Derris dust containing 1 percent of rotenone was more effective than Cubor dust against overwintered beetles, larvae, and newly developed beetles.

Howard, Brannon, and Mason (193) in 1933 reported that in 1931 they had found a commercial dust containing 0.15 percent of rotenone to be ineffective; in 1932 a commercial dust containing 0.275 percent of rotenone gave fair results. A commercial extract of derris root, containing 5 gm. of rotenone per 100 cubic centimeters, with other extractives, gave satisfactory control at Norfolk, Va., in light to medium infestations, when used at dilutions of 1: 250, 1: 500, 1: 800, and 1: 1,000. In medium to heavy infestations, in Ohio in 1932, at 1: 250 and 1: 400, it gave results equal to or better than magnesium arsenate at 2 pounds to 50 gallons and cryolite at 2 pounds to 50 gallons of water, and better than a well-known pyrethrum extract at 1: 400. Derris extract appears to be superior to pyrethrum extract and equal to a combination of the two, and far superior to pure rotenone.

The Suffolk County, N. Y., Farm Bureau (361) in 1933 called attention to the use of rotenone and pyrethrum insecticides for controlling the Mexican bean beetle on both string and lima beans. In spraying lima beans the pyrethrum- or rotenone-spray extracts may be added to the bordeaux mixture. In this way the bean beetles, lice, and mildew or pod mold may be controlled with one spray. Apparently the bordeaux decreases the killing properties of the rotenone or pyrethrum a little, but the sprays should give good control if applied as soon as mixed. Bordeaux is not needed on string beans.

Should beans require spraying against the Mexican bean beetle after the pods have set, pyrethrum or derris extracts must be used.--United States Department of Agriculture, Bureau of Entomology (386) in 1933.

In 1934 Cory (388) led a discussion of field results with arsenical substitutes for the control of vegetable insects. Headlee, of New Jersey, discussed derris for the control of the Mexican bean beetle. During the season of 1934 the following materials were studied: (1) Home-mixed derris dust containing 25 parts of 4 percent rotenone and 75 parts of talc; (2) derris dust containing 16 parts of ground derris running 5 percent of rotenone and 18 percent of total extractives, 25 parts of finely ground dusting sulfur, and 59 parts of finely ground clay; (3) derris dust containing 16 parts of ground derris root, running 5 percent of rotenone and 18 percent of total extractives, 20 parts of Copasil and 64 parts of talc; (4) a dust consisting of a fine grade of gypsum impregnated with derris extract in quantities sufficient to give 0.5 percent of rotenone; (5) a similar dust made in the same way, so as to carry 0.75 percent of rotenone; (6) a similar dust made so as to contain 1 percent of rotenone. Each of these dusts was used on beans in 1/7-acre blocks. Two applications were made before the beans were picked for market.

The materials made up with ground derris dust were much more effective in reducing the feeding injury to foliage than were the materials composed of impregnated dusts. The plants treated with ground derris dusts showed about 10 percent of the foliage eaten at the time the beans were harvested, while the impregnated materials showed from 30 to 60 percent of the foliage destroyed. A study of the beetles returning to the treated blocks showed reinfestation of the impregnated material treatments first, and later the ground-derris-dust treatments. Furthermore, the last of the ground-derris-dust materials to be reinfested was the derris-sulfur-clay combination, indicating that this particular derris dust had a much greater residual effect than any of the others. These materials were applied by means of a two-row duster, using metal single-row hoods 6 feet long, 12 inches wide, and 14 inches high. The use of these hoods made it possible to effect satisfactory coverage and to obtain complete kill by the use of 10 pounds of dust per acre, as compared with 25 to 30 pounds per acre when applied without the hoods. In view of the fact that the derris dusts were sold to the consumer at the rate of from 18 to 22 cents per pound, the resultant saving made the use of the hoods very attractive. Moreover, the use of the hoods made it possible to apply the dust in the presence of considerable wind, instead of having to work early in the morning or late in the evening or at night. These single-row hoods are described in Circular 311 of the New Jersey Agricultural Experiment Station.--Headlee (183) in 1935.

Crosby and Chupp (91) in 1934 recommended rotenone dust for use against the Mexican bean beetle after the pods have begun to form. Bordeaux should not be mixed with rotenone.

Garman and Turner (161) in 1934 discussed substitutes for lead arsenate for use in Connecticut on fruits and vegetables. A dust containing 0.6 percent of rotenone was recommended for the control of the Mexican bean beetle.

Huckett (202) in 1934 reported that during 1933 on Long Island dusts containing from 0.5 to 1.0 percent of rotenone had been used successfully as substitutes for magnesium arsenate for the control of the Mexican bean beetle on snap and lima beans while the pods were forming.

Huckett (203) also reported in 1934 that against insects attacking vegetables derris dusts were usually slightly superior to derris sprays. The Mexican bean beetle may be effectively controlled by the use of a derris-clay, kaolin, or talc dust mixture of not less than 0.5-percent-rotenone content, applied much in the same manner as recommended for arsenical dusts. Hydrated lime or a mixture of hydrated lime and mono-hydrated copper sulfate affect rotenone adversely, hence their use as a diluent for derris dust is not recommended. During the summer months it will usually be necessary to apply sprays or dusts once every 10 days to 2 weeks, whereas with the shorter, cooler days of autumn, once every 2 to 3 weeks may be quite satisfactory. If derris powder is applied in a spray mixture it is advised that a strength comparable to 10 pounds of a derris-clay dust of 1 percent rotenone strength be used in 100 gallons of water, or 2 pounds of an undiluted powdered derris root of 5 percent rotenone content in 100 gallons of water, plus the addition in either case of a spreader, such as dry skim-milk powder, 4 pounds, or a miscible sulfonated oil or neutral coconut-oil soap, 2 quarts. Both derris powder and skim-milk powder should be made into a paste before being added to the tank. Hydrated lime, bordeaux mixture, or ordinary laundry soap are considered undesirable in a derris spray, owing to their adverse effect on rotenone. Although spraying may be found to be a little cheaper than dusting, insofar as costs of ingredients are concerned, it will generally be found necessary to spray at slightly shorter intervals to obtain results similar to those obtained with the dust.

The South Carolina Agricultural Experiment Station (346) in 1934 reported the results of tests with various nonarsenical insecticides against the Mexican bean beetle. Various commercial preparations containing pyrethrum, rotenone, nicotine, and other materials as the active ingredients were tested. Best results were as follows:

Material	Dilution	Average kill			
		Old Adults	New Adults	Larvae	Foliage injury
		Percent	Percent	Percent	Percent
Black Arrow	None	55	47.7	30.6	None
Kubatox	None	52.5	55.7	64.6	Slight
Red Arrow	1:200	17.5	16.4	35.3	None

Average of two tests using 20 hibernated adults in each, 10 to 14 tests using 25 recently raised adults, and 6 tests using 25 larvae in each.

Turner and Friend (378) in 1934 reported that the use of pyrethrum and rotenone dusts following applications of arsenicals prevented Mexican bean beetle damage, and a higher percentage of marketable pods resulted. These nonpoisonous dusts were also effective when used throughout the season.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (367) in 1934 made the following recommendation: "The best control for the bean beetle is spraying with magnesium arsenate, the spray mixture being used at the rate of 2 pounds to 50 gallons of water or 2 ounces to 3 gallons. If later treatments prove necessary, a derris or a rotenone dust (containing from 0.5 to 0.6 percent rotenone) should be used."

Derris dust (0.5 percent of rotenone) and spray (4 pounds of powder of 4 percent rotenone content) are effective.--Alabama Polytechnic Institute (8) in 1935.

Bobb (31) of the Virginia Agricultural Experiment Station reported in 1935 that rotenone dust at certain strengths was effective in destroying Mexican bean beetles.

In 1935 Brannon (34) reported that sprays were superior to dusts in control of the Mexican bean beetle in Virginia. A spray composed of 3 pounds of synthetic cryolite in 50 gallons of water and a derris-root-powder spray containing 0.025 percent of rotenone gave perfect foliage protection against the bean beetle and increased the yields 38 and 33.5 percent, respectively, as compared with similarly situated untreated plots. A dust mixture composed of synthetic cryolite and talc (60-40) and a derris-talc dust containing 0.22 percent of rotenone gave fairly satisfactory results and increased the yields 32.9 and 23.8 percent, respectively, as compared with untreated plots. These materials were applied with a traction duster and a traction sprayer, respectively, on 1/2-acre replicated plots.

Cory (388) in 1935 stated that Marcovitch, of Tennessee, reported in December 1934 that Cubor, 1 pound to 50 gallons of water, gave the best control of the Mexican bean beetle. Turner, of Connecticut, reported that Cubor spray and Cubor and Kubatox dusts gave good control of this insect. A dust containing 0.4 percent of rotenone applied once on first-generation and 3 times on second-generation larvae gave excellent control. Sherman, of South Carolina, reported that Kubatox killed 52.5 percent of the old adults, 55.7 percent of the new adults, and 64.6 percent of the larvae.

N. F. Howard in a typewritten report to the Division of Truck Crop and Garden Insect Investigations in 1935 reported the results of tests with cube against the Mexican bean beetle at Columbus, Ohio. Cube (rotenone, 7.7 percent) at 3 pounds per 100 gallons, applied at the rate of 118 gallons per acre, and derris containing 4.4 percent of rotenone gave 92 percent better control than the check. The addition of 1 pound of Kayso or 1 pound of soap to the cube spray gave about the same result. Both derris and cube sprays gave better control than either magnesium arsenate or synthetic cryolite. A cube powder diluted with talc to a rotenone content of 0.77 percent and applied as a dust at the rate of 21 pounds per acre gave as good results as sprays of magnesium arsenate or cryolite. Derris and cube dusts did not give so satisfactory controls as did the sprays.

Howard, Brannon, and Mason (104) in 1935 reported that finely ground derris root in water appeared to be one of the best insecticides ever tested for the control of the Mexican bean beetle. When used alone it gave better results than when used with powdered soap, lime-casein, or Bentonite-sulfur. Derris stays in suspension and sticks well, even to cabbage leaves, and has about as lasting effect as any material yet treated. Very good control was obtained at dosages of 3, 4, and 5 pounds of derris, of 4.4 percent rotenone content, in 100 gallons of water. The water suspensions of derris powder were superior to the extracts of derris or pyrethrum, or a combination of the two. The increase in residual effect of the ground root over that of the extract was marked. Laboratory tests indicated that derris dusts and sprays are toxic to the eggs of the bean beetle.

Ground derris root with a carrier used as a dust gave very promising results. The general conclusion from a large number of applications was that a dust should contain from 0.5 to 0.75 percent of rotenone (10 pounds of 5 percent derris to 90 pounds of carrier or 15 pounds of 5 percent derris to 85 pounds of carrier). Of six carriers, and combinations of carriers, comprising talc, tobacco dusts, infusorial earth, ground marc (extracted pyrethrum flowers), inert clay, and hydrated lime, talc is generally proved to be the best. Very good control of the bean beetle was obtained when 20 to 25 pounds was used to the acre. Hydrated lime in some instances appeared to reduce toxicity and should not be recommended.

The same authors (195) in 1935 issued instructions for the control of the Mexican bean beetle in the Eastern States. Derris was one of the insecticides recommended. To prepare a derris spray use 4 or 5 pounds of finely ground derris (rotenone content 4 percent) to 100 gallons of water. These sprays will have a rotenone content of approximately 0.02 and 0.025 percent, respectively. No spreader or sticker is required. Directions are given for preparing dusts containing 0.5 or 0.75 percent rotenone from derris of 4 percent rotenone content and talc. Other diluents which may be used are infusorial earth, kaolin (china clay), dusting gypsum, wheat flour, and tobacco dust. Fine dusting sulfur may be mixed with the infusorial earth or clay to the extent of 25 pounds of the sulfur substituted for a like amount of the earth or clay. Some prepared dusts may be thoroughly mixed by placing the ingredients in a drum or barrel, not over two-thirds full, and rolling and tilting for 5 minutes. Commercial dusts may be obtained already mixed. Dusts are usually applied at dosages of 20 to 25 pounds per acre on snap and bush beans, but with careful application the dosage may sometimes be reduced.

Howard and Davidson (197) in 1935 tested the devil's -shoestrings root against the Mexican bean beetle in Ohio. They reported that both a dusting mixture of this root containing approximately 0.6 percent of rotenone and a spray with a content of 0.01 percent of rotenone gave satisfactory control on small plots of heavily infested beans in the field.

Howard, Mason and Davidson (200) in 1935 reported that 3 pounds of derris containing 4.4 percent of rotenone to 100 gallons of water was effective against Mexican bean beetle. Derris spray was better than derris dust but 20 to 25 pounds per acre of the dust (0.5 to 0.75 percent of rotenone) was fairly effective.

Huckett (204) in September 1935 recommended derris as a spray or dust for the control of the Mexican bean beetle. As a spray, use 4 pounds of derris (4.5 to 5 percent rotenone content and 15 to 18 percent total extractives) and 4 pounds of Kayso or skim milk powder to 100 gallons of water. A suitable dust may be made by mixing 12 pounds of derris of above grade with 88 pounds of talc, clay, or air-floated gypsum.

Huckett and Hervey (207, 388) in 1935 reported that derris and cube sprays and dusts have shown promising results for the control of the Mexican bean beetle on lima and snap beans on Long Island.

Hutson (211) in 1935 reported derris preparations to be superior to those of pyrethrum for Mexican bean beetle control, chiefly because they have a slight residual action, whereas there is none with the pyrethrum products. Derris dusts are usually made with some bland material such as talc, bentonite, chalk, tobacco dust, or flour, and contain at least one-half of 1 percent of rotenone. It is often possible to purchase the ground derris and make up the dust by adding the diluent at home. From 25 to 35 pounds of dust per application per acre will usually give good control.

The Kentucky Agricultural Experiment Station (246) in 1935 reported that talc was more effective as a diluent and carrier for nicotine, pyrethrum, and rotenone than was fuller's earth, bentonite or tripoli, when used to control the Mexican bean beetle. Very absorptive clays, like fuller's earth, were difficult to use on mornings when plants were wet with heavy dew, if the machine drew air from around the plants.

The Maine Agricultural Experiment Station (270) in 1935 mentioned derris as effective for the control of the Mexican bean beetle when properly used, but somewhat expensive.

The Massachusetts Agricultural Experiment Station (275) in 1935 reported that rotenone sprays and dusts gave excellent control of Mexican bean beetle larvae, and the sprays also gave a high percentage of kill of adult beetles.

The New Jersey Agricultural Experiment Station (296) in 1935 reported that a combination of 16 parts of finely ground derris root containing 4 percent of rotenone and 16 to 18 percent of total acetone extractives, 25 parts of finely ground sulfur (300 mesh), and 59 parts of a finely ground clay gave practically 100-percent control of the Mexican bean beetle.

R. J. Prontiss & Company, Inc. (323) in 1935 argued that for the evaluation of the insecticidal value of dusts less emphasis be placed on rotenone content and more on total ether extractives. Dusts were prepared from derris containing 5 percent of rotenone and 18 percent of total ether extractives and also from another lot of derris testing 1 percent of rotenone and 18 percent of extractives. Dusts were made from them containing in each case 15 pounds of powdered derris and 85 pounds of clay. The first dust tested 0.75 percent of rotenone and the second only 0.15 percent of rotenone, yet both gave substantially the same satisfactory results when used in the field on several types of insects, including Mexican bean beetles. In both cases the total active ingredients of the dust, of course, were the same, viz.: 2.70 percent ether extractives.

The South Carolina Agricultural Experiment Station (347) in 1935 reported the results of tests of rotenone dusts and sprays on larvae and adults of Mexican bean beetles placed on caged plants after the plants had been sprayed. The derris and cube powders each contained 5 percent of rotenone. Results were as follows:

Material	Average kill of -	
	Larvae	Adults
Dusts:	Percent	Percent
Derris-talc (0.75 percent rotenone)	47.2	51.1
Cube + talc (0.75 percent rotenone)	32.8	41.8
Derris-tobacco (0.75 percent rotenone)	25.6	42.7
Cube-tobacco (0.75 percent rotenone)	24.8	22.2
Derox -----	40.8	47.6
Cubor dust -----	32.0	33.8
Kubatox dust -----	30.4	22.7
Sprays:		
Derris (3.5 lb. per 100 gal.)	18.4	20.5
Cube (3.5 lb. per 100 gal.)	2.4	19.0
Cubor spray (2 lb. per 100 gal.)	4.8	17.3

Turner (377) in 1935 reported that one application of derris dust containing 0.6 percent of rotenone, or pyrethrum dust containing 50 percent of pyrethrum, controlled a light infestation of bean beetles. Three applications of derris dust containing 0.4 percent of rotenone, or pyrethrum dust containing 25 percent of pyrethrum, controlled a moderate infestation of bean beetles and also reduced the injury caused by the bean leafhopper (*Empoasca fabae* (Harr.)). Both of these dusts controlled bean beetles as efficiently as did two sprays of magnesium arsenate at the rate of 3 pounds in 100 gallons of water. Bordeaux mixture (4-4-50) applied to lima beans three times during the season was slightly less effective in controlling bean beetles than copper-lime-calcium arsenate dust applied once and followed by two applications of derris dust containing 0.6 percent of rotenone.

Turner and Friend (379) in 1935 reported results of tests for the control of the Mexican bean beetle in Connecticut. Derris dusts containing 0.4 and 0.6 percent of rotenone, and pyrethrum dust containing 25 percent and 50 percent of pyrethrum flowers, were used in 1934. The 25-percent pyrethrum dust was less effective than the derris dust containing 0.4 percent of rotenone. All these dust applications were very effective in producing a high percentage of uninjured pods. Use of derris and pyrethrum sprays following magnesium arsenate applications invariably caused foliage injury, probably due to the action of soap spreaders on the arsenical residue. Such sprays cannot be used with safety on vines previously sprayed with arsenical compounds. Derris and pyrethrum dusts caused no foliage injury in any test.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (389) in 1935 issued changes and additions in the recommendations for the control of the Mexican bean beetle. The following were recommended as superior to magnesium arsenate:

SPRAYS

Derris (finely ground root), 4-percent-rotenone content, 2 to 2.5 pounds to 50 gallons of water.

Sprays to contain approximately 0.02 and 0.025 percent of rotenone respectively.

When derris contains a higher rotenone content, less of the material may be used to obtain sprays of the rotenone content mentioned above. No spreader or sticker is required.

DUSTS

Finished dust to contain 0.5 to 0.75 percent of rotenone.

Derris (4 percent rotenone content) 12.5 pounds, talc or other diluent 87.5 pounds.

Derris (4 percent rotenone content) 19 pounds, talc or other diluent 81 pounds.

Other diluents that may be used are infusorial earth, kaolin (china clay), dusting gypsum, wheat flour, or tobacco dust. Fine dusting sulfur may be mixed with the infusorial earth or clay to the extent of 25 pounds of the sulfur substituted for a like amount of the earth or clay. Home-prepared dusts may be thoroughly mixed by placing the ingredients in a drum or barrel, not over two-thirds full, and rolling and tilting it for 5 minutes. Commercial dusts may be obtained already mixed. Dusts are usually applied at dosages of 20 to 25 pounds to the acre on bunch beans, but when careful applications are made the dosage may sometimes be reduced.

Walker and Anderson (407) in 1935 wrote that bean growers reported obtaining very satisfactory control of the Mexican bean beetle with a derris dust containing 0.75 percent of rotenone applied at the rate of 15 to 20 pounds per acre and some growers reported getting good control with 10 pounds per acre.

White (412) in 1935 recommended derris sprays (0.02 or 0.025 percent of rotenone) and dusts (0.5 to 0.75 percent of rotenone) for the control of the Mexican bean beetle.

Brannon (35) in 1936 reported that best simultaneous control of the Mexican bean beetle and powdery mildew on snap beans at Norfolk, Va., was obtained by adding 2 pounds of wettable sulfur to derris- or cube-powder suspensions containing about 0.02 percent of rotenone or by diluting derris or cube powder with sulfur to a rotenone content of 0.5 percent.

Brannon (36) in 1936 summarized the results of the field control experiments of 1935 against the Mexican bean beetle on lima beans at Mappsville, Va., as follows: In an experiment conducted on 1/2-acre plots of Fordhook lima beans (using power machinery) in which cryolite spray (3:50), powdered derris-root spray (0.025 percent of rotenone), cryolite-talc dust (60:40), and derris-talc dust (0.22 percent of rotenone) were compared. The results after six treatments showed that cryolite spray (3:50) was equally as effective as powdered derris-root spray (0.025 percent of rotenone), and that cryolite-talc dust (60:40) gave a considerably larger yield increase than did derris-talc dust having a rotenone content of 0.22 percent. In comparing the yield increases at the time of the various pickings of this long-growing crop, there was an indication that powdered derris-root spray failed to afford the residual effect obtained following applications of the cryolite spray. This had not been observed on the relatively short-growing snap-bean crop. The net profit per acre due to treatment was considerably greater from the application of cryolite spray than from the other materials used in the experiment, partly because of the higher yield increase obtained with cryolite but mainly because of the lower cost of that treatment.

Brown (59) in 1936 referred to the use of derris dust (0.6 percent rotenone content) for the control of Mexican bean beetles whenever these insects become troublesome. From 25 to 30 pounds per acre applied once or twice is usually sufficient.

Fenton (127) in 1936 referred to the recommendations of Robinson of Alabama (8) and Thomas of Texas (367) concerning derris dusts and sprays for the control of the Mexican bean beetle.

Howard (190) in 1936 reported tests made at Columbus, Ohio, in 1935 with insecticides against the Mexican bean beetle. Satisfactory control was obtained with suspensions of derris-root powder and cube-root powder in water at dilutions of 0.01, 0.015, 0.02, and 0.25 percent of rotenone. Fairly satisfactory results were obtained with derris sprays containing 0.005 percent of rotenone. The incorporation of various wetting agents, spreaders, and stickers did not improve the efficiency of these spray suspensions. In general, cube proved to be approximately equal in effectiveness to derris when tested at the same dilution of rotenone. Derris- and cube-dust mixtures containing 0.4, 0.5, and 0.75 percent of rotenone with various diluents, all gave satisfactory control. As a result of special tests of various diluents, it was concluded that it was not important to obtain any particular diluent for use with derris or cube dust, provided such diluent is nonalkaline in character. The results indicated that talc-flotation sulfur (50:50), wheat flour, ground [pyrethrum] marc, talc, bentonite, and finely ground dusting sulfur, in the order named, with the last two almost equal in effectiveness, were as good as, or slightly superior to, any of the diluents tested. In general, derris dusts appeared to be slightly superior to cube dusts in effectiveness.

In a limited number of experiments the ground root of devil's-shoestrings (*Tephrosia virginiana* L.) at a dilution of 0.01 percent of rotenone gave approximately equal results to those obtained with derris-root powder sprays containing the same proportion of rotenone. Devil's-shoestrings-root dust mixtures containing 0.39 and 0.4 percent of rotenone, respectively, gave satisfactory control and were approximately equal to derris-dust mixtures of the same rotenone content.

Howard (191) in 1936 reported some rather interesting results from a cooperative experiment with other field laboratories of the Bureau to determine the lasting effects of derris on bean foliage. Bean plantings were made at the following locations throughout the United States: New Haven, Conn., Norfolk, Va., Columbus, Ohio, Baton Rouge, La., Madison, Wis., Manhattan, Kans., Grand Junction, Colo., Twin Falls, Idaho, Ventura, Calif., Corvallis, Oreg., Puyallup, Wash., and Phoenix, Ariz. These plantings were treated with a derris spray and samples of leaves were taken at given intervals and sent to Columbus for analysis. In every case derris was recovered in sufficient quantities at the end of 2 weeks to be detected by the colorimetric and goldfish methods. At Madison, Grand Junction, Twin Falls, Corvallis, and Columbus derris showed a slower loss of toxicity than at other laboratories. Light alone did not seem to account for the decomposition rate, neither did high humidity. At Phoenix, where daily temperatures averaged over 100° F., derris was recovered after 10 days. At Ventura, where no rain fell during the test, all the toxicity had disappeared at the end of 4 weeks. During this test period Ventura had 9 foggy days, being the only laboratory where fog was reported.

Howard, Brannon, and Mason (196) in 1936 recommended derris or cube spray as the best control measure for the Mexican bean beetle. Three pounds of powder (containing 4 percent of rotenone) per 100 gallons gives a rotenone content of about 0.015 percent. The treatment should be started when beetles are found in the field and should be repeated at intervals of 7 to 10 days. Dusts containing 0.5 percent of rotenone may be used at the rate of 20 to 25 pounds per acre per application. Sprays are recommended in preference to dusts for bean beetle control because spraying will give better control and longer protection to the plants. In the case of home-mixed dusts, either talc, dusting sulfur, infusorial earth, kaolin (china clay) or other finely ground inert clay, gypsum, diatomaceous earth, wheat flour, or tobacco dust may be used as a diluent or carrier, but recent experiments have indicated that talc is the most satisfactory. Dusts containing 0.5 or 0.75 percent of rotenone should not be used for making sprays. Begin spraying when the adults are found in the field or when the eggs become numerous on the undersides of the leaves. One to four applications are required, depending on the abundance of the insect.

Derris dust (0.5 to 0.75 percent of rotenone) applied at the rate of 15 to 25 pounds per acre will control the Mexican bean beetle.--Hutson (212) in 1936.

Langford and Crosthwait (256) in 1936 reported experiments on the control of the Mexican bean beetle. The experiments were made under conditions normally encountered in commercial bean production. The spraying was done with a 4-row traction sprayer with angle nozzles, and the dusting was done with a 6-row power take-off, self-mixing bean duster. Two treatments were made with each material, on June 12 and June 26. The plants were checked for bean beetle injury on July 3. The results for sprays were as follows: The plots treated with 2 pounds of magnesium arsenate in 50 gallons of water had 58.5 percent of the plants injured by the beetle, whereas the plot treated with natural cryolite, 2 pounds in 50 gallons of water, had only 19 percent of the plants injured. Two pounds of a 2.5-percent rotenone showed 25 percent injury; barium fluosilicate, 1.25 pounds in 50 gallons of water, had 55 percent of the plants injured. The dusts of rotenone and pyrethrum gave excellent results. The plot dusted with a 60-percent pyrethrum dust (0.054 percent of pyrethrins), applied at the rate of 16 pounds per acre, had 5.6 percent of the plants injured by the beetles. Another plot dusted with a rotenone dust (0.75 percent of rotenone) applied at the rate of 26.5 pounds per acre showed only 4.8 percent of the plants injured by beetles, whereas another plot dusted with a rotenone dust containing 0.5 percent of rotenone applied at the same rate had beetle injury on 22.1 percent of the plants.

The South Carolina Agricultural Experiment Station (348) in 1936 recommended derris or cube for the control of the Mexican bean beetle. Sprays (3.5 pounds of powder containing 5 percent of rotenone per 100 gallons) applied at the rate of 100 to 150 gallons per acre gave slightly superior results to dusts (0.5 or 0.75 percent of rotenone) applied at the rate of 20 to 25 pounds per acre at each dusting.

The United States Department of Agriculture (381) in 1936 referred to the effective use of derris and cube against the Mexican bean beetle.

The Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture (393) in 1936 reported results of various tests with rotenone, derris, and cube. Field experiments with insecticides in Ohio and Virginia, on beans grown for the greenbean market or for canning, have demonstrated that the Mexican bean beetle can be controlled at a minimum cost by applying sprays or dusts containing rotenone derived from derris or cube without danger of incurring harmful residues on the market product. Laboratory studies disclosed that the active ingredients of derris were adsorbed and translocated in treated plants in such a manner as to prevent extensive feeding of bean beetle larvae on foliage that developed on the plants after the insecticides had been applied. This residual effect of rotenone-containing insecticides had been observed previously under field conditions.

Wallis (408) of Grand Junction, Colo., in 1936 reported that the results of field-control experiments performed against Epilachna varivestis in 1936 on beans grown under irrigation revealed that a derris-spray suspension containing 0.015 percent of rotenone is as effective as a derris spray containing 0.02 percent of rotenone. Sprays containing 3 pounds of cryolite to 50 gallons of water, or derris containing 0.015 percent of rotenone, or cube sprays containing 0.02 percent of rotenone, were more efficient than a spray containing 1 pound of zinc arsenite to 50 gallons of water. The latter spray is most commonly used by growers of beans in the Grand Junction district.

Rotenone sprays or dusts after pods have formed were recommended by Bourne and Boyd (33) in 1937.

Brannon (40) in 1937 summarized the results of insecticide tests performed against the Mexican bean beetle in 1936 on Fordhook lima beans at the Norfolk, Va., laboratory. The best control was obtained with dust mixtures of derris-sulfur and cube-sulfur, each containing 0.5 percent of rotenone. Derris-wettable-sulfur and cube-wettable-sulfur sprays (each containing 0.01 percent of rotenone) also gave good control of the insect. The percentage of control with the dust mixtures was slightly superior to that obtained with the sprays.

Brannon (42) in 1937 reported that recent experiments at the Norfolk laboratory, designed to determine the relative effectiveness of derris, derris-sulfur, cube, cube-sulfur, pyrethrum-sulfur, and sulfur alone, applied as dusts or as sprays for the control of the Mexican bean beetle in association with the green clover worm (Plathypena scabra (F.)) infesting snap beans, showed that in instances where this pest occurs in association with a Mexican bean beetle infestation, sulfur should be used as a diluent for derris, or cube for the combined control of the two insects. The derris and cube dust mixtures contained 0.5 percent of rotenone, the derris and cube sprays contained 0.015 percent of rotenone, and the pyrethrum-sulfur dust mixture contained 0.1 percent of total pyrethrins. Wettable sulfur was used as a spray at the rate of 2 pounds to 50 gallons of water.

The Colorado Agricultural Experiment Station (84) in 1937 reported that a dust containing 0.75 percent of rotenone used on the Mexican bean beetle failed to give satisfactory control. A spray of 4 pounds of derris containing 4 percent of rotenone to 100 gallons of water gave control equal to that effected by zinc arsenite and magnesium arsenate or phenothiazine, 4 pounds to 100 gallons of water, under heavy infestation.

15

Fulton and Mason (151) in 1937 reported that when derris is sprayed on bean plants its constituents are adsorbed and translated to new growth. Two varieties of beans (Pinto and Burpee Stringless Greenpod), grown in pots under greenhouse conditions, were treated, before the first trifoliate leaves appeared, with suspension of derris in water, containing 0.025, 0.05, and 0.25 percent of rotenone. Some of the plants were treated by spraying the entire plant with a compressed-air hand sprayer, some by painting only the first pair of true leaves, and some by painting only the stems. As soon after treatment as the first trifoliate leaves had attained a fair size or about the time the second trifoliate leaves were opening, the first trifoliate leaves were removed from the plants and used for tests. Larvae of the Mexican bean beetle confined in open glass cells were allowed to feed on these leaves and the leaf areas consumed were measured. There was very low mortality among the larvae feeding on the new growth from either the treated or the untreated plants. There was, however, a definite reduction in feeding area of new growth on treated plants over that on untreated plants. This reduction in feeding area was observed on the first, second, and third trifoliate leaves.

Chloroform extracts, from the same plants as those used for the feeding tests, were prepared for biological and chemical tests by evaporating to dryness and removing the residue with acetone. An aliquot of the acetone solutions was tested against goldfish (Carassius auratus) in water suspension and 100-percent mortality was observed in every case. No mortality was observed in every case. No mortality was observed in extracts prepared from untreated plants. Where sufficient leaf material was available an aliquot was used for the colorimetric analysis.

The Georgia Agricultural Experiment Station (163) in 1937 reported the value of several nonpoisonous insecticides in controlling this insect when tested in cages. A commercial dust containing 0.75 percent of rotenone in talc and one of Pyroclide, a trade product made from pyrethrum, mixed with nine parts of kaolin, gave 100-percent kill of beetles and complete protection to the bean plants. Egg masses dusted with the rotenone dust hatched but the larvae died before leaving the eggshell. A third commercial material, Florote, containing rotenone and other materials, killed beetles more slowly than the others but protected the plants.

Hamilton (172) in 1937 reported that Mexican bean beetles on beans were controlled by a spray of 4 pounds of derris or cube powder (4 percent of rotenone) and 4 pounds of rosin-residue emulsion per 100 gallons of water. The spray acts as a contact poison and as a repellent. The effective period is 8 days. Eighty percent kill of larvae and 20 percent of repellency on beetles was obtained. Repeated sprayings would give good control.

Howard and Mason (198) in 1937 reported that the Mexican bean beetle can be effectively controlled by derris or cube dust (0.5 percent of rotenone) applied at the rate of 20 to 25 pounds per acre; or a spray containing 0.15 percent of rotenone. It has been found by growers in New Jersey that the use of hoods behind power or traction dusters allows a considerable saving in the amount of dust applied for the control of the Mexican bean beetle. When hoods were used in dusting on the experimental plots of Howard and Mason, one-half the dosage gave as satisfactory results as did a full dosage without the hoods. These hoods may be constructed of light framework, such as barrel hoops and bamboo poles, and may be covered with a cheap grade of muslin and attached behind the duster. They are, of course, not practicable for use on the hand machines.

Experiments performed in 1937 at South Point, Ohio, against Epilachna varivestis by Howard and Mason (199) gave the following results with the various insecticides tested: Phenothiazine at 2 pounds to 50 gallons of water gave good control, but slight plant injury resulted; derris, cube, timbo, and devil's-shoestrings gave good control at a concentration of 0.015 percent of rotenone and usually at concentration of 0.01 percent of rotenone. While the use of a varnish sticker with derris and cube increased the degree of control in one instance, no increase could be noted in two other experiments. The use of sulfur with derris or cube sprays, and its use as a diluent with dust mixtures of these materials, does not consistently result in improved control in Ohio; however, its use farther east usually results in better bean crops.

Hutson (213) in 1937 recommended derris dust (0.6 percent of rotenone) for the control of the Mexican bean beetle.

A derris dust containing 0.75 percent of rotenone killed 97 percent of the larvae and 83 percent of the adults on lima beans. A spray of derris powder (4 percent of rotenone) at the rate of 2 pounds per 100 gallons of water plus about 2 pounds (dry basis) of coconut-oil soap killed 90 percent of the larvae and 94 percent of the adults.--Manschke (272) in 1937.

Derris dust has given satisfactory results on the Mexican bean beetle.--New Jersey Agricultural Experiment Station (297) in 1937.

The New York Agricultural Experiment Station (301) in 1937 made comparative tests of derris, cube, and timbo powder having about the same content in active ingredients in spray and dust mixtures for the control of the Mexican bean beetle. The results showed that all three powders when used at comparable strengths in terms of active ingredients were effective, a slight superiority favoring derris. Spray mixtures containing 2 to 3 pounds of good-grade powdered root in 100 gallons of water with sticker gave satisfactory results. Sprays during the current season were more beneficial to plant growth than were dusts. Of the dust mixtures tested, those containing 0.5 and 0.75 percent of rotenone gave the best results. It is interesting to note that the yield of snap beans from plants effectively sprayed or dusted did not invariably result in marked increases in yield of pods. From such evidence it seemed highly probable that to formulate a rational method of control for the Mexican bean beetle emphasis should be placed more on the making of a few opportune applications and less on the necessity for fulfilling a definite series of applications according to schedule.

The South Carolina Agricultural Experiment Station (349) reported that insecticide tests were continued during 1937 but nothing developed to indicate that changes are desirable in the 1936 recommendations, i.e., 5 percent of rotenone used as a spray at the rate of 3 pounds to 100 gallons of water, or 5 percent of rotenone used as a dust diluted with talc or inert clay at the rate of 15 pounds to 85 pounds of the diluent.

C. L. Smith (339) in 1937 reported that a spray of derris powder (4 percent of rotenone) 2 pounds per 100 gallons of water, plus 2.5 pounds of coconut-oil soap (anhydrous basis) reduced the larval population of the Mexican bean beetle 90 percent and the adult population 94 percent at the end of 24 hours. McCormick's 0.75-percent-rotenone dust caused a larval reduction of 97 percent and an adult reduction of 83 percent.

The United States Department of Agriculture (383) in 1937 released information concerning the work of the Bureau of Entomology and Plant Quarantine. The problem of the practical control of the Mexican bean beetle was advanced by a demonstration that some of the new insecticides containing rotenone are taken up by the bean plant and distributed to the leaves in a way that ensures protection against the beetles for 10 days or longer, cutting down the number of applications needed.

The United States Bureau of Entomology and Plant Quarantine in a picture sheet in June 1937 recommended 3 pounds of finely ground derris or cube (rotenone, 4 percent) to 100 gallons of water as a spray or a dust containing 0.5 percent of rotenone for the control of the Mexican bean beetle. Suitable diluents are talc, clay, sulfur, tobacco, gypsum, or other powders, except lime. Spraying has given better results than dusting. The under sides of the leaves should be thoroughly covered. The first application of insecticide (spray or dust) should be made when the beetles are found in the field or when eggs become numerous on the under sides of the leaves. Repeat every week or 10 days if the insects are numerous.

The Bureau of Entomology and Plant Quarantine (394) in 1937 reported that sprays or dusts of cube or derris control the Mexican bean beetle at a minimum cost.

Ultrawet added to cube dusts (0.75 percent of rotenone) and sprays (3 pounds per 100 gallons of water) did not improve their control of the Mexican bean beetle.--Walker (406) in 1938.

White in 1936 (413) and 1937 (414) recommended derris or cube sprays or dusts for the control of the Mexican bean beetle. The spray should contain about 0.015 percent of rotenone (3 pounds of powder containing 4 percent of rotenone per 100 gallons of water) and the dust 0.5 percent of rotenone. Sprays are recommended in preference to dusts because they give better control and longer protection. No spreader or sticker is necessary with derris or cube in water for use on beans.

Brannon (43,44) in 1938 reported the results of an experiment conducted at Norfolk, Va., against Mexican bean beetles on the spring crop of snap beans, to determine the relative effectiveness of derris, cube, and cryolite dusts and sprays. Based on the degree of foliage injury, derris and cube sprays containing 0.015 percent of rotenone and dust mixtures containing 0.5 percent of rotenone are the most effective materials yet devised for the control of the Mexican bean beetle. Dust mixtures containing combinations of derris, pyrethrum, and sulfur were equally as effective as derris-talc or cube-talc dust mixtures containing the same percentage of rotenone. In December 1938 he reported that tests made at Norfolk demonstrated that dusts or sprays containing derris,

cube, or cryolite are effective against *Epilachna varivestis* on crops of lima beans grown commonly on poles and from which pickings are made throughout a long period. Insecticide applications made to the pole beans on June 14, July 1, and July 14 were apparently reflected throughout the season in increased yields, as compared with comparable untreated plots, pronounced increases in yield being noted on the treated plots at the end of the seventh picking (about September 30). The effect of the insecticide treatments on the first and second pickings of the crop earlier in the season were also strikingly apparent, as judged from the yield records made at that time. It appears that sprays or dust mixtures containing derris, cube, or cryolite, when applied properly, are effective in controlling the Mexican bean beetle on both bush and pole beans.

Lima bean leaves sprayed with dilute solutions of rotenone were unattacked by Mexican bean beetles.--Breakey and Olcott (48) in 1938.

According to Burkholder and Crosby (60) in 1938, the best means of controlling the Mexican bean beetle is to dust with a derris powder containing 0.75 percent of rotenone. Good results can also be obtained by spraying with 5 pounds of a finely ground rotenone-bearing powder (4 percent of rotenone) in 100 gallons of water. This dust or spray may be used in place of an arsenate or cryolite dust or spray before bean pods begin to form. Because of the danger of arsenical residues on harvested beans, the rotenone dust or spray must be used when the bean pods are present. Arsenical or fluorine (cryolite) poisons may be substituted for rotenone only before the small bean pods appear. All the insecticides are more effective when applied to the lower surface of the bean plants where the beetles and their young do most of their feeding, than to other parts of the plants.

Rotenone dust is especially efficient.--Cory (87) in 1938.

Dunlap and Turner (106) in 1938 recommended rotenone dusts and sprays. The dust should contain at least 0.5 percent of rotenone, and be applied at the rate of 25 pounds per acre; the spray, 3 pounds of cube (4 percent of rotenone) in 100 gallons of water.

Fulton and Howard (150) in 1938 reported the results of studies of derris residues on bean leaves. Experiments conducted at 13 laboratories of the Bureau of Entomology and Plant Quarantine from coast to coast indicate that the most important factor concerned in the decrease of rotenone from sprayed bean plants was rainfall, heavy rains causing greater loss, as would be expected. The loss in toxicity was comparatively slight after 31 days where no rainfall occurred (Twin Falls, Idaho), but very rapid at Columbus, Ohio, within 4 days, owing to rainfall. Intense sunlight in the Southwest and the South did not account for so great a loss in toxicity as did rainfall, although it appeared to be a factor.

Fulton and Mason (152) in 1937 noted that in certain field tests with insecticides for the control of the Mexican bean beetle the growth of the bean plants that formed after the application of a suspension of derris or cube in water appeared to receive some protection from infestation.

It was suspected that this protection was due to the adsorption-absorption and translocation of the derris or cube constituents. With this in mind, tests were undertaken to determine whether this phenomenon could be explained. Feeding tests were made with the larvae. Chloroform extracts of leaves were also tested on goldfish. The authors concluded that a definite retarding in the feeding of Mexican bean beetle larvae has been observed on the new growth of bean plants treated with derris powder. First, second, and third trifoliolate leaves, formed after the first pair of true leaves had been treated, were found to be less palatable to bean beetle larvae than similar leaves from untreated plants. Extracts prepared from first, second, and third trifoliolate leaves formed after the application of derris powder to the first pair of true leaves caused 100-percent mortality to goldfish. Extracts prepared from first, second, and third trifoliolate leaves from untreated plants were not toxic. A water extract prepared by macerating new growth of bean plants that had been treated with derris was fatal to goldfish. In one instance, where a large quantity of new-growth material was available, a crystalline substance resembling rotenone was isolated. The material when purified had a melting point of 163.5° C., gave the characteristic color with the Gross-Smith method, and the blue color test of Durham. One mg. of this substance in 650 cc. of water at 26.7° C. killed three goldfish in an average of 77 minutes. These experiments demonstrate that derris constituents are translocated from the outer surfaces of leaves to first, second, and third trifoliolate leaves formed after the application of derris powder in water suspension to the first true leaves and stems of bean plants.

Huckett (206) in 1938 reported tests of cube mixed with each of the following: Sulfur, sulfur and celite, bordeaux mixture, and celite and clay for the control of the Mexican bean beetle. Two samples of cube powder were compared, one analyzing 2 percent of rotenone and 18 percent of total ether extractives and the other 5 percent of rotenone and 12 to 14 percent of total ether extractives. These powders were applied in sulfur spray and dust mixtures at strengths equivalent to 4 pounds of cube powder to 100 gallons of wettable-sulfur spray and 10 pounds of cube powder in 100 pounds of a cube plus celite plus ground-sulfur-dust mixture. Huckett concludes that according to larval population counts and yield of pods, mixtures containing cube powder of 2 percent of rotenone and 18 percent of total ether extractives were as effective at the dosages used as those containing cube powder of 5 percent of rotenone and 12 to 14 percent of total ether extractives. In field tests on lima beans sprayed and dusted with copper-lime mixtures for control of plant diseases it was observed that bordeaux mixture, as applied, possessed considerable merit in that it had notably reduced the amount of feeding by Epilachna varivestis. This effect, it was observed, was slightly enhanced by the addition of cube powder to the mixture at the time of application or by making separate applications of cube-clay dusts following treatment with bordeaux mixture.

The Indiana Division of Agriculture (219) in 1938 published information on the control of the Mexican bean beetle. Derris or cube powder, containing 4 percent of rotenone, should be used in the proportion of 3 pounds of powder to 100 gallons of water. Rotenone dusts are inferior to rotenone sprays.

G. D. Jones (231) in 1938 wrote that derris or cube dusts containing 0.5 percent of rotenone have proved most satisfactory under eastern conditions for the control of the Mexican bean beetle.

The Maine Agricultural Experiment Station (271) in 1938 reported that rotenone dusts, which should be applied at least 10 days prior to the picking of green beans, appear to give good control and are safe to use on beans for market or canning.

The New Jersey State Agriculture Experiment Station (298) in 1938 reported that a spray of derris or cube powder plus rosin-residue emulsion in water was effective against the larvae of the Mexican bean beetle and has some contact and repellent action against the adults. This station stated that, out of over 500 synthetic organic compounds tested during the preceding 3 years, 13 which proved toxic to silkworms were tested on the Mexican bean beetle and 1 of these proved superior to lead arsenate in toxicity and equal to or better than derris.

The New York Agricultural Experiment Station (302) in 1938 reported the results of tests against the Mexican bean beetle, made with bordeaux mixture and rotenone-containing powders as a combination fungicide-insecticide spray for use on fall-grown lima beans. The results indicated that a spray consisting of timbo powder in combination with bordeaux mixture was as effective as one of timbo powder alone.

New York County Agents Training School (300) in 1938 announced the following results of tests for the control of the Mexican bean beetle: "On dry field beans, very good kill with Pyrocid No. 5 dust at 30 pounds per acre. Same is true with 0.75 percent of rotenone. Rotenone spray of 3 pounds of 5 percent of rotenone, with 2 to 3 pounds of skim milk per 100 gallons, is also very good. On lima beans on Long Island the most effective results for the third successive season were obtained where applications of bordeaux mixture and rotenone-bearing powder had been made, whether the materials were applied separately or in combination. Similarly successful results were obtained where Cupro-K was substituted for bordeaux mixture. The fact that there are indications that rotenone-bearing powder can, with certain mild reservations, be combined with bordeaux mixture for spraying purposes without losing thereby its effectiveness greatly simplifies the problem of furnishing a practical formula to the grower that may be used for control of most parasites attacking lima bean foliage and pods.

Howard (306) discussed green bean pests in 1938 as follows:

Our primary recommendations for the control of the Mexican bean beetle are derris and cube dusts and sprays. We do not need quite so strong a derris and cube dust and spray for the control of the Mexican bean beetle as for the other truck-crop insects. A 0.015-percent-rotenone spray or a 0.5-percent-rotenone dust is strong enough, but we do not like to encourage the selling of a 0.5-percent dust because in the garden generally we should probably use a 0.75-percent dust.

Rotenone sprays or dusts were recommended by Parks and Pierstorff (312) in 1938.

Roark (327) in 1938 referred to the work of Howard (190), who found derris dust superior to cube dust, but both derris and cube sprays equally effective against the Mexican bean beetle; also to the South Carolina Agricultural Experiment Station (347), which found derris and cube equally good whether in the form of dusts or sprays; and to the New York Agricultural Experiment Station (301), which found derris better than cube, whether in the form of dusts or sprays.

The South Carolina Agricultural Experiment Station (351) in 1938 reported that the control recommendations as first advocated in 1936 have been very effective in all tests at this station. The recommended treatment is to spray with a mixture consisting of 3.5 pounds of 5-percent rotenone in 100 gallons of water or to dust with a mixture of 15 pounds of 5-percent rotenone and 85 pounds of talc or inert clay.

Todd (374) in 1938 reported that derris-talc dust containing 0.75 percent of rotenone applied to bean foliage did not afford protection against the Mexican bean beetle beyond 7 days of exposure under field (sun) conditions. In the shade derris was effective for 2 weeks or as long as the plants held up. A spray containing 0.018 percent of rotenone was less effective than the dust.

The United States Bureau of Entomology and Plant Quarantine (398) in 1938 gave the results of much work with rotenone products. Field experiments in Ohio and Virginia on beans grown for the green-bean market or for canning showed conclusively that the Mexican bean beetle can be satisfactorily controlled by the use of sprays or dust mixtures containing rotenone derived from derris, cube, timbo, or devil's-shoestrings. In Colorado the results from test on irrigated beans grown for the dry-bean market demonstrated that sprays containing derris and cube gave better results than any other materials tested, and that cryolite sprays gave the next best results.

Wallis (409) in 1938 summarized the results of tests performed with insecticides against the Mexican bean beetle in Colorado in 1937. He reported that sprays containing derris and cube gave better results than any other materials tested, the increase in yield ranging from 10.4 to 48.7 percent over the check plots.

Brannon (46) in 1939 summarized the results of an experiment conducted on Fordhook lima beans at Norfolk, Va., late in the summer and early in the autumn of 1938. Dust mixtures or sprays containing cryolite controlled successfully an infestation of *Epilachna varivestis* in association with *Heliothis obsoleta* (F.). The cryolite-dust mixtures consisted of 60 parts of cryolite to 40 parts of sulfur or of talc, by weight. The cryolite sprays were made up at the rate of 3 pounds of cryolite to 50 gallons of water. Cryolite dusts and sprays increased the yield approximately 70 percent, as compared with the check, whereas plots to which sprays of derris or cube had been applied showed yield increases ranging from 30 to 40 percent. In view of the fact that the Mexican bean beetle infestation in the field where the experiment was staged was not usually severe, the larger yield increases from the use of cryolite

were attributed principally to the superior effectiveness of this material against the corn earworm, since previous experiments have demonstrated that derris and cube are of little value against this pest.

Good control of the Mexican bean beetle can be obtained by using a dust containing from 0.5 to 0.75 percent of rotenone. Good results can also be obtained by spraying with 4 pounds of finely ground rotenone-bearing powder (4 percent of rotenone) in 100 gallons of water to which has been added about 2 pounds of skim-milk powder.--Crosby, Chupp, and Leiby (92) in 1939.

in 1939

C. B. Dibble in a "Bug Flash" [post card] advised Michigan farmers to apply derris or pyrethrum sprays or dusts to control the Mexican bean beetle. Some preference seems to be shown at present for derris dust, and this material should contain from 0.55 to 0.75 percent of rotenone and should be applied at the rate of 25 to 40 pounds per acre of snap beans. To give effective results, the material must be blown under the plants and bounded back onto the under sides of the leaves. One treatment may be sufficient, if timed exactly right, but ordinarily two treatments are required for a season's protection.

A mixture of 15 parts of ground rotenone-bearing root (5 percent of rotenone), 15 parts of lithopone-zinc sulfide pigment, and 70 parts of kaolin or other inert carrier was toxic to bean beetles for a longer time (85 percent longer on bean plants) than ordinary rotenone dust. During these tests there was a normal rainfall.--Falcon (117) in 1939.

M. P. Jones (233) in 1939 recommended derris or cube for the control of the Mexican bean beetle.

Nettles (294) in 1939 recommended derris dust (0.75 percent of rotenone) or spray (3 pounds cube or derris of 4 percent rotenone content per 100 gallons of water) for the control of the Mexican bean beetle in South Carolina.

The New York State Agricultural Experiment Station (303) in 1939 reported that rotenone dusts and sprays apparently are effective and practicable for control of the Mexican bean beetle in the field.

Sherman and Todd (338) in 1939 recommended rotenone dusts (0.5 or preferably 0.75 percent of rotenone) or sprays for the control of the Mexican bean beetle in South Carolina. Tests are recorded with the proprietary rotenone products Cubor dust, Cubor spray, Kubatox, Red Arrow, and Pysol, and with dusts made by mixing cube or derris with talc, tobacco dust, kaolin, sulfur, hydrated lime, and talc plus lampblack.

The United States Bureau of Entomology and Plant Quarantine (399) in 1939 quoted the County Agent of Crawford County, Ind., as reporting that rotenone [derris]-sulfur dust on the Mexican bean beetle gave 100 percent kill in every case.

Epilachna vigintioctomaculata ab. niponica Lew.

Takagi and Ito (363) in 1932 reported that derris is very effective against Epilachna niponica Lew. [E. vigintioctomaculata ab. niponica Lew., according to Muesebeck].

Epilachna vigintioctopunctata (F.)

A potato field near Sindanglaja, Java, attacked by both adults and larvae of different instars, was dusted with laleur plus talc 1:1 by means of a hand duster, at about 9 o'clock on sunny mornings. After the dusting 20 adults and the same number of larvae were gathered from this plot and from a neighboring untreated plot. The dusted beetles showed signs of paralysis after about 1 hour and secreted an abnormal amount of liquid; after 2 hours nearly all were completely paralyzed and only a few still tried to stretch their wings. After 24 hours, 12 were dead and the rest died the following day. Also, the larvae ceased feeding after the dusting; 17 were dead after 24 hours, and the other 3, which at that time still reacted to contact by moving their feet, died the following day. The untreated insects were observed for 4 days, and remained alive during that time.--Van der Vecht (401) in 1936.

Yoshida (418) in 1936 reported that adults in Formosa are killed by pyrethrum with soap as a spray or with ash as a dust, sprays of derris or nicotine being much less effective.

Epilachna sp.

Extracts of seeds of Tephrosia candida and stem bark of Mundulea sericea were effective at 2- and 3-percent concentrations, respectively, in 24 hours against the larvae.--Bhatta and Marayanan (29) in 1938.

Water suspensions and alcoholic extracts of Derris elliptica roots (rotenone nearly 7 percent) grown in Mysore, India, were effective against Epilachna grubs.--Mysore, India, Department of Agriculture (291) in 1938.

Hippodamia convergens Guér., the convergent ladybeetle

De Ong (100) in 1930, in testing the comparative insecticidal value of four species of derris from the Philippine Islands, used this species as one of the test insects.

Haus and Peterson (182) in 1938 tested derris powder (5 percent of rotenone, 14 percent of other extractives) at a concentration of 3 pounds per 100 gallons against the convergent ladybeetle. The authors concluded that of the insecticides tested, phenothiazine and derris proved to be the most toxic to all stages of this acicnelliid. Phenothiazine killed 95 to 100 percent of the adults, eggs, and larvae, and derris killed approximately 70 percent of the adults, 46 percent of the larvae, and 14 percent of the eggs. The egg mortality reported with derris is much greater if the large number of larvae that died a short time after they hatched are included with the number of dead eggs.

Coccinellidae (unidentified spp.), ladybeetles.

McIndoo and Sievers (265) in 1924 reported derris powder used as a fumigant (burned) to be effective against the ladybeetle tested.

Derris powder, 1.5 pounds per 100 imperial gallons of water plus soap, killed the larvae.--Kelsall et al. (244) in 1926.

Killed by a derris-gyosum dust (0.4 percent of rotenone).--Herman and Hockey (185) in 1936.

Butac (62) in 1938, in dusting cotton with a 50:50 mixture (by weight) of derris and gawgaw for the control of the spotted bollworm, noticed that all ladybird beetles were dead within 6 hours of the application.

Garman (159) in 1938 stated that derris and cube have been shown to be destructive to ladybeetles.

Garman and Townsend (160) in 1938 reported that derris powder (4 percent of rotenone) at 4 pounds per 100 gallons of water killed 82 percent of ladybeetles. This observation was made when testing derris for the control of the European red mite in apple orchards in Connecticut.

The New Jersey Agricultural Experiment Station (298) in 1938 reported that derris-root dusts destroyed a large number of ladybeetles, which are natural enemies of the pea aphid.

An anonymous (4) writer in the Palestine Gazette in 1939 stated that 12-spotted ladybeetle adults are easily destroyed by derris dusts. The larvae are not so much affected by it, but if well coated by the derris dust they also perish very soon. A 50:50 mixture of pure barium or sodium fluosilicate and derris dust should effectively protect cucurbits against attacks of the ladybeetle and its larvae, provided the whole mixture contains 0.75 percent of rotenone.

Colydiidae

Bothrideres (?) andrewesi Grouv.

Feeds on derris roots in storage.--Corbett (86) in 1931.

Cryptophagidae

Atomaria linearis Steph.

Resistant to derris.--Anonymous (2) in 1937.

Cucujidae

Ahasverus advena (Waltl.)

Craufurd-Benson (89) of the Cooper Technical Bureau, London, in 1938 described an improved method for testing liquid contact insecticides in the laboratory. This bureau has for some time past been engaged in chemical

and biological studies of insecticidal substances derived from rotenone-containing plants. Rotenone-containing plants, e.g., species of Derris, Lonchocarpus, Tephrosia, and Mudulea, are essentially contact insecticides: therefore the present work has been devoted to evaluating only contact action. An improved immersion method for laboratory testing of contact insecticides is described and the rigid technique necessary is detailed. The effect on the resistance of A. advena to a derris insecticide of varying the time of immersion, the age of the insects, the temperature, and the humidity before, during, and after immersion is illustrated and shows the necessity of controlling all these factors. Results with a standard derris insecticide were given to show the great accuracy that can be obtained by the new method; that the same result with the same insecticide can be repeated from day to day; and that two workers using the same insecticide have obtained identical results.

Laemophloeus turcicus Grouv.

The adult is very susceptible to derris.--Craufurd-Benson (90) in 1938.

Oryzaephilus mercator (Fauv.)

The adult is very susceptible to derris and is a suitable test insect for evaluating derris preparations in the laboratory.--Craufurd-Benson (90) in 1938.

Oryzaephilus surinamensis (L.), the saw-toothed grain beetle

The adult is very susceptible to derris and is a suitable test insect for evaluating derris preparations in the laboratory.--Craufurd-Benson (90) in 1938.

Used by Martin (273) in 1940 in determining the relative toxicities of different species of derris. The insects were reared in a constant-temperature and humidity room (27° C. and 70 percent relative humidity) on sultanas and flaked maize. Spraying trials, using for each concentration a 5-fold replication of 25 insects, were carried out in an apparatus, devised by C. Potter, a description of which will be published later. The apparatus is designed to give a uniform deposit over an area of approximately 70 cm², and is suitable for use with quickly moving insects. Trials were first carried out using the resins suspended in a medium of 0.5 percent of sulfonated loral containing 10 percent of alcohol. The deposit used was of the order of 1.2 mg. per square centimeter. The insects after being sprayed were returned to the constant temperature room and examined 24 hours later. The percentages of badly affected, moribund, and dead insects were taken in assessing the results.

Curculionidae

Amorphoidea lata Motsch.

All adults on cotton plants in one of the plots at the Philippine Carnival Exposition were killed by a derris-gawgaw dust.--Butac (62) in 1938.

Anthrenomus eugenii Jano, the pepper weevil

R. E. Campbell, of the Alhambra, Calif., laboratory, in a typewritten report to the Division of Truck Crop and Garden Insects of the U. S. Bureau of Entomology and Plant Quarantine, in 1934 stated that in cage tests derris dust killed 51 percent of pepper weevils, as compared with 54 percent for cube dust. Both dusts contained 1 percent of rotenone. A derris dust containing 2 percent of rotenone killed 63 percent of the weevils.

Anthrenomus grandis Boh., the boll weevil

Smith, Clark, and Scales of the Tallulah, La., laboratory, in a typewritten report to the Division of Cotton Insect Investigations of the Bureau of Entomology and Plant Quarantine in 1934, compared the effectiveness of derris, cube, and other insecticides against the boll weevil in cage tests. Derris and cube containing 4 percent of rotenone, and derris mixed with clay, sulfur, tobacco dust, and lime to 2-, 1-, and 1/2-percent rotenone content were used. The derris-sulfur mixtures were considerably better than those with the same proportion of lime, but in all cases the mortalities were low with 1- or 1/2-percent rotenone. The results with the undiluted cube and derris as compared with calcium arsenate were as follows:

Insecticide (applied as a dust—		:
"average field dusting" with a small		:
hand dust gun)		:
		Mortality
		Percent
Cube (4% rotenone)		75.0
Derris (4% rotenone)		91.6
Calcium arsenate		81.8
Check		32.8

As shown in the table, cube was not equal to derris of equal rotenone content in killing these insects.

Gaines, Young, and Garrison (153) in 1935 reported field tests made at Tallulah, La. The average yields of cotton treated with derris diluted with sulfur to 0.5 and 1.0 percent of rotenone indicated that these mixtures had little if any value for the control of the boll weevil.

Smith, Clark, and Scales (341) in 1936 reported the results of cage toxicity tests made at Tallulah, La. Derris containing 4 percent of rotenone killed 69 percent of the boll weevils as compared with 60 percent with calcium arsenate; but when diluted with sulfur or kaolin to 2 percent, 1 percent, or 0.4 percent rotenone content, the kill was greatly reduced and was not comparable with that from calcium arsenate. Smith and Scales, in a typewritten report to the Division, reported the following results of cage tests made at Tallulah, La., during 1936:

<u>Treatment</u>	<u>Control</u> <u>Percent</u>
Cube 40 percent, sulfur 60 percent (rotenone 1.96 percent)	45
Cube 20 percent, sulfur 80 percent (rotenone 0.98 percent)	28
Cube 10 percent, sulfur 90 percent (rotenone 0.49 percent)	6
Cube 10 percent, pyrethrum 10 percent sulfur 80 percent (rotenone 0.49 percent)	9
Cube (rotenone 4.9 percent)	80
Derris (rotenone 3.9 percent)	67
Devil's-shoestrings (rotenone 1.7 percent)	26
Calcium arsenate	73

Young and Smith (419) in 1936 reported the results of field-plot and cage tests for boll weevil control. Derris dusts were made by mixing derris powder, containing 4 percent of rotenone, with flour or with kaolin to rotenone contents of 2, 1, and 0.5 percent. In cages the boll weevil mortality observed at Tallulah, La., in 1934 was as follows:

<u>Treatment</u>	<u>Average Mortality</u> <u>Percent</u>
Calcium arsenate	81.8
Derris dust (2 percent rotenone)	72.9
Derris dust (1 percent rotenone)	52.6
Derris dust (0.5 percent rotenone)	42.5
Untreated	32.8

The authors concluded as follows:

Derris-root dust mixtures containing 0.5, 1, and 2 percent of rotenone, based on the square infestation and yield records, gave very little, if any, weevil control. The failure of the plots treated with derris-root dust in two tests to yield as well as the untreated plots indicates that the derris-root dust mixtures, when used at the rate of 4 to 6 pounds per acre, had no value as a means of boll weevil control. The results with derris in cage tests do not agree with the results in field-plot tests. The higher boll weevil kill in the cages was probably due to the fact that the boll weevils were stupefied shortly after the applications of derris-root mixtures were made and would fall to the cage bottoms, where they lay exposed to the sun and were killed before they recovered from the effects of the derris.

The Division of Cotton Insect Investigations, United States Bureau of Entomology and Plant Quarantine, in a memorandum to the chief of the Bureau, dated December 2, 1936, reported the following results of tests made at Tallulah, La., and Port Lavaca, Tex., during 1936:

<u>Treatment</u>	<u>Mortality</u> <u>Percent</u>
Derris 40 percent, sulfur 60 percent (rotenone 1.6 percent)	49.1
Derris 20 percent, sulfur 80 percent (rotenone 0.8 percent)	38.7
Derris 10 percent, sulfur 90 percent (rotenone 0.4 percent)	27.6
Derris (rotenone 4 percent)	72.5
Cube(rotenone 4 percent)	83.4
Devil's-shoestrings (rotenone 1.7 percent)	37.3
Calcium arsenate	77.0
Check	15.7

Smith and Seales (342) in 1937 reported the results of insecticide tests against 3 cotton insects. Tests were planned to compare derris, cube, and devil's-shoestrings containing equal quantities of rotenone, in mixtures with sulfur. The mixtures were prepared, however, before the analyses were received, and the rotenone contents of the mixtures are only approximately equal. Cube containing 4.9 percent of rotenone produced a higher mortality of boll weevil than did derris containing 3.9 percent of rotenone, devil's-shoestrings (1.7 percent of rotenone), or calcium arsenate. The mortality from calcium arsenate, however, was higher than that from derris, devil's-shoestrings, or mixtures of cube, derris, and devil's-shoestrings with sulfur. The results were as follows:

<u>Material</u>	<u>Mortality</u> <u>Percent</u>	<u>Control</u> <u>Percent</u>
Derris-sulfur 40:60 (rotenone 1.56)	49	40
Derris-sulfur 20:80 (rotenone 0.78)	39	27
Derris-sulfur 10:90 (rotenone 0.39)	28	14
Cube-sulfur 40:60 (rotenone 1.96)	53	45
Cube-sulfur 20:80 (rotenone 0.98)	39	28
Cube-sulfur 10:90 (rotenone 0.49)	21	6
Devil's-shoestrings-sulfur 94:6 (rotenone 1.6)	37	25
Devil's-shoestrings-sulfur 47:53 (rotenone 0.8)	38	26
Devil's-shoestrings-sulfur 23.5:76.5 (rotenone 0.4)	31	18
Derris (rotenone 3.9, total extractives 11.6)	72	67
Cube (rotenone 4.9, total extractives 17)	83	80
Devil's-shoestrings (rotenone 1.7, total ex- tractives 7.5)	37	26
Calcium arsenate No. 2	77	73
Checks	16	--

Cube with pyrethrum and sulfur was tried against the boll weevil with the following results:

Material	Mortality	Control
	Percent	Percent
Pyrethrum-cube-sulfur 10:10:80	74	9
Pyrethrum-sulfur 40:60	36	12
Pyrethrum (0.76 percent total pyrethrins)	37	14
Checks	27	--

Anthonomus musculus Say, the cranberry weevil

In 1937 the Massachusetts Agricultural Experiment Station (277) reported that 100 pounds of derris dust (1 percent of rotenone) per acre, applied on June 5, gave a poor kill of the cranberry weevil. A spray of 8 pounds of derris powder (4 percent of rotenone) and 4 pounds of fish-oil soap in 100 gallons of water, used at the rate of 400 gallons per acre, failed to give a good kill. In 1938 this station (278) reported that at the Cranberry Station, East Wareham, Mass., a spray of 15 pounds of derris powder (4 percent of rotenone) and 1/2 pound of Areskap in 100 gallons of water, used at the rate of 400 gallons per acre on August 3, failed to give a good kill of the cranberry weevil.

Anthonomus pomorum (L.), an apple blossom weevil

Tests of derris dust to prevent oviposition were of sufficient promise to justify further trials.--East Malling Research Station (111) in 1934.

Hey, Massee, and Steer (186) in 1934 reported a test made in Kent, England, to control the apple blossom weevil. A proprietary derris dust of somewhat heavy type, containing 0.13 percent of recrystallized rotenone, was tested. When applied at the green-bud stage it halved the injury caused by the apple blossom weevil, but had no appreciable effect if applied a week earlier.

The East Malling Research Station (112) in 1935 reported dusting and spraying tests with derris. Steer and Thomas of this station reported that derris dust (10 parts of derris powder of 3.63 percent crude rotenone plus 90 parts of china clay) reduced the amount of capping by the apple blossom weevil 50 percent. It was concluded that derris dusts, in two consecutive seasons' trials, have given promising results, but to obtain a satisfactory measure of control it would probably be necessary to make several applications and renew the dust deposit whenever it is washed off by rain. A derris dust gave promising results in preventing oviposition but weather conditions impose a limit to the degree of control that can be obtained with it.

A derris dust containing 0.5 percent of rotenone and 1.25 percent of ether extractives prevents the adult insects from laying their eggs in the blossoms.--De Bussy: et al (61) in 1936.

The East Malling Research Station, England (114), in 1936 reported that a proprietary derris powder was used in the routine spraying program in 1935 for the apple blossom weevil on apples.

Two applications of a dust containing 0.75 percent of rotenone killed 50 to 80 percent.--Anonymous (2) in 1937.

Kearns and Marsh (238) in 1937 reported that application of derris dusts at the early green-flower stage do not provide a sufficiently high control of the blossom weevil to warrant the expense. Sack banding applied to the boles of the trees in June at times provides a means of capturing large numbers of weevils. It is desirable that the bands be removed from the trees before the end of October, and the weevils killed by immersing the sacking in derris wash.

This pest on apple trees was mitigated by a product containing 12 percent of powdered Lonchocarpus nicou root (of 6 percent rotenone content) and 88 percent of talcum, according to Etablissements Rotenia in a letter to R. C. Roark in 1938.

Hanf (174) in 1938 reported on the control of the apple blossom weevil. Of many insecticides tested, the pyrethrum-derris preparations were the best. Quassia was useless. Nicotine often acted more quickly than pyrethrum and derris but the insects were only stunned and later revived. The opinion was expressed that an insecticide should be at least 90 percent efficient in laboratory tests to be potentially of commercial value, as in practice not all insects are hit; hence the overall efficiency is reduced. It was recommended (1) that trap bands be applied to the trees in February (2) that the usual preblossom spray with supplements of pyrethrum or pyrethrum-derris be applied just after the first green on the buds, and (3) that in small orchards, bands be applied in June.

Kearns and Martin (239) in 1939 wrote on the use of post-dormant combined sprays on fruit crops in England. Sprays containing 0.004 percent of crystalline rotenone have been found satisfactory against fruit pests and are recommended for apple, plum, and Rubi crops. The addition of derris to the spray does not prevent severe infestations by the apple blossom weevil, although a high kill of weevils on the trees at the time of spraying is obtained. The failure to prevent an appreciable infestation of the blossom is due to the fact that it is only rarely that the greater part of the blossom weevil population congregates on the tree at any one time, and this may not coincide with the time of application of the spray.

Niklas (305) in 1939 reported that rotenone at 0.4 percent concentration as a spray had killed 100 percent of A. pomorum adults after spraying.

Anthonomus pyri Koll.

Etablissements Rotenia in 1938 reported in a letter to R. C. Roark that "Anthonomus cinctus" on cauliflower was killed by a product containing 12 percent of powdered Lonchocarpus nicou root (of 6 percent rotenone content) and 88 percent of talcum, and on pear trees was mitigated by this product. [According to Muesebeck, this species is probably A. cinctus Redt., a synonym of Anthonomus pyri Koller.]

(305)

Niklas/ in 1939 reported that rotenone at 0.4-percent concentration as a spray killed 90 percent of Anthonomus pyri adults after 1 day and 100 percent after 2 days.

Anthonomus rubi (Hbst.), a strawberry blossom weevil

Derris spray was ineffective.--Spoon (352) in 1933.

Jary and Austin (225) in 1937 reported that field trials with derris dust (0.5 percent of rotenone) were continued in Sussex for the control of a strawberry blossom weevil. Two separate plots of strawberries were used, one receiving 3 applications of dust and the other 10 applications, at 2- to 3-day intervals. The amount of dust used was at the rate of approximately 11 pounds per acre for each application. An untreated plot, separated from the remainder by a large hawthorn hedge, was used as a roughly comparable control plot. No reduction in the numbers of attached buds could be detected, all plots showing an average of about 30 percent, and this result corroborates the information obtained in previous years.

Jary (224) in 1937 reported the results of 3 years' tests of insecticides against the strawberry blossom weevil, under insectary conditions in England. Derris dusts containing from 0.2 to 0.5 percent of rotenone and a finely ground pure-derris root having an ether-extract value of about 20 percent gave poor results.

Jancke (232) in 1938 reported that tests with several proprietary insecticidal dusts in May 1937 against Anthonomus rubi on strawberry in a heavily infested field near Speyer showed that the best control (88 percent) was given by a single application of a derris dust, which was more effective than others containing mixtures of pyrethrum and derris, or pyrethrum alone. Dusting should be carried out when the first injured blossoms are observed.

Anthonomus signatus Say, the strawberry weevil

W. A. Thomas (271) in 1936 reported that a strawberry plot treated with a dust containing 0.5 percent of rotenone ranked first in production of marketable fruit. The most satisfactory material for reducing the number of weevil-cut buds was a mixture of 1 part of calcium arsenate and 5 parts of sulfur. These materials were tested for the control of the strawberry weevil at Chadbourn, N. C.

A mixture of calcium arsenate and sulfur was the most satisfactory material for reducing the number of weevil-cut buds on the strawberry plant. Nonarsenical insecticides proved to be less effective, although dust mixtures containing rotenone resulted in the production of larger quantities of marketable fruit than any of the other insecticides tested.-- United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (393), in 1936.

Anderson and Walker (16) in 1937 reported that strawberries on the Eastern Shore of Virginia, infested with the strawberry weevil, were dusted with a mixture of 85 pounds of dusting sulfur plus 15 pounds of derris (5 percent of rotenone) and with other insecticides. Each material was applied at the rate of 40 pounds per acre per application to plats of 4 beds, 5 feet wide by 120 feet long, replicated 4 times. Untreated check plats of similar size were included with each replication. Treatments were made with a Niagara 6-nozzle 1-horse traction duster equipped with a 20-foot burlap trailer covering 1 bed at a time. Records were taken of the relative number of buds cut, by counting 3 representative samples of 100 buds in each plat, making a total of 1200 buds for each treatment. Such counts were made on April 24, April 29, and May 6. Very little injury occurred after May 6. Yield records were taken on May 22 and 25. The results are shown in the following table:

Material	Buds cut ¹	Yield per acre ²	Increase in yield over untreated plats
	Percent	Quarts	Percent
Sulfur-lead arsenate 5:1	15	390	62
Lime-lead arsenate 5:1	14	390	62
Sulfur-derris (0.75 percent rotenone)	14	350	45
Sulfur-calcium arsenate 5:1	7	318	35
Untreated	39	241	--

1 A difference of 6.27 may be considered significant.

2 A difference of 59.9 may be considered significant

Kalsall and Stultz (245) reported in 1937 that derris-gypsum dusts gave results as follows in laboratory tests:

(Rotenone content)	Mortality in 3 days
Percent	Percent
1.0	100
.5	100
.5	90
.2	100
.2	80
.1	90

W. A. Thomas (368) at Chadbourn, N. C., reported in 1937 that two or three applications of a clay dust containing 0.5 percent of rotenone gave a significant degree of control against the strawberry weevil when measured in terms of the numbers of marketable strawberries, but not when measured in terms of reduction in numbers of weevil-cut buds.

A mixture of rotenone [derris] 1 part and sulfur 9 parts, applied as a dust, gave as good control of the strawberry weevil as the standard treatment of lime-calcium arsenate but injury to the plants resulted. The experience seems to be that sulfur treatments may be safe in some reasons but dangerous in others. Pyrethrum proved inferior to the rotenone-sulfur or the lime-calcium arsenate treatments. In general, growers do not make applications frequently enough. Dusts are removed by rains and more frequent applications are needed in rainy seasons. Satisfactory results may be expected only where a good coverage is maintained throughout the danger period.--New York County Agents' Training School (299) in 1938.

Derris (4 percent of rotenone) at 4 pounds per 100 gallons of spray proved somewhat less effective than cryolite spray or 85:15 dusts of sulfur with either lead arsenate or calcium arsenate.--Sterns (355) in 1937.

Amos and Pierpont (11) in 1939 reported the results of dusting experiments for control of the strawberry weevil in Delaware. Ground derris root containing 4 percent of rotenone was added to a mixture of inert clay, 4 parts, and Celite, 1 part, to make dusts containing 0.5, 1.0, or 1.5 percent of rotenone. Results were as follows:

Treatment	Rate per acre	Buds cut	Increase in uninjured buds over untreated check
	<u>Pounds</u>	<u>Percent</u>	<u>Percent</u>
Inert clay + Celite 4:1	25	55	11
Inert clay + Celite 4:1 + 0.5 percent rotenone	28	47	24
Inert clay + Celite 4:1 + 1.0 percent rotenone	25	32	50
Inert clay + Celite 4:1 + 1.5 percent rotenone	30	28	55
Lead arsenate-sulfur 1:5	30	47	24
Untreated check	--	62	--

Haude (181) in 1939 recommended dusting with cube or derris plus sulfur.

Anthonomus vestitus Boh., the Peruvian boll weevil

Wille, Ocampo, Weberbauer, and Schofield (415) of the Agricultural Experiment Station at La Molina, Peru, in 1937 reported that dusts of ground cube root of 5 and 1 percent rotenone contents gave 50 and 15 percent mortality, respectively, of adults of this species in the laboratory.

Anthonomus sp.

The Wageningen Plantenziektenkundige Dienst (402) in 1933 reported a derris powder (2 percent of rotenone) at 1:50 in a 1-percent-soap solution to be ineffective against Anthonomus on strawberries.

(Otiorrhynchus) Brachyrhinus ovatus (L.), the strawberry root weevil

Resistant to derris.--Anonymous (2) in 1937.

Brachyrhinus singularis (L.), a clay-colored weevil

Kearns and Umpleby (241), of the Long Ashton Research Station, England, in 1937 reported that grafts can be effectively protected from weevil injury by liberally painting them with a mixture consisting of 1 pound of derris or ground barbasco root containing not less than 1.5 percent of rotenone, plus 2 pounds of lead arsenate powder (or 4 pounds of paste or 2 quarts of colloidal), plus 4 ounces of size. The derris and arsenate should be mixed with water to a consistency of thick cream and to this mixture the size added (previously soaked in 1 pint warm water). The grafts should be painted just prior to bud burst, and in some seasons a second application may be necessary, as the leaf weevils feed over a long period. These weevils are the clay-colored weevil, "Otiorrhynchus" singularis [Brachyrhinus singularis (L.)], according to Muesebeck] and the leaf-eating weevils Phyllobius pyri and P. oblongus.

Brachyrhinus sulcatus (F.), the black vine weevil

(Otiorrhynchus) Brachyrhinus sulcatus is not affected by derris.--Van der Laan (252) in 1936.

Calendra sp., corn billbugs

Not affected by derris.--Van der Laan (252) in 1936.

Caulophilus latinasus (Say)

The adult is not susceptible to derris.--Craufurd-Benson (90) in 1938.

Centorhynchus assimilis (Payk.), the cabbage seedpod weevil or turnip-seed weevil

The Seale-Hayne Agricultural College, England (334) in 1933 stated that no definitely successful control measures for the turnip-seed weevil attacking seed pods of broccoli are known, but that spraying with sprays containing derris or pyrethrum, such as are used in the control of the raspberry beetle, would probably succeed.

Centorhynchus macula-alba (Hbst.), a poppy weevil

Szelenyi (362) in 1935 reported that of insecticides tested for the control of a poppy weevil in Hungary, the best results were obtained with a derris preparation applied during the flowering period.

Centorhynchus pleurostigma (Marshall), a turnip gall weevil

K. M. Smith (343) in 1925 reported that tests were made with various insecticides for the control of the turnip gall weevil. A mixture of 1 ounce of derris with 2 ounces of soot per square yard did not give results promising enough to justify further trials with it.

Ceutorhynchus sulcicollis (Payk.)

This pest on cauliflower was killed by a product containing 12 percent of powdered Lonchocarpus nicou root (of 6 percent rotenone content and 88 percent of talcum, according to a letter from Etablissements Rotenia, of Antwerp, Belgium, to R. C. Roark in 1938.

Chalcodermus acneus Boh., the cowpea curculio

Arant (19) in 1938 reported tests of insecticides against the cowpea curculio. A suitable method of testing the efficiency of insecticides against the cowpea curculio consisted in confining the insect for 6 to 8 hours in a Petri dish containing a film of the powdered insecticide, then transferring the insect to food, and making regular observations to determine the percentage of kill. Large numbers of the beetles were used and tests of the various insecticides were conducted simultaneously. Derris (4 percent of rotenone), derris with talc, and derris with sulfur were relatively ineffective.

Arant (20) later in 1938 further reported on the control of the cowpea curculio, in Alabama. This is one of the major insect pests in Alabama and other Gulf Coast States. Among the insecticidal dusts tested during 1931-35 were derris plus talc, and derris plus sulfur (each containing 2 percent of rotenone), and Florote, which is defined as follows: A commercial dust, containing rotenone, 5 percent; pyrethrins, 1 percent; nicotine, 1 percent; residual deposit of rotenone, 2.5 percent; and inert materials, 90.5 percent. Later samples contained a lower percentage of active ingredients. The derris dusts and Florote caused very little or no burning but gave negative or very low positive percentages of control. The author's conclusions are as follows:

According to results of field experiments in 1931-35 calcium arsenate is significantly more efficient than any other insecticide tried for controlling the cowpea curculio; sodium fluosilicate is next in efficiency. The percentages of control for the various materials used in the experiments were as follows: Calcium arsenate, 74.53; sodium fluosilicate, 67.11; magnesium arsenate, 61.57; acid lead arsenate, 50.93; barium fluosilicate, 40.06; cryolite, 26.22; pyrethrum, 28.68; Florote, 3.71; derris, -2.97 percent. Both calcium arsenate and acid lead arsenate caused severe burning of foliage.

Florote was applied eight times; the derris mixtures five times each.

A derris-kaolin dust (1 percent of rotenone) was applied seven times in the field during the period June 29 to August 25. The pods were picked four times in the period August 5 to September 27. The degree of insect control in the first picking was 40.5 percent and for four pickings 33.3 percent.--Georgia Experiment Station (154) in 1938.

The South Carolina Agricultural Experiment Station (351) in 1938 reported that laboratory tests were made using lead arsenate, calcium arsenate, magnesium arsenate, and paris green as undiluted dusts for the control of the cowpea curculio. Synthetic cryolite, natural cryolite, and derris were used as sprays in the same series of tests. Magnesium arsenate and calcium arsenate produced 20-percent mortality, lead arsenate 10-percent mortality, and the other materials no mortality. Under laboratory conditions paris green caused severe burning of the foliage. Only one series of tests was made, and the results were not conclusive. Replicated field plots were treated with undiluted lead arsenate, calcium arsenate, and magnesium arsenate, and a 0.75 percent derris-talc mixture was used on one replicated plot. Because of unfavorable weather conditions only one insecticide treatment was given the plots. All the arsenicals caused foliage injury under field conditions while the derris dust treatment resulted in no injury. None of the treatments were entirely satisfactory.

Conotrachelus nenuphar (Hbst.), the plum curculio

Flint (144) in 1929 reported very poor control of the curculio in a southern Illinois apple orchard by the application of a white-oil emulsion plus Derrisol.

Rotenone in oil was ineffective.--Turner (376) in 1932.

Garman (156) in 1934 reported that, in general, nicotine, pyrethrum, and rotenone preparations are ineffective against the adult plum curculio and that standard acid lead arsenate is the most effective of the arsenicals.

Garman (157, 158) reported tests made in 1935 with substitutes for lead arsenate. Ground derris root in combination with bentonite and skim-milk powder gave poorer results than either cryolite or lead arsenate, notwithstanding an additional application in August. Control of the curculio was particularly poor with this combination. No foliage burn was noted in the cryolite-sulfur plot and the trees in the derris-sprayed plot were in particularly good condition at the end of the season. All trees received a pink spray of lead arsenate and flotation sulfur. The condition of the trees is shown in the following table.

Treatment	Without external insect injury	Marked by curculio	Conspicuous spray russet
	Percent	Percent	Percent
Lead arsenate plus flotation sulfur	91.5	0.4	---
Natural cryolite plus flotation sulfur	65.4	9.7	---
Cryolite plus Coposil ↓	48.3	18.8	35.8
Derris spray	32.0	22.4	---
Check (pink spray only)	24.4	23.8	1.3

↓ Fruit russet very severe. Talc substituted for Coposil in July sprays.

Stearns (355) in 1937 tested derris, 4 pounds per 100 gallons, with 1 pound of rosin residue as a sticker, in comparison with lead arsenate and other insecticides for the control of the plum curculio. From the standpoint of insect control alone, lead arsenate was unquestionably the most effective. But if due consideration be given to equally important factors, such as general foliage conditions and the size and finish of the peaches, there was but a slight balance, if any, in its favor. These results are significant in view of the increasing demand and the greater premium paid for fruit of high quality.

Chapman (79) in 1938 reported on control of the plum curculio in New York. This is probably the second most important insect pest of deciduous fruit trees in New York. In a test conducted in 1938, several trees sprayed with powdered cube root, 2 pounds in 100 gallons of water, showed considerable reduction in curculio injury over control trees. Cube apparently inferior to lead arsenate and cryolite, which were also included in this experiment.

Cylas formicarius elegantulus (Summers), the sweetpotato weevil

The Louisiana Agricultural Experiment Station (263) in 1938 reported that derris dust containing 0.75 percent of rotenone was less effective than calcium arsenate or cryolite in controlling the sweetpotato weevil on growing plants in the insectary. When applied directly to the potatoes, derris dust containing 1 or 4 percent of rotenone was equal to calcium arsenate or cryolite in effectiveness.

Diorymerellus laevimargo Champ., an orchid weevil

Hamilton (173) in 1938 reported tests to control the orchid weevil. Derris powder (3 percent of rotenone and 15 percent of total extractives) diluted with clay at 1:1 and also at 1:2 was less effective than dry Pyrocyde (5 percent of pyrethrins) at the same dilutions. Pyrethrum powder (0.9 percent of pyrethrins) was more effective than derris powder (4 percent of rotenone and 16 to 18 percent of total extractives) plus 5 percent of D. H. S. (a pine oil activating agent made by the Hercules Powder Company).

Echinocnemus binunctatus Roelofs

Neaton, 1 pound in from 36 to 40 imperial gallons of water, killed all larvae; all adults were killed by 1 pound in 32 imperial gallons of water.--Institute of Physical and Chemical Research (220) in 1927.

Hylobius abietis (L.)

Thomson and Wichmand (371) in 1933 reported that in laboratory tests against this species derris powder proved to be useless.

Hypera postica (Gyll.), the alfalfa weevil

Hamlin, in typewritten quarterly reports to the Division of Cereal and Forage Insect Investigations of the Bureau, in 1938 reported tests made at Medford, Oreg. by R. W. Burn and R. C. Newton, with insecticides for the control of the alfalfa weevil. Rotenone sprays and dusts had considerable effectiveness against the larvae. In July 1939 he reported comparative

tests of calcium arsenate and derris sprays for the control of third and fourth instars of the alfalfa weevil in Utah. The sprays containing 0.015, 0.0175, or 0.020 percent of rotenone were less effective than calcium arsenate at 2 pounds per acre. It was concluded that a derris spray containing 0.020 percent of rotenone gives satisfactory control.

Hymera punctata (F.), the clover leaf weevil

Rockwood, in a typewritten report to the Division of Cereal and Forage Insect Investigations in 1936, stated that a derris-infusorial-earth dust (1 percent of rotenone) killed weevils that had gathered on fence posts to escape flood waters.

Listroderes obliquus Klug, the vegetable weevil

The Alabama Agricultural Experiment Station (7) in 1938 reported on the toxicity tests with larvae of the vegetable weevil. Sodium fluosilicate killed 50 percent in 19 hours and 71 percent in 23 hours. Cube root killed 57 percent in 23 hours and 71 percent in 36 hours. Other materials tested killed a much smaller percentage of the larvae in the same period of time, except magnesium arsenate, which killed 71 percent in 36 hours. Toxicity tests with adult weevils resulted in the cube root and sulfur mixture (1:7), and sodium fluosilicate, killing 100 percent within 48 hours. All the other materials tested were less effective, cryolite and talc being least toxic.

Harrison (181) in 1937 reported on the efficiency of rotenone compounds against larvae of the vegetable weevil. In field experiments against the turnip aphid on turnips and mustard at the Baton Rouge, La., laboratory of the Division of Truck Crop Insect Investigations of the Bureau it was incidentally shown that dust mixtures containing 1.0 percent of rotenone, with equal parts of finely ground dusting sulfur and tobacco as the diluent, and derris sprays containing approximately 0.02 percent of rotenone, with or without alkylphenylbenzenesulfonic acid (1:1000) as a spreader and wetting agent, were effective in protecting the turnips and mustard from damage by larvae of Listroderes obliquus. The check plots and also the plots that received applications of sprays or dust mixtures containing nicotine sulfate were badly injured by the larvae. The insecticide applications were begun when the plants and the infesting weevil larvae were small. They were repeated at intervals of 14 days, from 4 to 6 treatments being applied. K. L. Cockerham and O. I. Deen, at the Biloxi, Miss., laboratory, found that sprays containing approximately 0.025 percent of rotenone, with or without alkylphenylbenzenesulfonic acid (1:600) as a spreader and wetting agent, were not effective against either quarter-grown or larger vegetable weevil larvae. Judging from these preliminary experiments, rotenone compounds may be effective against the vegetable weevil when applied to plants infested with small larvae.

F. S. Chamberlin (75) in 1936 reported that cube-root powder applied either as a dust or in a spray gave little control of vegetable weevil larvae in tobacco plant beds.

Cockerham and Deen (83) in 1938 reported in laboratory tests that a derris-dust mixture containing 2 percent of rotenone was effective against young larvae, causing 82.22 percent mortality. The 1-percent-rotenone-dust mixture killed 44.44 percent of the small larvae. The dust mixture containing

0.5 percent of rotenone and the derris spray containing 0.025 percent of rotenone in water, with or without a spreader, were not effective against the larvae. Preliminary field experiments in Louisiana indicated that rotenone compounds may be effective against vegetable weevil larvae if applied at frequent intervals to plants infested with small larvae. Against adult vegetable weevils, derris dust containing 1 percent of rotenone killed 6.66 percent and derris dust containing 2 percent of rotenone killed 24.44 percent. China clay was used as the diluent. All mortalities were observed 4 days after treatment.

The Louisiana Agricultural Experiment Station (263) in 1938 called attention to the report of Harrison (180), who found that a dust containing 1 percent of rotenone, with either tobacco dust or sulfur as a carrier, is very satisfactory for controlling the vegetable weevil on turnips, mustard, swiss chard, and other leafy vegetables. Good control was obtained by dusting once every 2 weeks during the growing season.

Pantomorus leucoloma (Boh.), the white-fringed beetle.

English and Graham (115) in 1938 reported that experiments with a number of insecticides for sterilizing soil containing larvae of the white fringed beetle, (Naupactus) Pantomorus leucoloma (Boh.), gave negative results at concentrations which were safe for nursery plants. Potassium cyanide in aqueous solution was the only chemical that showed definite toxicity to the larvae in the soil. This chemical offers promise for sterilizing soil that does not contain plants. Results with hot water, steam, and electrical heating devices were negative. Earth balls (12 inches in diameter) containing larvae were submerged for 15 minutes in various insecticides and were examined 48 hours later with the following results:

Insecticide	Dilution	Kill Percent
Derris extract (pine oil)	20 cc. per gallon of 1:500 $\downarrow$ IN 438	23
Derrisol	8 cc. per gallon of 1:500 $\checkmark$ IN 438	17
Cuba root	19 gm. per gallon of 1:500 $\downarrow$ IN 438	10
Foliasurf	20 cc. per gallon of 1:500 $\downarrow$ IN 438	13
Florida volck (gave the highest kill)	1:8	90
Nursery volck	1:50 + cuba root 1:200	0

$\downarrow$ This is a sulfated alcohol.

Philonedon plagiatus (Schaller) (syn., (Cnecorhinus) Curculio geminatus F.)

Resistant to derris.--Anonymous (2) in 1937.

Phyllobius oblongus (L.), a graft weevil

P. pyri (L.), a graft weevil

See Kearns and Umpleby (241) under Brachyrhinus singularis (L.), pages 94 and 99.

Phyllobius oblongus is resistant to derris, and P. pyri can be controlled by a dust containing 0.75 percent of rotenone.--Anonymous (2) in 1937.

Pissodes strobi (Peck), the white pine weevil

Potts (321, 322) in 1937 and 1938 reported complete control of the white pine weevil in an artificially infested tree by a spray of derris resins, and in August 1938 stated that in several small plots treated with mixtures containing lead arsenate, derris, derris resinate, cryolite, and free nicotine in oil, derris gave the most promising results against this species.

Rhinoncus pericarpus (L.)

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Katsumata and Murai (235) in 1930 reported derris spray with soap to be effective for the control of this weevil attacking hemp in Japan.

Rhynchaenus salicis (L.)

Rotenone-talc dust (0.15 percent of rotenone) killed 30 percent of (Orchestes) Rhynchaenus salicis (L.) 8 days after application in a dusting bell jar.--Trappmann and Nitsche (375) in 1935.

Rhynchites aeneovirens ab. minutus Hbst.

Derris spray was ineffective.--Spoon (352) in 1933.

Rhynchites aequatus (L.), an apple fruit rhynchites, or apple fruit weevil

R. coeruleus (Deg.), an apple twig cutter

The East Malling Research Station (112) in 1935 reported that, although experimental work has not been carried out on the control of the apple fruit rhynchites, it is known that the application of a single derris dust will destroy this insect. It should be applied about 2 weeks after petal fall, or as soon as the damage is detected on the fruitlets.

Massee (280) in 1937 reported that the application of a derris dust seems to be a foolproof remedy against the apple fruit rhynchites, but that it must be applied soon after petal fall, or much of the damage will have been done. Should the infestation be very severe, more than one application may prove necessary.

Jary and Austin (226) in 1938 reported that during 1937 a good deal of fruit marking was caused by the apple fruit weevil, Rhynchites aequatus, and that both in Kent and in Surrey the apple twig cutter, Rhynchites. coeruleus, was serious on young trees. Derris dusts or sprays appear to control both these weevils effectively.

Rhynchites heros Roel.

Neeton, 1 pound in 40 imperial gallons of water, was effective against the adults.--Institute of Physical and Chemical Research (220) in 1927.

Rhynchites pauxillus Germ.

Satisfactorily controlled by derris powder plus soap spray.--De Bussy et al. (61) in 1936.

Rhynchites sp.

Etablissements Rotenia, Antwerp, Belgium, reported in a letter to R. C. Roark that this pest on plum trees was killed by a product containing 12 percent of powdered Lonchocarpus nicou root (6 percent rotenone and 88 percent of talcum).

Sitona lineata (L.)

Unaffected by derris powder plus soap spray.--DeBussy et al. (61): Van der Laan (252) in 1936.

Sitophilus granarius (L.), the granary weevil

(Calendra) Sitophilus granarius (L.) is resistant to derris powder.--Anonymous (2) in 1937.

The adult is susceptible to derris but the effect is very slight. Craufurd-Benson (90) in 1938.

Sitophilus oryza (L.), the rice weevil

Tenhrisia candida seeds and Derris elliptica roots applied as dusts were not effective against (Calendra). Sitophilus oryza (L.).--Bhatta and Narayana (29) in 1938.

The adult is not susceptible to derris.--Craufurd-Benson (90) in 1938.

Sternochus paludatus Casey

Douglass (105) in 1933 reported that Cubor dust and derris containing 3 and 5 percent of rotenone were not effective in killing this weevil.

Sternochetus lapathi (L.), the poplar and willow borer

(Cryptorhynchus) Sternochetus lapathi (L.) is resistant to derris.--Anonymous (2) in 1937.

Tyloclerma fragariae (Riley), the strawberry crown borer

The Arkansas Agricultural Experiment Station (21) in 1936 reported results of experiments with strawberry plants. To get more definite data, strawberry plants were put in battery jars, the bases of the plants surrounded with cotton, and a known number of crown borers put on each plant. The treatments included the same mixtures used in the field experiments, and in addition derris dust (5 percent of rotenone) and calcium arsenate undiluted. Calcium arsenate and derris dust gave 58-percent control, lead arsenate 35 percent, and sodium fluosilicate 7 percent.

Curculionidae (unidentified sp.)

Neeton, 1 pound in 24 imperial gallons of water killed 80 percent of adult arrowhead bud weevils; 1 pound in 32 imperial gallons of water killed 40 percent.--Institute of Physical and Chemical Research (220) in 1927.

Derrisol plus oil (Verdol) was not so effective as lead arsenate against the curculio.--Farrar (118) in 1930.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (398) in 1938 reported that curculio control resulting from the use of a full schedule of derris powder was considerably inferior to that obtained by the use of lead arsenate.

Dermestidae

Anthrenus scrophulariae (L.), the carpet beetle

Back (22) in 1932 stated that when rotenone dissolved in acetone was applied to fabrics in laboratory tests it imparted a real moth resistance. A number of mothproofing solutions now on the market contain rotenone. Back reported using rotenone on carpet beetles with consistently good results, and exhibited samples of treated and untreated cloth to the subcommittee of the House Committee on Appropriations.

Anthrenus verbasci (L.), the varied carpet beetle

Yamada (417) in 1937 reported that clothes treated with rotenone (1 ounce to 25 pounds of cloth weight) were not attacked by larvae of this insect.

Anthrenus vorax Waterh.

Attagenus piceus (Oliv.), the black carpet beetle

Back, Cotton, and Roark (23) in 1930 reported that acetone containing only 0.05 percent of rotenone gave excellent protection to woolen goods thoroughly impregnated with the solution, against these species. Rotenone appears to equal any proprietary mothproofing solution now offered the public in imparting moth resistance to fabrics. This work was referred to by the United States Department of Agriculture, Bureau of Entomology (385) in its annual report for 1930.

Dermestes lardarius L., the larder beetle

The larva is susceptible to derris but the effect is very slight.--Craufurd-Benson (90) in 1938.

Dermestes vulpinus L., the hide beetle

The larva is susceptible to derris but the effect is very slight.--Craufurd-Benson (90) in 1938.

Dermestes sp.

Not affected by derris.--Van der Laan (252) in 1936.

Trogoderma versicolor (Creutz)

The adult is definitely susceptible, but the larva is not susceptible to derris.--Craufurd-Benson (90) in 1938.

Dynastidae

Heteroligus claudius Klug., a yam beetle

In 1929 the Imperial Institute of Great Britain(217) reported the results of tests made by the Entomological Branch of the Department of Agriculture in Nigeria, Africa, with Tephrosia vogelii against yam beetles. Yams were soaked for a day or more in aqueous extractions of the leaves of T. vogelii, and beetles were then put in a cage with the poisoned yam. The beetles readily fed on the yams, however strong the poison extract, without showing any ill effect. Pieces of yam were impregnated with the extract in vacuum, and yam was also coated with a mixture of cassava-starch paste and Tephrosia extract, but all with negative results. The extract was tested on small fish and found to be highly toxic. One of the toxic principles of the plant was extracted with chloroform, and the extract was taken up in a very small quantity of toluene and emulsified with water. This was then sprayed on yams, but the beetles would not touch it.

Elateridae

Limonius octypus (Say)

Morrill and Lacroix (289) in 1938 tested cube-root powder against wireworms, the principal species of which is Limonius agonus (Say), now known as octypus (Say). It was applied to the water used in connection with transplanting tobacco, but was ineffective as a repellent. Dichloroethyl ether gave the most promising results.

Phelates canus Lec.

Campbell (86) in 1932 reported work done by Lehman, who tested a wireworm bait containing 10 gm. of ground whole wheat, 1 gm. of rotenone, and 6 gm of water at Walla, Walla, Wash. The ball of bait was placed in a salve tin containing 16-mesh soil, and 25 wireworms that had starved for 2 months were placed in the tin. Five such tins were set up and the larvae were examined after 2 weeks. Since the greatest mortality was only 24 percent, the results were not considered promising.

Elateridae (unidentified sp.)

The ground containing many larvae was soaked with a suspension of derris powder containing 7 percent of rotenone and 17 percent of ether extract, the rotenone concentration in the suspension being 1:6,000, 200 liters being used for a surface of 6 square meters. The larvae appeared to be insensitive to derris powder applied in this manner.--De Bussy et al. (61) in 1936.

C. A. Thomas (366) in May 1940 reviewed work done to control wireworms. Reference was made to the reports of Lacroix (253) and of Morrill and Lacroix (289).

Galerucidae

Agelastica alni (L.), an alder beetle

Jancke (222) in 1934 reported the results of tests with derris and other insecticides against the alder beetle in Germany. An acetone extract of derris, at concentrations of 0.1, 0.2, 0.4, and 1.0 percent, and powdered derris root applied as a dust killed all third instars and also the adult beetles.

Trappmann and Nitsche (375) in 1935 tested a rotenone-talc dust (0.15 percent of rotenone) and a spray containing 0.15 percent of rotenone with Turkey red oil on larvae of the alder beetle under laboratory conditions. In all cases the dosage was regulated to give a deposit of 0.18 mg. of rotenone per 500 cm. ². The dust caused 80-percent mortality in 8 days; the spray, 95 percent.

Excellent control of this insect was obtained with derris dust. Field tests were made with gypsum (specific gravity 1.25), talc (specific gravity 1.1), and kieselguhr (specific gravity 0.6) as carriers for derris. The mixtures contained 0.5 percent of rotenone and 1.2 percent of ether extractives. Talc proved to be the best carrier.--De Bussy et al. (61) in 1936.

The destruction of the alder beetle by derris in the Netherlands was general practice in 1936.--Koloniaal Instituut of Amsterdam (12, 13) in 1936.

One of the principal uses of derris in the Netherlands is for the control of this beetle.--Van der Laan (252) in 1936.

Controlled by a dust containing 0.5 percent of rotenone.--Anonymous (2) in 1937.

This is one of the principal insects combated with derris preparations in the Netherlands.--Koloniaal Instituut (14) in 1938.

Lyctidae

Minthea rugicollis (Walk.)

Feeds on derris roots in storage.--Corbett (86) in 1931; Federated Malay States Department of Agriculture (124) and Miller (285) in 1934.

Meloidae

Epicauta gorhami Mars.

Katsumata (234) in 1938 reported that this meloid, which attacks various crops in Japan, is fairly resistant to derris insecticides.

Epicauta marginata (F.), the margined blister beetle

Dietz and Zeisert (103) in 1934 reported laboratory tests of insecticides against the margined blister beetle and the black blister beetle. The insects, confined in small screen cages, were immersed in 1.5-percent concentrations of the plant extracts which had each been dispersed in a 0.4 percent of coconut-potash soap (containing 40 percent of soap on a dry-weight basis). After such immersion and when all excess liquid had drained from the thoroughly wetted insects, they were confined as before with fresh goldenrod flowers in jelly tumblers. As long as the insects were wet they remained immobile, but movement and recovery began as soon as they dried. The total mortality based on records taken at the end of 48 hours was as follows:

Material	Active ingredient	Beetles dead Percent
Pyrethrum extract	pyrethrins, 2.15 percent	75
Derris	plant resins, 4.5 percent	0
Nicotine (50 percent free base)		80

These tests did not warrant further tests with more dilute application of these materials.

Brannon (39) in 1936 reported that the margined blister beetle on young Fordhook lima beans, grown on the Eastern Shore of Virginia, was not controlled with derris dust (0.75 percent of rotenone) or a calcium arsenate-sulfur-lime dust, but was controlled by the application of undiluted barium fluosilicate dust at the rate of 10 to 12 pounds per acre.

Epicauta pennsylvanica (Deg.), the black blister beetle

See Dietz and Zeisert (103) under E. marginata (F.), on page 105.

Haude (181) in 1939 recommended dusting with cube or derris (0.5 percent of rotenone) for the control of the black blister beetle.

Smith and Sullivan (340) in 1940 reported that, in field tests on china asters, sprays containing pyrethrum extracts (pyrethrins 1:10,000 and 1:22,000) killed 68.8 and 42.6 percent of the black blister beetle, as compared with complete mortalities of cucumber beetles, the tarnished plant bug, and the garden flea hopper, on the plants at the same time. Derris powder and derris extract (rotenone 1:18,000) when added to sprays containing pyrethrins 1:10,000 did not increase the mortality, but when added to sprays containing pyrethrins 1:5,000 a higher kill was obtained. The most effective spray was one containing pyrethrum extract (pyrethrins 1:5000) and derris powder (rotenone 1:4,000), which killed 91.6 percent of the beetles. The derris powder used alone killed 11.1 percent of the beetles. A spreader containing alkyl-phenylbenzenesulfonic acid was added at the rate of 2 gm. per gallon.

Lytta stygica (Lec.), a blister beetle

An application of 1-percent-rotenone dust caused the infernal blister beetle (L. stygica) to disappear. No dead ones could be found; however, following the dust application the beetles became very excited and immediately took flight for short distances.--L.G. Smith (344) in 1939.

Meloidae (unidentified sp.)

The Idaho Agricultural Experiment Station (216) in 1939 reported that preliminary observations indicated a possible effectiveness of rotenone dust against blister beetles.

McDaniel, as reported by O'Brien (308) in 1940, stated that blister beetles can be stopped with rotenone dust.

Nitidulidae

Carpophilus dimidiatus (F.)

The larva is not susceptible to derris.--Craufurd-Benson (90) in 1938.

Meligethes aeneus (F.)

Unusually sensitive to derris dust containing 0.5 percent of rotenone and 1.2 percent of ether extract. Rotenone spray 1:3,000 plus Agral also gives satisfactory results.--De Bussy et al. (61) in 1936.

Sensitive to derris.--Van der Laan (252) in 1936.

Two applications of dust containing 0.75 percent of rotenone were effective.--Anonymous (2) in 1937.

Ptinidae

Gibbium psylloides (Czemp.)

The adult is definitely susceptible to derris.--Craufurd-Benson (90) in 1938.

Niptus hololeucus (Feld.), the golden spider beetle

Not affected by derris.--Van der Laan (252) in 1936.

Ptinus fur (L.), the white-marked spider beetle

Feeds on derris roots in storage according to a letter dated December 14, 1937, from C. E. W. Muesebeck to G. A. Thompson, Jr., Kingston, R. I.

Ptinus tectus Boield., a spider beetle

The adult is susceptible to derris but the effect is very slight. Craufurd-Benson (90) in 1938.

Scarabaeidae

Anomala orientalis Waterh., the oriental beetle

Haude (181) in 1939 recommended spraying with cube or derris powder (4 percent of rotenone), 4 pounds per 100 gallons of water plus 3 to 5 pounds of wetter and sticker, e.g., rosin-residue emulsion. This acts as a repellent.

Apogonia cribricollis Burm.

Adults of this beetle were used by the Federated Malay States Department of Agriculture (125) in 1934 in testing the insecticidal value of Derris elliptica and D. malaccensis. Adults were dusted with a powder made by precipitating an aqueous extract of derris root (Derris malaccensis var. sarawakensis). The same preparation mixed with an equal weight of tapioca flour was also tested. Neither caused any mortality. Miller (286) in 1935.

Autoserica castanea (Arrow), the Asiatic garden beetle

Hamilton (172) in 1937 reported that Asiatic garden beetles on various flowers were fairly well controlled by a spray of 4 pounds of derris or cube powder (4 percent of rotenone) and 4 pounds of rosin-residue emulsion per 100 gallons of water. The spray acts as a repellent. The effective period was 4 to 5 days. Control is not so good as for Japanese beetle.

The New Jersey State Agricultural Experiment Station (298) in 1938 reported that Asiatic garden beetles were repelled for 4 to 8 days or more by the application of a spray of derris or cube powder plus rosin-residue emulsion in water.

Autoserica sp.

Adults of this beetle were used by the Federated Malay States Department of Agriculture (125) in 1934 in testing the insecticidal value of Derris elliptica and D. malaccensis.

Adult beetles were dusted with a powder made by precipitating an aqueous extract of derris root (Derris malaccensis var. sarawakensis). Only 20 percent were killed. The same preparation mixed with an equal weight of tapioca flour killed 15 percent. Miller (286) in 1935.

Cetonia aurata (L.)

This pest on roses was mitigated by a product containing 12 percent of powdered Lonchocarpus nicou root (of 6 percent rotenone content) and 88 percent of talcum, according to a letter from Etablissements Rotenis, Antwerp, Belgium, to R. C. Roark in 1938.

Macroductylus subspinosus (F.), the rose chafer

According to a schedule of treatments by Cory (87) in 1938 issued for the control of rose pests in Maryland, rotenone dust was recommended for use against rose bugs.

The New Jersey State Agricultural Experiment Station (295) in 1938 reported that rose chafers were repelled for 4 to 8 days or more by the application of a spray of derris or cube powder plus rosin-residue emulsion in water.

Parke and Pierstorff (312) in 1938 recommended rotenone spray (4 pounds of derris of 4 percent rotenone content per 100 gallons of water) for the control of the rose chafer.

Maladera holosericea (Scop.)

Neumann (295) in 1937 reported that in attempts to control this beetle derris dusts gave no results.

Melolontha sp.

A rotenone spray applied at the rate of 0.18 mg. of rotenone per 500 cm. ²killed none of the larvae of this beetle within 8 days.--Trappmann and Nitsche (375) in 1935.

Oryctes nasicornis (L.)

A rotenone spray applied at the rate of 0.18 mg. of rotenone per 500 cm. ²killed none of the larvae of these insects within 8 days.--Trappmann and Nitsche (375) in 1935.

Phyllopertha horticola (L.), a cockchafer

Derris dust and lead arsenate spray were ineffective against the cockchafer.--East Malling Research Station (112) in 1935.

Phyllophaga hirticula Knoch

The Madison, Wis., laboratory of the Division of Cereal and Forage Insect Investigations of the Bureau of Entomology and Plant Quarantine in a quarterly report in 1937, reported tests made by Fluke, Seaton, and Chamberlin with insecticides against this species. Derris and other materials were tried but lead arsenate spray appeared best. June beetles were confined in large tin cans, 25 beetles in each, containing sifted soil, a vial of water, and treated bur-oak foliage, and all tests were run in duplicate. Checks were carried for each series of tests.

Phyllophaga (Phytalus) sp.

De Sornay in 1931 (345) suggested that derris be tried against the scarabaeid Phytalus.

Phyllophaga spp.

Hamilton (172) in 1937 reported that June bugs, (Lachnosterna). Phyllophaga spp, on oak were fairly well controlled by a spray of 4 pounds of derris or cube powder (4 percent of rotenone) and 4 pounds of rosin-residue emulsion per 100 gallons of water. The spray acted as a repellent. The effective period was 6 days, and feeding was checked for 6 or 7 days.

K. Ishigai in 1937 stated in a letter to C. C. Concannon of the Bureau of Foreign and Domestic Commerce that May beetles attacking the leaves of growing derris were driven away by spraying with ground fresh derris roots plus soap.

The New Jersey State Agricultural Experiment Station (298) in 1938 reported that June bugs were repelled from feeding for 4 to 8 days or more by the application of a spray of derris or cube powder plus rosin-residue emulsion in water.

Popillia japonica Newm., the Japanese beetle

The United States Department of Agriculture, Bureau of Entomology (384) in 1929 stated that in tests against the Japanese beetle derris was most effective when extracted with coal-tar naphtha or ethyl alcohol. Extracts of pyrethrum and of derris were about equally effective.

Davidson (97) in 1930 reported the following results with suspensions of rotenone in water against adults on smartweed foliage in screen cages:

<u>Concentration</u>	<u>Mortality</u>
<u>Grams: cc.</u>	<u>Percent</u>
1:1,000	100
1:5,000	97.3
1:7,500	88.8
1:10,000	85.8
1:15,000	86.1
1:20,000	60.9

Richmond (325) in 1931 reported on the relative attractiveness or repellency of certain materials to the Japanese beetle. A 5-percent solution of Derrisine was mildly repellent to the Japanese beetle in field tests in New Jersey in 1925 and 1926. A footnote at the end of the paper states:

Since this paper was prepared, all the materials listed as mild repellents and as repellents have been retested, and it is believed that none can be considered as practical repellents for the Japanese beetle.

Metzger and Grant (283) in 1932 reported tests of 474 extracts representing 390 plant species taken from 326 genera and 108 families, as repellents to the Japanese beetle. Benzene, 95-percent alcohol, and 47.5-percent-alcohol extracts of the dry roots of derris (stated to be *Derris malaccensis* Benth.), applied at dilutions of 1:25, 1:35, 1:50, and 1:100 (ratios of dry plant material to spray fluid in kg.: liters) were ineffective in repelling these beetles. The process of the United States Pharmacopoeia (10th ed.) for preparing fluid extracts was followed in making extracts of these plants. Commercial derris and pyrethrum powders used at the rate of 6 pounds to 100 gallons of water were more repellent than were 11 of the more promising plant extracts. An extract of the whole plant of *Tephrosia virginiana* L. in flower in 47.5-percent alcohol at a dilution of 1:25 was ineffective.

Gnädinger (165) in 1933 referred to unpublished work by Ginsburg which indicates that the pyrethrins are more toxic than rotenone to the Japanese beetle.

The toxicity of rotenone and derris as contact insecticides to the Japanese beetle is increased by the addition of soaps.—United States Department of Agriculture, Bureau of Entomology (386) in 1933.

Fleming and Baker (135) in 1934 reported the effectiveness of stomach-poison insecticides on the Japanese beetle. Dihydrorotenone, rotenone, and derris (4 percent of rotenone) were sprayed or dusted on the foliage of potted smartweed, Polygonum pennsylvanicum, and after standing 24 hours the plants were placed in glass cages with Japanese beetles. The cages were kept at 85° to 90° F., with a relative humidity of 90 to 95 percent, under artificial yellow light of an intensity of 85 candleimeters. Lead arsenate at 8 pounds per 100 gallons was taken as the standard of comparison (coefficient of effectiveness 1.000), the mortality being figured at the end of 48 hours. Results obtained with dihydrorotenone, rotenone, and derris were as follows:

Material	Concentration :	
	: of material : lb./100 gal.	: Coefficient of : effectiveness
Pure powdered dihydrorotenone		
plus fish oil (4:1)	2	0.148
Do.	4	.384
Do.	6	.421
Do.	dust	.981
Pure powdered rotenone	dust	.772
Derris (4 percent rotenone)	20	.517
Do.	40	.680
Do.	60	1.410
Do.	80	1.275

When dihydrorotenone was dissolved in acetone at the rate of 2 gm. to 100 cc. and added to water, it was found that a concentration equivalent to 6 pounds to 100 gallons of water was the maximum that could be kept in suspension, and it was less than half as effective as the standard. The beetles were largely repelled from foliage sprayed with derris powder mixed with water in concentrations ranging from 20 to 80 pounds to 100 gallons. From the coefficients of effectiveness it appears that about 50 pounds of derris powder should be equivalent to 8 pounds of lead arsenate as a stomach poison against the Japanese beetle.

Later in 1934 these authors, in a typewritten report to the Chief of the Bureau of Entomology and Plant Quarantine, stated that under artificial conditions of heavy infestation complete protection was afforded to the fruit and foliage of Yellow Transparent apples by the application of sprays containing derris or rotenone. Lime sprays did not protect the fruit from attack, although the feeding on foliage was somewhat reduced. Beetles fed to only a limited extent on fruit sprayed with acid lead arsenate.

Hellebore and pyrethrum have no value as stomach poisons or as repellents against the Japanese beetle. Derris is a weak stomach poison but a definite repellent. The repellent action of derris appears to be due to the rotenone and the deguelin. The toxicarol, tephrosin, and resinous residue appear to be of no value as repellents. Deguelin was found to be equal to neutral potassium-oleate soap as a contact insecticide, and rotenone was 2.3 times as effective. Derris was only about one-third as effective when used alone; but, when 0.125 percent of potassium-coconut-oil soap, an amount below that effective against the beetle, was added, derris became 1.765 times more effective than the potassium-oleate soap in killing beetles.

Exposure to ultra-violet light definitely decreased the effectiveness of derris, rotenone, and deguelin as repellents. Phenothiazine had a narcotic effect on the beetle but when added to derris decreased the effectiveness of derris as a repellent. The addition of fish oil or tannic acid to a derris suspension did not modify the repellent action of the material. Sodium-silicate solutions appeared to decompose derris. Derris can be readily washed from foliage. The action of rain in the field is believed to be one of the most important, if not the most important, factor limiting the effectiveness of derris sprays. Several materials were tested as stickers-for derris, the most promising being a paraffin emulsion.

Miscellaneous tests with extracts of petunia, carrot, devil's-shoestrings, and bitterwood showed that these materials were of little value as repellents against this insect. Cube resin, n-methyl phenothiazine, 2-phenyl benzothiazole, and picrasmin A and B also proved unsatisfactory as stomach poisons and as repellents.

Fleming, Baker, and Koblitsky (139, 140) in 1934 reported that chemically pure rotenone, 90 percent rotenone, and derris containing 4 percent of rotenone were ineffective as stomach poisons to third instars of the Japanese beetle when added to soil at rates ranging from 500 to 5,000 pounds per acre.

Osburn (311) in 1934 reported trials of repellents against the Japanese beetle. During the season of 1932 it was found that the application of five sprays, each consisting of 1 pound of 90-percent rotenone to 500 gallons of water, appreciably reduced the number of Japanese beetles on peach and apple trees; less concentrated sprays were less effective. In 1933 the following sprays, containing 100 gallons of water, 0.1 pound and 0.2 pound of rotenone plus 0.4 gallon of summer oil, 2.5 pounds and 5 pounds of derris root (4 percent of rotenone), and 2.5 pounds and 5 pounds of derris root (4 percent of rotenone) plus 0.4 gallon of summer oil, were applied to the following varieties of fruit trees: Apple--Henry Clay, Star, Wealthy, Stayman Winesap, Yellow Transparent, and Williams Early Red; Peach--Hale and Elberta. The sprays were applied at weekly intervals, except that additional sprays were applied immediately after heavy rains, not more than six applications being made. The results may be summarized as follows: Derris was more repellent to the Japanese beetle than rotenone, rotenone with oil was more repellent than rotenone alone, derris alone was better than rotenone and oil, while derris and oil gave the best results. That is, derris and oil > derris > rotenone and oil > rotenone. The check trees were defoliated rapidly.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (390) in 1935 reported various tests with derris. Derris is a weak stomach poison but has a definite repellency for the adult Japanese beetle, the repellent action apparently being due to the rotenone and deguelin content. Exposure to light decreased the effectiveness of derris, and the material was readily washed from foliage by rain. Several materials have been tested as sticker and as means to prevent the decomposition of derris in the field. Oils, while very effective stickers, have been found to accelerate the decomposition of derris when spread in a thin layer on the surface of the leaf. The emulsified residue from rosin stills has been found to be the cheapest and most effective sticker that does not accelerate the decomposition. The addition of magnesium silicate to the spray increased the period that the material is effective as a repellent. Derris without a sticker appeared to be of little value in the protection of early ripening apples from attack by the beetle.

Derris with the sticker has given promising results. The derris spray has a disadvantage in that it is necessary to repeat the application every week to maintain good control.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, Japanese Beetle Laboratory (391), found that samples of Tephrosia virginiana were not effective as stomach poisons or repellents for the Japanese beetle. Hydrated lime was mixed with derris as a spray without destroying the repellent value of the material. Exposure of rotenone to sunlight for 2 days definitely decreased the effectiveness as a repellent and stomach poison. Several different oils, waxes, resins, asphalt, latex, agar-agar, flour, and other materials were tested to determine the effectiveness of these materials as stickers for derris. It was found that rosin residue, the residual material left in the still during the manufacture of rosin, when emulsified with ammonium caseinate, was a satisfactory and inexpensive sticker for derris, as tested in the experimental orchards. More recent experiments indicated that replacing the ammonium caseinate with gum arabic produced a better sticker for derris.

A large number of materials have been added to derris in various ways to overcome the decomposition of the material in sunlight. Some mixtures were made by adding derris to emulsions or dispersions of the material in water; other mixtures were made by coating the derris with the material. In the latter case the coating material was dissolved in a suitable solvent, the finely divided derris added, and then the solvent removed by evaporation. It appears that, in general, better protection is obtained by the latter procedure. Among the materials which have been added to derris in different ways are lamp black, white, black, and green pyroxylin, different grades of wood rosin, rosin residues of different types, asphalt, coal tar, pine tar, pine pitch, paraffin, beeswax, spermaceti, carnauba wax, gilsonite, sulfur, lime-sulfur, bentonite, titanium oxide, magnesium silicate, calcium carbonate, aluminum sulfate, montan wax, pine oil, blown sardine oil, blown castor oil, glue and formaldehyde, bone glue, boiled linseed oil, halowax, apple wax, raw menhaden oil, and casein. The oils, in general, were found to be good stickers for derris, but accelerated the decomposition of the derris. Magnesium silicate gave indications under laboratory test of retarding the decomposition, but under field conditions it appeared to have no effect on the decomposition. Laboratory tests indicate that rosin is a good protective agent for derris. When derris was coated with rosin, the decomposition was greatly retarded. Physical mixtures of derris and rosin were not satisfactory.

A study was made of the relation between temperature and light on the decomposition of derris. Derris deposits, in the absence of light, were not appreciably decomposed at temperatures ranging from 37° to 70° F. Derris exposed to direct sunlight in the winter with low temperatures decomposed less rapidly than when exposed to sunlight in a greenhouse at a temperature of 70° F. The results indicate that temperature and light are important factors influencing the decomposition of derris.

Three applications of derris and rosin-residue emulsion gave almost complete protection to early ripening peaches, while no fruit was harvested from unsprayed trees. The effectiveness of the derris as a repellent spray disappeared in 9 to 12 days, even in the absence of rain, making it necessary to repeat the applications at about weekly intervals. The addition of magnesium silicate to the derris spray appeared to have no effect in retarding the oxidation of derris. As this spray leaves no objectionable residue on the fruit, the trees can be sprayed up to a few days before harvest. Derris and rotenone were found

unsatisfactory as stomach poisons for third instars of the Japanese beetle when mixed with soil at concentrations ranging from 250 to 2,000 pounds per acre.

Fleming and Baker (136) in 1936 reported as follows on the use of derris and its components as repellents for the Japanese beetle:

A study was made of derris and its components under artificially controlled conditions to obtain further information on the value of these materials for the control of the Japanese beetle. Rotenone was found to be 2.3 times as effective as neutral potassium oleate as a contact insecticide, deguelin was equally as effective as the soap, and derris was 0.387 times as effective. When an equal weight of castor oil was added to the derris, the coefficient of effectiveness was increased to 0.556. When added to a 0.125-percent solution of coconut-oil soap, which alone did not kill beetles, the effectiveness of derris was increased to 1.765 times that of potassium oleate. These data indicate that if a small quantity of soap is added to the derris spray in the field the effectiveness of the material as a contact insecticide may be greatly increased.

Derris and its components, with the possible exception of rotenone, were found to be of little value as stomach-poison insecticides against this insect. Rotenone when used at the rate of 4 pounds to 100 gallons was 53.4 percent as effective as acid lead arsenate used at the rate of 8 pounds to 100 gallons of water. Beetles fed only slightly on derris when used at the rate of 2 pounds to 100 gallons. It is apparent that the repellent action of derris can be attributed to its rotenone and deguelin content. Toxicarol, tephrosin, and the derris resin from which all crystalline substances had been removed had little deterrent effect on the insect.

Under artificial conditions of heavy infestation, where the beetles were stimulated to feed and had no choice between sprayed and unsprayed foliage, derris and rotenone afforded complete protection to the fruit and foliage of Yellow Transparent apples, being superior to acid lead arsenate and the lime sprays, which have given satisfactory results under favorable field conditions. Exposure to ultraviolet light definitely reduced the value of rotenone as a stomach poison against the Japanese beetle. It was not possible to detect the change in effectiveness of derris because of the low toxic value of the material. The value of derris and rotenone as repellents was only slightly reduced by exposure to ultraviolet light for 24 hours, indicating that the repellent effect is not destroyed so rapidly as the toxicity. Fish-oil and tannic acid did not modify the effectiveness of derris as a stomach-poison insecticide or as a repellent. Sodium silicate decomposed the derris and destroyed its value as a repellent.

Derris is readily washed from foliage by water. It is believed that this mechanical loss by the action of rain, and possibly dew, is one of the most important factors limiting the effectiveness of derris sprays for control of the Japanese beetle. Several stickers were tested, but none of them proved satisfactory.

The stickers tried included light-pressed fish oil; bone glue; bone glue and triethanolamine; rosin and castor oil; a mixture of castor oil, oleic acid, bone glue, and triethanolamine; a mixture of paraffin, oleic acid, and triethanolamine; and tannic acid. Materials mixed with derris and tested as a stomach-poison insecticide and also as a repellent included light-pressed fish oil, molasses, phenothiazine, sodium silicate, and tannic acid.

In 1936 Fleming and Baker (137) reported the results of tests of sprays for the protection of early ripening tree fruits from Japanese beetle attack. These studies were conducted in the laboratory under controlled conditions of temperature, relative humidity, and light, in special glass cages, as previously described by these authors (133, 135). They found that Tephrosia virginiana with a rotenone content of 1.7 percent was only about one-fourth as effective as a repellent as was derris having a rotenone content of 4 to 5 percent. Cube and timbo with a rotenone content and total extractives equivalent to derris were only half as effective as repellents. The impregnation of derris with rosin to increase the resistance of the deposits to removal by water or decomposition by light significantly reduced the value of the derris as a repellent, while the addition to the rosin of a small quantity of cresol, beta naphthol, thymol, quinine, or naphthalene appeared to overcome the detrimental effect of the rosin. The addition of red, orange, yellow, green, blue, violet, and black dyes with the rosin used to impregnate the derris did not modify the repellency of the derris. Impregnation of derris with cumer, coal tar, or gilsonite improved the resistance to removal by water and decomposition by light but completely destroyed the value of the material as a repellent. The impregnation of derris with pine products--pine oil, pine pitch, pine tar, or dipentene--improved the resistance of derris to removal by water and decomposition by light, but completely destroyed the value of the material as a repellent. The addition of bordeaux mixture appeared to decrease the repellency of derris. Sulfur increased the resistance of derris to removal by water and decomposition by light, while sulfur alone had no repellent value. Lime-sulfur likewise increased the resistance of derris to removal by water and decomposition by light, although lime-sulfur alone, or in combination with aluminum sulfate, copper sulfate, iron sulfate, or zinc sulfate, was neither toxic nor repellent to the beetles; the addition of these materials to derris definitely increased the effectiveness of derris as a repellent and greatly reduced the removal of the repellent substance by water.

Fleming and Chisholm (142) in 1936 reported on derris as a repellent for the Japanese beetle. A series of derris compounds containing rosin and white pigments was prepared to determine the effect of these materials on the adhesion of derris deposits and the effect of sunlight on these deposits. Of the several pigments tested, the best protection was shown with zinc oxide, titanium pigment (barium base), and titanium pigment (calcium base); each of these materials showing over 50 percent of the initial deposit still active after the exposure period, the greatest initial deposit being obtained with zinc oxide. Derris compounds containing 10 percent of rosin and 2 percent of phenol and other organic compounds were tested to determine their resistance to decomposition on exposure to light. The best protection resulted from the use of phenol, aniline, and quinine, there being in each case 50 percent of material undecomposed on exposure to light.

Fleming and Metzger (143) in 1936 published information on the control of the Japanese beetle on fruit and shade trees. Peaches that ripen in July can be protected by spraying with 3 pounds of derris, containing 4 percent of rotenone, and 3 pounds of rosin-residue emulsion in 100 gallons of water, provided orchard sanitation is practiced. Prematurely ripening or diseased fruit should be removed from the trees, as such fruit is attacked by the beetles, even when thoroughly coated with the spray residue, and when this fruit is consumed the beetles begin to feed on the sound fruit. All fruit on the ground should also be removed, as its odor attracts beetles. A thin paste of derris is poured into the spray tank after the rosin-residue emulsion and water have been added. The spray of derris-rosin residue emulsion is also recommended for early ripening varieties of plums.

Headlee (184) in 1936 recommended, as one of the materials to make foliage and fruit unattractive to the adult Japanese beetle, a mixture of 3 pounds of powdered derris (containing 4 to 5 percent of rotenone and 16 to 18 percent of acetone extractives) plus 3 pounds of rosin-residue emulsion (Goodhue's formula) to 100 gallons of water.

Metzger (282) in 1936 called attention to the derris plus rosin-residue spray as a repellent for Japanese beetles attacking early ripening peaches. Three pounds of derris (rotenone = 4 percent; total acetone extractives = 16 percent or more) plus 3 pounds of 50-percent rosin-residue emulsion are used to 100 gallons of water. The first application of this spray should be made when the beetles first appear in the orchard, and subsequent applications should follow at intervals of 7 to 10 days, the number of applications depending on the degree of infestation in the vicinity.

Van Gundle (400) in 1936 reported that control of the Japanese beetle with applications of rotenone dust, made from either cube or derris, was unsatisfactory. He said: "We are not particularly interested in killing them by contact where the foliage is sacrificed, but we are interested in keeping them away from those treated plants."

Baker and Fleming, in a typewritten report in January 1937 on the work conducted during the summer of 1936, on the protection of apples and peaches from attack by the adult Japanese beetle, stated that various derris combinations were tested in an attempt to increase the period of effectiveness of derris. Derris plus-rosin-residue emulsion, the least expensive combination tested, was as good as any other. The addition of rosin, rosin-phenol, or rosin-zinc oxide did not improve the spray combination from the standpoint of effectiveness in controlling the beetle.

In February 1937 these authors stated in a typewritten report that a spray containing 3 pounds of derris (rotenone 4 percent) and 3 pounds of rosin-residue emulsion per 100 gallons of water maintained in effective control against adult Japanese beetles on azaleas for 11 days; and in March 1937 they (24) reported tests of sprays for protecting ornamental plants against Japanese beetle attack. Derris and rosin-residue emulsion maintained an effective control on azaleas for 11 days, showing that this spray was as effective under conditions in the commercial nursery as in the orchards.

Bromley (58) in 1937 stated that derris or cube with rosin-residue emulsion is a promising repellent for the Japanese beetle.

Fleming (134) in 1937 reported tests with derris as a repellent for the Japanese beetle. Fine powder (200-mesh) is more effective than coarse. Materials added to inhibit the decomposition of derris by sunlight failed to do so and in some cases reduced the initial repellency. Certain rosin oils can be substituted for rosin residue as a sticker for derris.

Fleming and Baker (138) in 1937 reported on large-scale field tests, made during the 1936 season, of materials used for the protection of early ripening peaches and apples from injury by the adult Japanese beetle. Various combinations of derris were tested to ascertain whether any more satisfactory combinations than that of derris plus rosin-residue emulsion, now recommended, could be developed. It was found that the derris-rosin residue combination was equally as good, if not superior to, any other derris combination for protection of early ripening peaches.

Guy and Schmitt (170) in 1937 reported on repellents for the Japanese beetle. In 1935 derris, thiuram sulfides, phenothiazine, and lime were tested as repellents for the Japanese beetle at Yorklyn, Del, on apple and peach trees. Three sprays at 300-pounds' pressure with a single-nozzle gun were applied on July 2, July 16, and August 30. Good coverage was obtained with every material at the rate of 3.5 gallons per tree. None of them caused foliage injury. The first application was made before the Japanese beetle appeared in large numbers. When feeding became noticeable the additional coverage was provided. The best protection afforded by tetramethyl thiuram disulfide plus 1 pint of a 40-percent rosin-residue emulsion. Good results were given by certain other combinations which, although of almost equal efficiency, may be rated in the following order: (1) Derris plus 3 pounds of rosin sticker No. 1 (50-percent emulsion); (2) tetramethyl thiuram monosulfide plus 1 pint of rosin-residue (40-percent) emulsion; (3) derris plus 3 pounds of rosin-residue (50-percent) emulsion (Goodhue-Fleming formula); (4) phenothiazine plus 1 pint of rosin-residue (40-percent) emulsion; (5) derris plus 3 pounds of rosin-residue sticker No. 2 (50-percent emulsion).

All the mixtures of hydrated lime were inferior to these materials. The addition of 3 pounds of aluminum sulfate to hydrated lime gave greater foliage protection than the addition of either 3 pounds of rosin-residue emulsion or 1.5 pints of fish oil. Although the hydrated lime-fish-oil spray produced an unremovable residue on peaches, it was the least effective combination tested. All the hydrated-lime sprays were responsible for residues which rendered the early peaches unfit for the market. The synthetic compounds and derris combinations, on the contrary, had the advantage of leaving no conspicuous residues; in fact, there was no indication at harvest time of the sprays that had been applied. The results indicate that either tetramethyl thiuram disulfide or derris plus a rosin-type sticker offers considerable promise as a Japanese beetle repellent.

Hamilton (172) in 1937 reported that Japanese beetles on various trees, shrubs, and flowers were fairly well controlled by a spray of 4 pounds of derris or cube powder (4 percent of rotenone) and 4 pounds of rosin-residue emulsion per 100 gallons of water. The spray acts as a repellent. The effective period is 6 to 7 days. Satisfactory repellency can be obtained by spraying 6 or 7 days apart.

Hodgkiss (189) in 1937 recommended derris for the protection of early ripening peaches and plums against the Japanese beetle. The spray consists of 3 pounds of derris powder (4 percent of rotenone), 3 pounds of rosin-residue emulsion (See U. S. Dept. Agr. Cir. 237, rev. 1936), and 100 gallons of water. Start spraying as soon as the beetles get into the orchard and apply later treatments every 7 or 10 days.

C. L. Smith (339) in 1937 reported that a spray of derris powder (4 percent of rotenone) 4 pounds per 100 gallons of water, plus 2-1/2 pounds of coconut-oil soap (anhydrous basis), was sprayed on Japanese beetles infesting marigold. At the end of 24 hours 48 percent were killed; at the end of 48 hours 82 percent were killed. The plants sprayed with derris retained a marked repellency and prevented a reinfestation for at least 3 days.

Stearns (355) in 1937 reported that derris with rosin residue as a sticker proved highly effective as a foliage protectant against the ravages of the Japanese beetle in Delaware.

Britton and Johnson (57) in 1938 reported on the control of the Japanese beetle in Connecticut. As a protective spray for flowering plants, derris powder (4 to 5 percent of rotenone), 1/3 pound in 10 gallons of water, will not leave an undesirable residue and gives a fair degree of efficiency. Early ripening peaches and plums may be protected by spraying with 3 pounds of derris containing 4 percent of rotenone and 3 pounds of rosin-residue emulsion in 100 gallons of water, provided orchard sanitation is practiced. This spray does not leave an objectionable residue on the fruit at harvesttime.

Dietz and Pierpont (102) in 1938 reported tests to determine the value of derris, phenothiazine, tetramethyl thiuram disulfide, and other materials as foliage protectants against the ravages of the Japanese beetle. Sprays that included derris were as follows:

<u>Material</u>	<u>Pounds per gallon of water</u>
Tetramethyl thiuram disulfide	1.25
Derris	1.25
Rosin-residue emulsion	1.00
Ground derris	4.00
Rosin-residue emulsion	4.00
Derris	4.00
Rosin-residue emulsion (special)	4.00

The results indicated that ground derris and a tetramethyl thiuram disulfide mixture (80 percent active) are at present the most effective foliage protectants against the ravages of the Japanese beetle. Applications should be made prior to heavy invasion by this insect and the proper adhesive should be used.

The New Jersey State Agricultural Experiment Station (298) in 1938 reported that Japanese beetles were repelled from feeding for 4 to 8 days or more by the application of a spray of derris or cube powder plus rosin-residue emulsion in water. Derris or cube powder used at the rate of 3 pounds to 100 gallons of water with 3 pounds of rosin-residue emulsion,

applied at weekly intervals, gave good control of Japanese beetles on blueberries, red raspberries, the foliage of grapes, and the foliage and bloom of roses, calendula, dahlias, marigold, and zinnias. Dust applications of derris and cube powder containing 5 percent of rotenone, at the rate of 3 pounds per acre, prevented the beetles from feeding on commercial plantings of blueberries.

The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine (398) in 1938 reported preliminary results with ground derris, which indicated that the more finely divided materials may prove more effective than the coarser ones as repellents for the adult Japanese beetle. Results with various materials intended to inhibit decomposition of the active ingredients of derris by sunlight failed to reveal any satisfactory material for this purpose. The work on the decomposition of rotenone, as measured by chemical means, indicated that some constituent of derris other than rotenone may be an important factor in its repellent effect on the Japanese beetle.

Fleming and Burgess (141) in 1939 reported the results of tests against Japanese beetles with various materials. These tests were conducted during the summer of 1938 at the Japanese beetle laboratory, Moorestown, N. J. Comparative tests were made with derris and cube having the same rotenone content (4 percent) and practically the same percentage of total extractives (14 and 16 percent, respectively). Neither material appeared to have any appreciable value as a stomach poison. Derris, however, has a high rating as a repellent to the beetle, and the tests indicated that for repellent purposes either cube or timbo could be substituted for derris, provided the rotenone content of the materials was about 4 percent and the total extractives about 16 percent.

Guy and Dietz (169) in 1939 reported the results of tests with tetramethyl-thiuram disulfide as a Japanese beetle repellent. A mixture of 1 pound of this plus 1 pound of derris (rotenone 4 percent) permitted 10 percent of the foliage of bean plants to be eaten, as compared with 16 percent when 2 pounds of tetramethyl thiuram disulfide was applied. The best repellent consists of Tetramethyl-thiuram disulfide 80 percent, clay 14 percent, bentonite 5 percent, and Lorol alcohol 1 percent. This is referred to as 793 A₂O. Phenothiazine was better than derris. Derris plus Grasselli Spreader-Sticker was better than derris plus rosin-residue emulsion, the least effective treatment. Two and one-half pounds of 793 A₂O was more effective than 4 pounds of derris (rotenone 5 percent) plus 4 pounds of rosin-residue emulsion. In field tests the mixture of rosin-residue emulsion and cube foamed so badly that the spray-tank agitator had to be stopped. The other cube sprays also foamed, but to a lesser degree.

Johnson (230) in 1940 wrote that derris (containing at least 4 percent of rotenone) with rosin residue must be used weekly to give protection to the foliage. Derris and tetramethyl-thiuram disulfide leave very little visual spray residue and may be used where white discoloration is undesirable. Two proprietary sprays containing 4 percent of rotenone were used and compared favorably with the derris spray mentioned above.

Pierpont (319) in 1939 reported a study of repellents for the Japanese beetle on American elm trees in Delaware. He concluded from these results that either ground derris (4 pounds) or tetramethylthiuram disulfide (5 pounds)

combined with a suitable adhesive, such as the rosin-residue emulsion of Goodhue and Fleming, are at present the most effective protectants for the foliage of American elm trees against the ravages of the Japanese beetle. These combinations may be used without fear of injury to, or a building up of conspicuous residue on, such trees. An application should be made prior to any heavy invasion by this insect and the spray should be repeated as soon as any reinfestation is noted. Derris powder was used at the rate of 4 pounds per 100 gallons of water plus 2 or 4 pints of the rosin-residue emulsion.

Scarabaeidae (unidentified sp.)

Cockchafer beetles in a rose garden may be controlled by spraying the foliage with lead arsenate (3 pounds per 100 imperial gallons of water) and watering the roots with Derrisol 1:600.--Andries (18) in 1932.

Scolytidae

Hypothenemus eruditus Westw.

Feeds on derris roots in storage.--Corbett (86) in 1931; Federated Malay States Department of Agriculture (124); and Miller (285) in 1934.

Scolytus scolytus (F.), a large elm engraver beetle

The adults are sensitive to derris dust and derris spray, but the larvae are not affected by dusting with derris. Dusting mixtures containing 0.25, 0.5, and 1.0 percent of rotenone and 0.6, 1.2, and 2.4 percent of ether extract gave, respectively, 32, 85, and 96 percent of dead insects.--De Bussy et al. (61) in 1936.

Not affected by derris.--Van der Laan (252) in 1936.

Fransen (146) in 1937 reported that in a preliminary investigation of the effect of derris on S. scolytus adults shaken up with a powder containing 1 percent of rotenone for 5 minutes, then blown clean and placed in a chamber at 10° C. [50° F.] were all dead the next day, whereas only 2 percent of a batch treated in the same way with wheat flour died. In another test disks of felt dusted with derris powder were blown and beaten so as to leave only traces of the powder. All beetles kept between two such disks (held 0.4 inch apart by a wire ring) for 15 hours at 10° C. died, whereas 95 percent of those between disks treated with wheat flour survived.

Stephanoderes hampei Ferr., a coffee-berry borer

Friedrichs (147) in 1924 reported the results of tests in Java with Phytophiline, which is stated to be a proprietary preparation of the root of Derris elliptica and soap. This preparation proved ineffective and too costly for use against the coffee-berry borer.

Gandrup (155) in 1924 reported tests made in Java for the control of the coffee-berry borer. A special "Antiborer Phytophiline" had no effect in either laboratory or field trials.

Xyleborus discolor Blandf.

Attacks branches of boga nedeloa (Taphrosia candida) in Ceylon.--Light (260) in 1928.

Xyleborus fornicatus Eichh., a shot-hole borer of tea

Attacks Derris robusta Benth in the field in Ceylon.--Light (260) in 1928.

Scolytidae (unidentified sp.)

A scolytid feeds on derris roots in storage.--Gater (162) in 1925.

Staphylinidae

Oxytelus sculptus Grav.

Two applications of dust containing 0.75 percent of rotenone were effective.--Anonymous (2) in 1937.

Tenebrionidae

Alphitobius laevigatus (F.) [sic.]

Feeds on derris roots in storage.--Federated Malay States Department of Agriculture (124) and Miller (285) in 1934.

"Cameria geometrica"

Neeton, 1/2 pound plus 1 pound of soap to 40 imperial gallons of water killed 100 percent of the larvae.--Institute of Physical and Chemical Research (220) in 1927.

Gnathocerus cornutus (F.)

Sensitive to derris powder containing 1 percent of rotenone. --Anonymous (2) in 1937.

The larva of this species was used by Craufurd-Benson (90) in 1938 in testing the susceptibility of stored-product insects to derris, but it was killed by the wetter used.

Tenebrio molitor L., the yellow mealworm

The larvae are insensitive to derris dust.--De Bussy et al. (61) in 1936.

The larva is not susceptible to derris.--Craufurd-Benson (90) in 1938.

Tenebrio obscurus F., the dark mealworm

The larva is not susceptible to derris.--Craufurd-Benson (90) in 1938.

Tribolium castaneum (Hbst.) (= T. ferrugineum F.), the red flour beetle

Resistant to derris powder.--Anonymous (2) in 1937.

The adult is not susceptible to derris.--Graufurd-Benson (90) in 1938.

Tribolium confusum Duv., the confused flour beetle

Billings, according to Campbell (66) in 1932, tested the action of rotenone upon the confused flour beetle, but the results are not recorded.

The larva is not susceptible to derris.--Graufurd-Benson (90) in 1938.

Tenebrionidae (unidentified sp.)

A tenebrionid feeds on derris roots in storage.--Gater (162) in 1925.

Coleoptera (unidentified sp.)

For "brown beetle," see Kearns (236) under *Phyllodecta* sp., on pages 55 and 121.

Daniels (95) in 1905 stated that some coleopterous larvae are only temporarily injured by derris.

Flippance (145) in 1920 suggested derris powder for combating various small beetles attacking palms in the Straits Settlements.

Grist (167) of the Federated Malay States Department of Agriculture, in 1926 wrote that tuba root had been found to contain borers, which not only eat the root but also destroy its toxic qualities.

Neeton, 1 pound in 80 imperial gallons of water plus 2 pounds of soap, killed 100 percent of the larvae of the strawberry beetle and was effective against both adults and larvae of leafbeetles.--Institute of Physical and Chemical Research (220) in 1927.

Bock (32) in 1934 wrote that an alcoholic extract of derris plus soap had proved equal to an arsenical mixture when sprayed on beetles.

Leaf beetles can be destroyed by derris.--Koloniaal Instituut of Amsterdam (12, 13) in 1936

Caldwell (65) in 1937 reported on the control of the red-shouldered leaf beetle in Queensland. Dusts containing either or both pyrethrum and derris as toxic ingredients were used on citrus trees carrying a fairly heavy infestation of beetles. The results with pyrethrum were particularly satisfactory. There was an almost complete drop of semiparalyzed beetles within a few minutes, and observations suggested that only a very small proportion of these recovered sufficiently to fly or to climb the trunks of the trees. Growers are, therefore recommended to combat this pest by the use of a pyrethrum dust. If pure pyrethrum is purchased, it can be mixed with equal parts of weight of kaolin (a cheap filler) to reduce the cost of the treatment. As derris is somewhat slower in action and considerably less effective against this pest than pyrethrum, dusts containing the former insecticide alone cannot as yet be recommended for the control of the red-shouldered leaf beetle.

An anonymous writer (3) in 1938 reported that the red-shouldered leaf beetle on cultivated fruit trees and ornamental plants in Queensland can be controlled by the use of either pyrethrum or pyrethrum plus derris dusts. Dusts containing pyrethrum and derris are available in several proprietary lines.

Rotenone spray was recommended against the 12-spotted leaf beetle on aster by Parks and Pierstorff (312) in 1938.

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