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RECOMMENDATIONS FOR CONTROL OF CATERPILLARS ON CABBAGE
IN THE SOUTH UNDER PRESENT WARTIME CONDITIONS

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INTRODUCTION

Cabbage is one of the important vegetable crops for which increased production is urged by the authorities to meet wartime needs. During the period of its growth this crop is often damaged by one or more kinds of insect pests, including several species of caterpillars, or "worms". Experiments by workers of this Bureau during the last 10 years have shown that these caterpillars can be controlled at any stage of the growth of cabbage by the application of various insecticides. The supply of some of these insecticides, especially those

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containing rotenone or pyrethrum, has been curtailed seriously by war conditions. The situation with respect to the availability of rotenone-containing materials is particularly critical because this insecticide is obtained from the roots of several species of tropical or subtropical plants such as derris, cube, barbasco, tuba, and timbo, imported principally from areas in the South Pacific which have been cut off as a result of warfare. In order, therefore, to conserve supplies of rotenone-containing insecticides for use on certain crops and on certain animals where the need is considered most urgent, the War Production Board has issued a conservation order specifying the use of these materials. The provisions of this order do not permit the use of rotenone-containing insecticides for the control of insects on cabbage.

The principal purpose of this circular, therefore, is to furnish home gardeners, commercial growers, insecticide dealers, and other interested persons with recommendations as to the use of available insecticides and other control measures for combating caterpillars on cabbage under the emergency conditions resulting from the war. While the information in this circular will be of particular value in the South, the recommendations contained therein will also apply to other parts of the country.

PRINCIPAL INSECTS INVOLVED

The principal species of caterpillars that cause damage to cabbage in the South are the cabbage looper, the diamondback moth (also known as the cabbage plutella), the imported cabbageworm (also known as the common cabbageworm), the cabbage webworm (or budworm), the corn earworm (also known as tomato fruitworm and cotton bollworm), and several species of true cutworms. Several other species, including the cross-striped cabbage worm, sometimes occur in injurious numbers in certain areas. All these caterpillars are the immature stages of moths or butterflies.

The cabbage looper, the imported cabbageworm, and the caterpillar (larva) of the diamondback moth are green and feed on the leaves, bud, or head of cabbage plants. They are sometimes known as the "green worms" of cabbage. The looper may be distinguished by its habit of forming a hump in its body, or "looping," as it crawls. The imported cabbageworm has a velvety appearance, a slender orange-colored stripe down the middle of its back, and a broken yellowish stripe along each side of its body. The cabbage looper and the imported cabbageworm are about $1\frac{1}{4}$ inches long when full grown. Caterpillars of the diamondback moth are only about one-third inch long when full grown, are somewhat tapered at each end, and usually wriggle actively when disturbed, often dropping from the plant and hanging by a silken thread. This species may

feed on any part of the leaves, bud, or head of the plant, but usually prefers the buds of young plants, crevices between leaves of heading plants, and the lower surface of the older leaves.

The cabbage webworm is about one-half inch long when grown, is dull grayish-yellow, and is marked with five brownish-purple stripes that run lengthwise of its body. The head is black and bears a V-shaped marking. This species feeds under a protecting web and prefers the buds of young plants, but may feed on other parts of the plant.

The corn earworm may vary considerably in color but usually is dark brown, with green, yellow, and black markings. This species usually feeds on the bud and heads of the plant, tunneling into these parts as a rule. Full-grown corn earworms are about $1\frac{1}{4}$ inches long.

Cutworms vary according to species as to color and markings, but usually are stout, soft-bodied caterpillars, from gray to brown to nearly black, and sometimes spotted or marked with stripes. They are about $1\frac{1}{4}$ inches long when full grown. Cutworms either live in the ground and cut off the stalks of plants, or live on the plant and feed on the buds, heads, or leaves.

USE OF INSECTICIDES

Unfortunately, not all species of cabbage caterpillars can be controlled with the same insecticide. Materials that kill one species may not be very toxic to others, and certain insecticides useful during the preheading period of plant growth, such as those containing arsenic and fluorine, should not be used during the heading period, on account of the harmful residue hazard. Rotenone-containing insecticides usually have proved most satisfactory for controlling the imported cabbageworm and the diamondback moth during the heading period of cabbage growth; pyrethrum insecticides usually have proved most effective against the cabbage looper during this period, and combinations of rotenone and pyrethrum have been effective against all these species. Pyrethrum insecticides, when used at the strength and rate recommended in this circular, will not leave harmful residues on the market product. The corn earworm and cutworms are not satisfactorily controlled by either rotenone or pyrethrum. These species must be combated, therefore, with arsenical and fluorine compounds, which also are toxic to the other species of caterpillars mentioned herein but should not be used during the plant heading period, for the reasons previously given.

The following recommendations are designed to provide for the control of caterpillars on cabbage without the use of rotenone-containing insecticides during the existing wartime emergency. These recommendations are also designed to conserve pyrethrum and arsenic,

because the supplies of these materials are limited. The adoption of the practices given in these recommendations should give satisfactory control of caterpillars on cabbage during the preheading period of this crop. They should also give a satisfactory control of these pests during the heading period of the crop unless the diamondback moth caterpillars are unusually abundant. In the latter event, the incorporation of nicotine in a pyrethrum dust or spray, as detailed later in this circular, should reduce infestations of this species to a worth-while extent.

In general, cabbage being grown in the extreme southern parts of the United States (the southern portions of Florida and Texas) usually requires protection against caterpillars during all or the greater part of its growth. That grown in other parts of the South usually requires insecticidal treatment during all periods except the winter months. In certain parts of the last-mentioned areas, control measures may be necessary during mild winters (those during which weekly mean temperatures do not remain below about 60° F.) or may prove unnecessary during spring seasons following severe winters. It is recommended that control measures be started as soon as the caterpillar population averages about one "worm" per plant or when approximately 25 percent of the plants in a field show signs of recent caterpillar feeding. In general, control measures are unnecessary when weekly mean temperatures fall below about 50° F. in the fall, and should be resumed in the spring when weekly mean temperatures are consistently above about 60°.

CONTROL DURING PLANT PREHEADING PERIOD

Soil-inhabiting cutworms

If cutworms are present in the soil before the crop is planted, the following poisoned bait should be broadcast on the soil surface late in the afternoon at the rate of about 25 pounds per acre:

Wheat bran - - - - -	25 pounds
Sodium fluosilicate - - - - -	1 pound
Water to moisten	

The bran and poison should be thoroughly mixed while dry and enough water added to dampen, but not wet, the mixture. This bait also may be used against cutworms after the plants are up, but to prevent serious burning, care should be taken to see that no bait lodges in or against the plants. For use when plants are present, it is safer and more economical to substitute cryolite for the sodium fluosilicate in the bait and to scatter the bait at the base of the plants at a rate of 10 to 15 pounds per acre per application. Several bait applications may prove necessary to reduce infestations satisfactorily.

Caution.--The poisoned bait should be scattered thinly. Special precautions should be taken to avoid leaving piles of bait on the soil surface. Experience and careful observation have shown that if the poisoned bait is prepared and applied properly, its use will not present a hazard to domestic animals or wildlife.

Cabbage Caterpillars, Corn Earworm,
and Climbing Cutworms

To prevent damage to young plants in the plant bed or in the field and to reduce the possibilities of damage during the heading period, which is especially important under present conditions of insecticide scarcity, either cryolite (natural or synthetic), calcium arsenate, paris green, or barium fluosilicate should be used at least every 10 days during the preheading period of plant growth if the caterpillars are present in damaging numbers -- that is, an average of more than about one caterpillar per plant.

Dusts.--Cryolite should be diluted to contain not less than 40 percent of sodium fluoaluminate, which usually means that the undiluted cryolite is mixed with approximately equal parts, by weight, of any of the diluents mentioned later. Barium fluosilicate should be used at about 75-percent strength, paris green at 10- to 15-percent strength, and calcium arsenate should be used undiluted, or at 75-percent strength if the brand being used causes plant injury when used undiluted. Talc, pyrophyllite, sulfur, or other nonalkaline materials may be used to dilute cryolite and barium fluosilicate. Hydrated lime should be used with paris green and calcium arsenate, but not with cryolite or barium fluosilicate.

Sprays.--Cryolite, barium fluosilicate, and calcium arsenate should be used at the rate of 2 to 3 pounds to 50 gallons of water (1 ounce to 1 gallon), and paris green should be used at the rate of one-half pound to 50 gallons of water (2 level teaspoonfuls to 1 gallon). Two pounds of hydrated lime should be used in each 50 gallons (2 level tablespoonfuls of lime to 1 gallon) of the paris green spray, and be added to the calcium arsenate spray if the brand used causes plant burning.

Supplementary poisoned bait.--If applications of these arsenical or fluorine compounds do not provide entirely adequate control of the corn earworm or climbing cutworms, a bait composed of 10 percent of cryolite and 90 percent of corn meal, by weight, mixed and used dry, should be sprinkled into the buds of the plants at the rate of about 25 pounds per acre just before the plants begin heading.

Precautionary preheading treatment.--To reduce the need for insecticides during the heading period, it is suggested that a thorough application of one of the aforementioned arsenical or fluorine compounds be given cabbage plantings (except those that will head and be

harvested during relatively worm-free periods) just before the plants begin heading, even though caterpillars may not be abundant at the time. This is particularly applicable to spring planting that normally would not require insecticide protection during the preheading period.

It is emphasized that treatments with arsenicals or fluorine compounds should not be made during the preheading period to loose-headed types of cabbage intended for marketing with more than four loose outer leaves.

Warning.--Calcium arsenate, paris green, cryolite, and barium fluosilicate are poisonous and should be handled with care and stored where children, careless persons, and domestic animals cannot reach them. Especial care should be taken in mixing or applying these insecticides not to inhale excessive quantities. Well-designed respirators affording protection to the entire face should be used whenever available. Wash the hands or other exposed parts of the body thoroughly after working with these compounds. It is repeated that these materials should not be applied to cabbage after that portion of the plant that is to be marketed or consumed becomes exposed to view. This means that cabbage to be marketed with four "wrapper" leaves (those at least two-thirds loose from and surrounding the firm head) should not be treated with these materials after the head begins to form (the bud leaves begin to "fold" or "cup over"), which usually occurs about 30 to 40 days before harvesting normally begins. The materials should never be used within about 2 weeks of harvest and all "wrapper" leaves should be stripped from the firm head if arsenical or fluorine compounds are used as a last resort in cases of severe infestations after cabbage begins to head. It probably will be found that this stripping of the loose leaves will not be a profitable commercial practice in most areas in the South. Cabbage to be marketed or consumed with more than four "wrapper" leaves should not receive arsenical or fluorine applications after the normal time for thinning or transplanting.

CONTROL DURING PLANT-HEADING PERIOD

For the control of the green-colored caterpillars on heading cabbage under present conditions, it is recommended that pyrethrum dusts or sprays be used at least every 10 days throughout the period, if there is an average of more than one caterpillar per plant.

Pyrethrum dusts.--Pyrethrum may be used in the form of finely-ground pyrethrum flowers in a dust or in a spray, or as extracts of these flowers incorporated into dusts or used directly in sprays. When used at comparable pyrethrins content (the active ingredients of pyrethrum flowers), the so-called "impregnated" or "coated" forms of dust which contain oil have proved slightly more effective than

simple dust mixtures of ground pyrethrum and a diluent. For use against caterpillar populations consisting chiefly of the cabbage looper, or the imported cabbageworm, or the diamondback moth, an "impregnated" or "coated" dust containing 0.2 percent of total pyrethrins or a pyrethrum powder dust (ground pyrethrum flowers) containing 0.3 percent of total pyrethrins is recommended.

The "impregnated" or "coated" pyrethrum dusts containing 0.2 percent of total pyrethrins may usually be purchased from dealers in a form which is ready to apply. If these materials contain more than 0.2 percent of total pyrethrins, however, they may be diluted to that strength by mixing with such nonalkaline diluents as talc, pyrophyllite, sulfur, or tobacco dust. For example, if an "impregnated" or "coated" dust contains 2.0 percent of total pyrethrins when purchased from the dealer, it should be diluted at the rate of 1 pound of this material to 9 pounds of the diluent. The pyrethrum powder dust (ground pyrethrum flowers) may be purchased from dealers in a form which is ready to apply. If the powder dust contains more than 0.3 percent of total pyrethrins, however, it may be diluted to that strength by mixing with the same diluents mentioned previously. For example, if the pyrethrum powder dust contains 0.9 percent of total pyrethrins it should be diluted at the rate of 1 pound of this material to 2 pounds of the diluent.

Dust mixtures prepared from finely ground pyrethrum flowers may be improved by the addition of 2 percent by weight of a light mineral oil (approximately SAE 10 specification) or by the addition of 1 percent of thiocyanate (available in commercial preparations containing approximately equal parts of an oil base). If either of these materials is added, the dust may be reduced to 0.2 percent of total pyrethrins content. The use of about 20 percent of sulfur (20 pounds of sulfur to 100 pounds of mixed dust) has been found to improve the effectiveness and stability of pyrethrum dusts. Kaolin clays reduce the effectiveness of pyrethrum dusts and should not be used as diluents, especially under present conditions.

Pyrethrum sprays.--Alcoholic or acetone extracts of pyrethrum in water or pyrethrum powders in suspension in water may be used as sprays. The extracts should be diluted and used according to the manufacturer's directions. Sprays consisting of pyrethrum powder and water should contain not less than 0.006 percent of total pyrethrins. For example, a high grade, fresh powder (ground pyrethrum flowers) containing about 0.9 percent of total pyrethrins should be used at the rate of 3 pounds to 50 gallons of water (1 ounce to 1 gallon). It usually will be found desirable to add a nonalkaline spreading or sticking agent such as a mild soap, a miscible or sulfonated oil, or a proprietary compound, designed especially for this purpose. Cake soap may be used at the rate of about 2 pounds to 50 gallons of spray and the liquid materials, in general, at the rate of 1 part to 400

parts of spray. The use of spreading agents has the disadvantage of removing some or all of the waxy "bloom" from cabbage leaves, thereby affecting the appearance of the plants and sometimes causing them to be more susceptible to damage by low temperatures.

Use of nicotine against diamondback moth.--If caterpillars of the diamondback moth are especially numerous, or if the history of the locality or crop is such that a heavy infestation of this species is expected, it is suggested that nicotine be added to the pyrethrum dust or spray. Nicotine, either the "free" or the "fixed" form, has been found to reduce infestations of diamondback moth caterpillars to a worth-while extent under present conditions, but is of little value in the control of the other important species of cabbage caterpillars. The free form of nicotine also will be effective against aphids, or plant lice, that may be present. About 2 percent of nicotine should be added to a pyrethrum dust. Approximately 0.07 to 0.1 percent of nicotine (1 part of nicotine sulfate to 400 parts of water, or 2 to 3 pounds of a 14-percent "fixed" nicotine powder to 50 gallons of water) should be added to a pyrethrum spray. The nicotine may be applied separately from the pyrethrum if desired, but should not be depended on entirely for caterpillar control. No lime should be involved in the application of nicotine if cryolite has recently been used, or if either cryolite or pyrethrum are to be used in the near future.

Caution.--Some observations indicate that materials such as nicotine, thiocyanates, and oils, which cause increased toxicity of pyrethrum-containing dust mixtures, may also have a deteriorating effect on such mixtures in prolonged storage. It is not advisable, therefore, to buy or to prepare a greater quantity of these dust mixtures than is likely to be needed in 1943, regardless of the availability of the materials.

Use of other insecticides and hand picking.--Thus far no entirely satisfactory, readily available substitute for pyrethrum and rotenone in the control of cabbage caterpillars has been found. The search for new insecticides and methods of improving known ones is continuing.

Phenothiazine, a comparatively new compound, is sufficiently toxic to cabbage caterpillars to be of value in case pyrethrum is not available. This material may be used as a dust at not less than 20-percent strength, diluted with talc, clay, pyrophyllite, or other nonalkaline materials. For use as a spray, phenothiazine should be used at the rate of 2 to 3 pounds per 50 gallons of water (1 ounce to 1 gallon) with a spreading and sticking agent.

If used regularly once a week, a relatively strong soap spray (1 pound of a mild laundry soap to 5 gallons of water) will give

fairly satisfactory results, but should not be used near or during below-freezing temperatures.

For small plantings, especially home gardens, hand removal of caterpillars is of value.

METHODS OF USING DUSTS AND SPRAYS

Dusts.---For best results, insecticidal dusts should be applied when the air is calm, or nearly so, when the atmosphere is so heavy as to hold the dust near the ground, and when the plants are slightly moist with dew. The period after sunset and for several hours thereafter usually is a favorable time of day for dusting. Arsonical and fluorine compounds also may be applied to advantage during the early morning. Pyrethrum, however, is more effective generally when the plants are dry or only slightly moist. Consequently, the early morning hours are not a favorable time for applying this insecticide because the plants are likely to be drenched with dew at that time. Dust should be applied at a rate ranging from 10 to 25 pounds per acre per application (about 2 ounces to 50 feet of row), depending on the size of plants, the spacing of the rows, and the dilution of the insecticide.

Sprays.---Sprays may be applied at any time of day, but the wind should not be so high as to interfere with thorough coverage and tender plants should not be sprayed with strong soap solutions while in direct sunlight during hot weather. Sprays should be used at a rate of 50 to 100 gallons per acre per application (about 2 quarts to 50 feet of row).

Dusting and spraying equipment should be adjusted so as to give thorough coverage of the plants, and such equipment should be kept in good mechanical condition, especially now that machinery is difficult to replace. When applying dusts to dry plants during slightly windy weather, especially dusts containing nicotine, the use of a cloth apron or trailer that extends for 10 to 20 feet back of the dust machine usually will be of value. The use of cloth bags for applying dusts and of watering cans, or similar containers, for applying sprays is not advised, as these methods usually result in relatively poor caterpillar control and in waste of insecticides.

Insecticide materials, especially those containing pyrethrum, which deteriorates relatively rapidly, should be used as soon as practicable after being mixed.

CULTURAL CONTROL MEASURES

To reduce caterpillar damage and the need for insecticides, cabbage should be grown whenever possible during periods when caterpillars usually are least abundant; the crop should not be planted near caterpillar-infested older plantings; the rows should be of uniform width in order to permit most effective adjustment of spraying and dusting equipment; the plants should be uniformly spaced along the row to prevent crowding and consequent poor distribution of insecticides; the heads should be cut as soon as ready for market or home use; and crop remains should be plowed under or otherwise disposed of as soon as harvesting is completed.

Caterpillar-infested plant beds should be poisoned with the insecticides discussed earlier in this circular before the plants are pulled, and an infested field planting should not be thinned before the described control measures are used. Plants with injured or destroyed buds should not be transplanted or be left in the row during thinning operations.

Sufficient seed should be used to insure a good plant stand without a waste of seed. Cabbage should be given good cultural care, and fungicides and fertilizers should be applied to keep the plants in a healthy condition.

WHERE INSECTICIDES MAY BE OBTAINED

Information regarding the purchase of the materials mentioned in this circular usually may be obtained from local dealers in agricultural supplies, seedsmen, general stores, and drug stores, or through the county agricultural agent, State agricultural experiment station, State department of agriculture, or the Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, United States Department of Agriculture.

SUMMARY

Recommendations are given for the use of available insecticides and other control measures for the control of cabbage caterpillars under emergency conditions resulting from the war. Rotenone-containing insecticides are not available for use on cabbage. The only satisfactory substitute for rotenone insecticides for use on cabbage after the heads begin to form are those containing the active principles of pyrethrum. It is recommended that dust mixtures contain at least 0.2 percent of pyrethrins. If a simple mixture of ground pyrethrum flowers and an inert diluent is used, it should contain 0.3 percent of pyrethrins.

To avoid a harmful residue hazard the arsenical or fluorine compounds should not be used on any part of the cabbage plant that is to be marketed. This means that cabbage intended for marketing as U. S. Grade No. 1 (which allows four loose outer leaves) should not be poisoned with these materials after the heads begin to form or the leaves start "cupping," that is, when the leaves in the center of the plant cease to spread outward. This usually occurs 30 to 40 days before harvesting normally begins.

During the preheading period of cabbage growth, dusts or sprays containing cryolite, calcium arsenate, paris green, or barium fluosilicate should be used. If applications of these arsenicals or fluorine compounds do not provide adequate control for the corn earworm or climbing cutworm, a poisoned bait consisting of cryolite and corn meal should be sprinkled into the buds of the plants just before they begin heading.

Applications of insecticides should be made at 10-day intervals beginning as soon as there is approximately one "worm" per plant or when approximately 25 percent of the plants in a field show signs of caterpillar feeding.

Control of cabbage caterpillars can be aided by the destruction of crop remnants as soon as harvesting is completed; by growing cabbage whenever possible during periods when the caterpillars are less abundant; and by planting new cabbage as far as possible from older caterpillar-infested cabbage.

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