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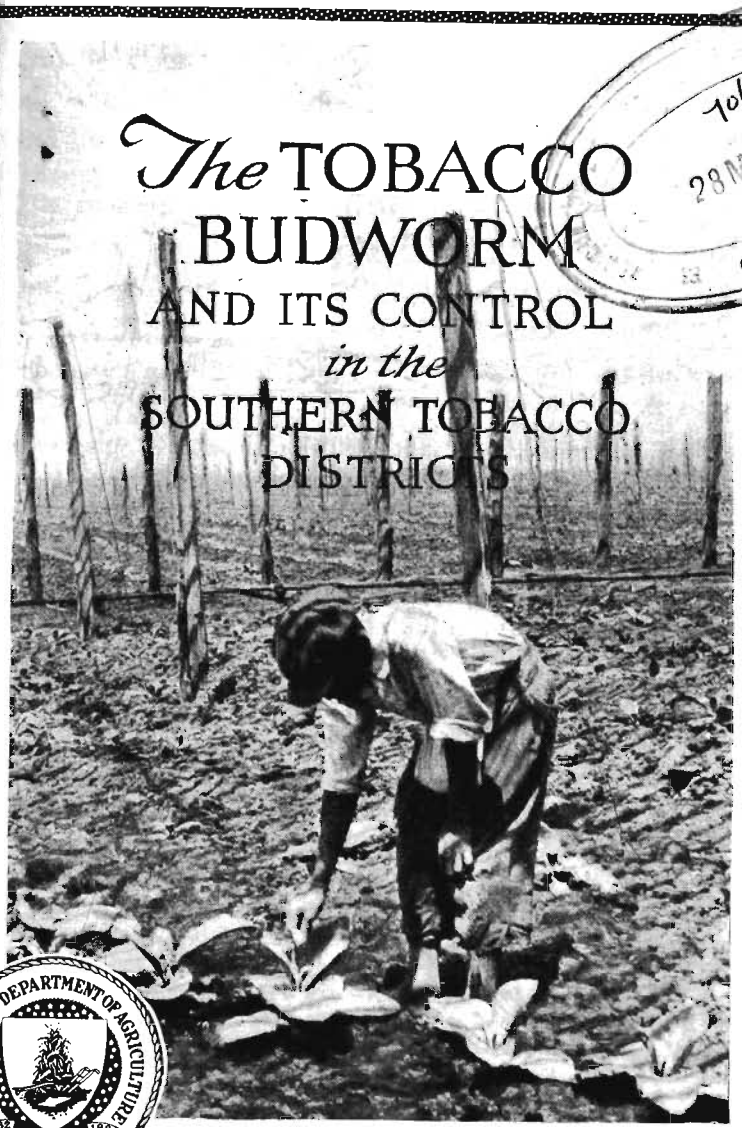
The TOBACCO BUDWORM AND ITS CONTROL *in the* SOUTHERN TOBACCO DISTRICTS



BUDWORMS eat holes through the tips of leaves in the developing bud of the tobacco plant, in both open and covered fields, reduce the yield, and render the product practically worthless except for cigar filler and plug filler. The seed also is injured.

The "worms," or larvæ, hatch from eggs laid on the leaves by a greenish moth, and injury begins as soon as they have migrated from the leaves to the bud—usually in about 24 hours.

Control measures, described on pages 7–11 of this bulletin, may be summarized as follows:

Cut and plow under the tobacco stalks as soon as possible after harvesting.

When fields are shaded with cheesecloth, provide cloth-covered gates and keep them closed, to exclude the budworm moths. Patch promptly all holes in cheesecloth shades.

Destroy plants in seed beds as soon as possible after a sufficient number have been taken for use in the fields.

Cover all seed beds with cheesecloth to exclude the moths.

As soon as plants have become established in the field, apply arsenate of lead and corn meal (1 pound of arsenate of lead to 75 pounds of the meal) to the buds. Continue applications twice a week until the plants are topped.

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THE TOBACCO BUDWORM[1] AND ITS CONTROL IN THE SOUTHERN TOBACCO DISTRICTS.[2]

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CONTENTS.

ONE of the most important insect enemies of tobacco, particularly in the South, is the tobacco budworm (Fig. 1). The presence of this pest in tobacco fields, even in very small numbers, may result in great damage to the crop. A thorough knowledge by the planter of the correct methods of control of this insect therefore is essential, especially in areas where the cultivation of tobacco for cigars is practiced.

Since the results of budworm attack on sun-grown and shade-grown tobacco are the same, the control measures outlined herein apply equally to both.

DESCRIPTION OF THE INSECT IN ITS DIFFERENT STAGES.

The tobacco budworm passes through four distinct stages in the course of its development—the egg, larva, pupa, and adult. The eggs are small, whitish, nearly dome-shaped objects, measuring about one-fiftieth of an inch in diameter. They are sculptured with radiating ribs and cross furrows.

The larva or worm stage (Fig. 1, *b*, *c*) varies greatly in color. The most common color is light green with paler stripes running lengthwise of the body, but the color may vary from green to yellowish, dark reddish brown, or even a very dark gray. Between these extremes there are many combinations of colors. Small larvæ which have passed through only one or two molts are much lighter in color than those which have fed more extensively and have cast their skins a greater number of times. When first hatched the larva measures about one-twentieth of an inch; when full-grown and ready

[1] (Chloridea) *Heliothis virescens* Fab.; order Lepidoptera, family Noctuidae. It was formerly known as *Heliothis rhexiae* S. & A.

[2] Revised by F. S. Chamberlin, scientific assistant, Southern Field Crop Insect Investigations, Bureau of Entomology.

[3] Resigned October 31, 1919.

to burrow into the soil for pupation it is about an inch and a half long.

The pupa, or quiescent stage (Fig. 1, *e*), which is spent in the ground, measures about three-fourths of an inch in length and is brown—almost the color of mahogany.

The adult, or parent (Fig. 1, *a*), of the budworm is easily distinguished from other insects found in tobacco fields. It is a greenish moth with a wing spread of about 1½ inches. The forewings are of a beautiful greenish color, obliquely crossed with three lighter lines, and the hind wings are whitish, bordered with a brownish fringe.

NATURE AND EXTENT OF INJURY.

Injury to the plants, which is entirely the work of the larvæ, or worms (Fig. 1, *b*, *c*), takes place as soon as the tiny larvæ, hatching from eggs laid on the leaves, reach the bud, although usually it is several days before planters become aware of the damage. The leaves of the bud have been developed somewhat, and examination reveals the presence of the small holes, which have increased in size. When these holes are made in the tips of the leaves in the developing bud, misshapen leaves often result; when the attack is made elsewhere large, unsightly holes develop as the leaf tissue expands (Fig. 2). In both cases the leaves are unfit for cigar wrappers, and must be placed in the lower grades, often at a loss of as much as $1 a pound. In growing tobacco for cigars it is necessary to produce entire leaves. So complete would be the loss in Georgia and Florida if no control measures were practiced against the budworm that the industry would have to be abandoned. Before the present investigation was begun the budworm was controlled entirely by use of the Paris green and meal mixture. In spite of the use of this insecticide as a means of control, the average loss per acre in shade-grown tobacco was estimated at $37.50. This was due in part to burning by the poison and in part to incomplete control of the insect.

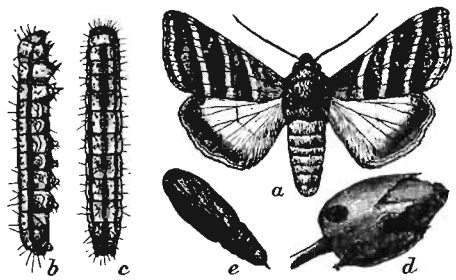

FIG. 1.—The tobacco budworm: *a*, Adult, or moth; *b*, *c*, full grown larva, from side and from above; *d*, seed pod bored into by larva; *e*, pupa. Natural size. (Howard.)

HISTORY AND DISTRIBUTION IN THE UNITED STATES.

The tobacco budworm is a very serious pest in the tobacco-growing sections of Florida, Georgia, Alabama, and Louisiana. Although common in North Carolina, South Carolina, and Virginia, it is much less injurious there than in the more southern part of its range. It is rarely injurious in Kentucky and Tennessee. It has been recorded from Missouri, Ohio, and Connecticut. Perhaps the earliest record of injury by this insect dates back to 1797. At that time Smith and

Abbot[4] wrote as follows: "[This species] eats the bud and blossoms of Rhexia, as well as of tobacco; to the latter it is very pernicious in Virginia and other places, as it destroys the main shoot."

In Georgia in 1886 it was reported by a planter to have been more injurious to tobacco than the hornworms.[5]

SEASONAL HISTORY.

Eggs and larvæ are present in tobacco fields in Florida and Georgia throughout the growing season. Moths often appear early enough in the spring to infest seed beds, and by setting-out time eggs are being deposited in large numbers. From the end of the growing season until the middle of August, larvæ are abundant upon stalks and suckers left standing in the fields. From this time on their numbers decline very rapidly, although they have been observed as late as November 23 at Quincy, Fla.

Eggs are deposited singly on the leaves, usually on the underside. In Florida, during the growing season of tobacco, they hatch in from three to five days. Newly hatched larvæ first feed sparingly on the shells of eggs from which they have issued and then eat small areas about the size of a pinhead from the leaf surface. These minute budworms then begin a migration and reach the bud of the plant in about 24 hours. They often stop to feed two or three times, but eat only one or two layers of the leaf cells and do no appreciable injury until they reach the bud.

When the bud is reached the characteristic injury is wrought. The young budworms conceal themselves between the immature, unfolding leaves and begin to feed very greedily. They are so small and so well concealed that they can be detected only by the very closest scrutiny, and if a dose of poison mixture has not been placed in the bud before their arrival extensive injury will have been done before any remedial measure can be made effective.

The larva or worm stage has been found to cover a period of from 18 to 31 days during May and June, at the end of which the mature larvæ burrow into the soil and pupate. The length of the pupa stage may vary during the summer, covering a period of from 13 to 21 days. The emergence of adults from the ground is affected materially by moisture conditions, for it has been observed that a great many moths often appear at the expiration of a dry period.

After the moths emerge a period of from four to five days may elapse before egg laying begins. Moths kept in captivity laid an average of 334 eggs. From observations during May and June of 1916 the average duration of the life cycle was determined to be 37½ days.

FOOD PLANTS.

Besides feeding on tobacco, the budworm has been recorded in the United States as attacking okra, deer grass,[6] geranium, and ageratum. It has been reported as feeding upon wild solanaceous plants, including ground cherry[7] and another species of the same genus.

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[4] Smith, Sir James Edward. The Natural History of the Rarer Lepidopterous Insects of Georgia. 1797.

[5] *Protoparce sexta* Joh. and *P. quinquemaculata* Haw.

[6] *Rhexia virginica.*

[7] *Physalis viscosa.*

Continued observations in the Florida shade-tobacco district, however, have made it apparent that in this region, at least, the tobacco budworm feeds sparingly, if at all, upon plants other than tobacco with the exception of beggarweed, which is fed upon to some extent during the fall months.

PREDACIOUS AND PARASITIC ENEMIES.

One of the important enemies of the tobacco budworm is a greenish spider,[8] which is extremely common on tobacco stalks in the South.

A certain wasp[9] also destroys many of the larger larvæ.

A fly[10] closely resembling the common house fly acts as a parasitic enemy of the budworm. This fly deposits eggs upon the body of the

FIG. 2.—Injury to tobacco plant by the tobacco budworm.

worm. These eggs hatch into tiny maggots, which burrow into the body of their host and after feeding there for some time finally destroy it.

The most important parasite of the tobacco budworm, however, is a small, black-winged, red-bodied, wasplike insect[11] which deposits its eggs in the bodies of the larvæ. These eggs hatch into maggots which ultimately destroy the worm. This parasitic insect may be seen continually flying from plant to plant examining the buds in search of budworms. Many farmers mistake these insects for the adult form of the budworm and often destroy them. Having seen the parasites enter the buds and fly away, the planters have examined the buds and, having found the small budworm within, have supposed that they were left there by the parasite.

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[8] *Peucetia viridans* Hentz.

[9] *Polistes bellicosus* Cress.

[10] *Sarcophaga sternodontis* Townsend.

[11] *Toxoneura* sp.

CONTROL MEASURES.

POISON APPLICATIONS.

It is evident from the habits of the budworm that the most feasible means of direct control are applications of some insecticide in the bud. Experience has shown that at least two applications a week are necessary in order fully to protect the bud, because the poison is scattered by the expansion of the rapidly developing leaves. The first two or three applications are made by the stick-and-cup method (Fig. 3). A quart cup with nail holes in the bottom is fastened to a stick and the poison mixture is sifted upon each plant as the operator walks slowly along the row. As the plants increase in size the leaves of the bud are more tightly folded and it becomes necessary to change the method of application by opening the bud with one hand and at the same time dropping a small portion of the poison mixture into the bud with the other hand. The poison is carried in a sack fastened around the waist. (See illustration on title page.)

FIG. 3.—Stick and cup method of applying poison mixture in the tobacco bud in combating the budworm early in the season before the bud leaves have become folded.

OBJECTIONS TO THE USE OF PARIS GREEN.

The insecticide in use in Florida at the time experiments by the Bureau of Entomology were begun was a mixture of 1 pound of Paris green to 150 pounds of corn meal. About 12 to 14 pounds per acre of this mixture is necessary for each application. The applications must be continued from the time tobacco is set until it is topped.

Shade-grown tobacco is very tender and very susceptible to injury from either a mechanical or a chemical source. In dry weather Paris green causes very little damage, but in wet weather considerable injury may result from the comparatively excessive amounts

that wash down and collect in the bud and in the axils of the leaves. Planters are familiar with this condition and attempt to avoid injury by making lighter applications. When such a course is adopted some of the poison injury is eliminated, but extra damage from budworm attack follows on account of the insufficient dosage. When Paris-green mixture is used there is always the possibility of damage, either from the action of the poison on the leaves or from budworm attack following the application of insufficient quantities of the mixture. The normal injury also is increased frequently because some laborers apply more of the mixture than is necessary for budworm control.

RELATIVE EFFICIENCY AND ECONOMY IN THE USE OF VARIOUS POISONS.

Owing to this danger of injury to the leaves by Paris green when used in sufficient amounts, and the imperfect protection afforded by smaller quantities, the discovery of a poison that would be safer under all conditions of weather and of application, and one that would at the same time give the greatest budworm control, was much to be desired.

During the seasons from 1913 to 1922, inclusive, experiments were performed with a large number of mixtures, including the following poisons, some of which have been used more or less commonly against the budworm: Arsenate of lead, arsenate of calcium, magnesium arsenate, antimony sulphid, Paris green, tripotassium arsenate, orthoarsenite of zinc, antimony arsenate, and antimony oxid.

These were tested in varying strengths and in combination with corn meal, gypsum, and fuller's earth as carriers. Of all the poisons used, Paris green, arsenate of lead, and golden antimony sulphid gave the most promising results, although these poisons differed greatly in efficiency and cost of application. Corn meal was found to be the most satisfactory carrier.

Table 1 indicates the average cost per acre per season of antimony sulphid, arsenate of lead, and Paris green, as well as the percentage of leaves free from budworm and poison injury. The cost data are based upon results obtained on 51 plantations, where 476 acres of tobacco were treated throughout the season. It was found that an average of 4.17 bushels of meal were necessary to the treatment of 1 acre. In calculating the total cost for the treatment of an acre, corn meal was valued at $1 per bushel (48 pounds). The prices per pound of antimony sulphid, arsenate of lead, and Paris green were taken as 35 cents, 25 cents, and 30 cents, respectively.

TABLE 1.—*Relative efficiency and economy of antimony sulphid, arsenate of lead, and Paris green in controlling the tobacco budworm.*

Poison used.	Cost of poison.	Cost of meal.	Cost of labor.	Total cost per acre per season.	Per cent of leaves free from budworm and poison injury.
Antimony sulphid, 1 pound; corn meal, 24 pounds..	$2.92	$4.17	$2.25	$9.34	98.35
Arsenate of lead, 1 pound; corn meal, 75 pounds.....	.66	4.17	2.25	7.08	98.25
Paris green, 1 pound; corn meal, 150 pounds.....	.40	4.17	2.25	6.82	92.50

From Table 1 it will be seen that where antimony sulphid had been used at the rate of 1 pound to 24 pounds of corn meal, 98.35 per cent of the leaves were free from budworm and poison injury; and that where arsenate of lead had been used at the rate of 1 pound to 75 pounds of corn meal, 98.25 per cent of the leaves were perfect. The cost of the applications of antimony sulphid per acre per season was $2.26 more than for the arsenate of lead, and of course the difference of one-tenth of 1 per cent in the efficiency of these applications in favor of the antimony sulphid would not compensate for the extra expense.

Where Paris green had been used at the rate of 1 pound to 150 pounds of corn meal, 92.5 per cent of the leaves were free from injury—5.75 per cent less than where arsenate of lead had been applied—and the cost of application per acre per season was 26 cents less than for the arsenate of lead. The injury following the use of Paris green has been shown to result in a loss of $37.50 per acre. In studies made in the Bureau of Entomology arsenate of lead has been shown to save $28.75 of this amount. The actual saving due to the use of arsenate of lead is $28.75 minus 26 cents (for arsenate of lead costs 26 cents per acre more than does Paris green), or $28.49. It will be understood, therefore, that the possibility of incurring a loss of $37.50 per acre will not justify the use of Paris green to effect a saving in material of 26 cents per acre.

A mixture of 1 pound of arsenate of lead and 75 pounds of corn meal has proved to be the most effective combination against budworms. As already stated, on account of the method of application necessary in controlling budworms, it is impossible to avoid some variation in the quantity applied to each bud. The arsenate of lead and corn meal mixture can be employed without fear of injury in case any amount within reason is used.

Poisons mixed with corn meal are more readily fed upon by budworms than those mixed with other carriers. This material appears to be attractive to the worm, apparently serving as a bait, whereas other carriers seem more or less distasteful. Then, too, corn meal is the most desirable material for this purpose because it does not interfere with the development of the immature leaves. Even when saturated during periods of showers, corn meal does not often become compact and cause damage such as takes place when other carriers are used.

As calcium arsenate is now being used rather extensively throughout the South as a poison for the cotton boll weevil, a word of warning may be needed in regard to its use in a budworm poison mixture. Calcium arsenate has been tried with various carriers and in various strengths over a period of several years and has invariably given unsatisfactory results.

Even in very dilute quantities, calcium arsenate burns tobacco severely, especially in rainy weather, and if used strong enough to serve as an effective poison it usually causes serious damage.

Tests have shown that the effectiveness of arsenate of lead when employed against the budworm varies with the carrier with which it is used, as indicated in Table 2.

TABLE 2.—*Relative efficiency against the tobacco budworm of arsenate of lead with different carriers.*

Poison.	Experiment No.	Budworm injury.
		Per cent.
Arsenate of lead, 1 pound; corn meal, 75 pounds	1	0.79
Arsenate of lead, 1 pound; gypsum, 25 pounds	2	3.00
Arsenate of lead, 1 pound; fuller's earth, 16 pounds	3	2.50

In experiment No. 1 arsenate of lead was used at the rate of 1 pound to 75 pounds of corn meal and only 0.79 per cent of leaves showed injury. In experiment No. 2 the arsenate of lead was used three times as strong as in experiment No. 1 (1 pound to 25 pounds), but with gypsum as a carrier. Three per cent of the leaves were injured—nearly four times as many as in experiment No. 1. In experiment No. 3 the arsenate of lead was used nearly five times as strong as in experiment No. 1, yet the leaf injury amounted to 2.5 per cent—more than three times that in experiment No. 1. These experiments indicate that of the three carriers corn meal is preferable in budworm control.

GENERAL RECOMMENDATIONS.

At the end of the growing season tobacco plants from which the marketable leaves have been removed are often allowed to remain standing in the fields. These provide breeding places for the budworm as well as other insect pests. As soon as possible after harvesting is completed plants should be either cut or pulled up and then plowed under.

Where tobacco is grown under cheesecloth, preventive measures against budworm attack may be practiced with a great deal of success. In such cases care should be taken to patch all holes in the cloth. Since it is necessary to provide openings in these shades through which workmen with farm animals and implements may come and go, gates covered with cheesecloth should be provided, and kept closed as much as possible so as to exclude the moths, or adults, of the budworm.

Plants frequently are left growing within and around old seed beds. These invariably are infested and contribute considerably to the abundance of moths which deposit eggs on plants within the fields. Plants about the seed bed should be destroyed, therefore, as soon as the seed bed is abandoned.

Seed beds should always be covered and walled in with cloth so as to prevent the entrance of moths. In this way the number of eggs introduced into the fields on the plants will be held to a minimum.

Because of the nature of attack of this tobacco pest, much care is necessary in direct-control practices. A slight delay in making poison applications often results in great damage to the crop.

The necessity of applying the mixture directly to the leaves of the bud can not be too greatly emphasized. The effects of careless manipulation may be almost as bad as if no control measures were attempted.

Planters should keep these points clearly in mind, because the difference between a valuable tobacco crop and one of less than ordinary quality is often dependent upon the care with which budworm control is practiced.

Direct control in Florida and Georgia should begin as soon as possible after the plants have become established in the field. Applications of the poison mixture should be made in the buds from then until the plants have been topped. It is of special importance to emphasize the necessity of beginning the applications of the poison mixture as soon as the plants are set in the field. A delay in starting this work may give time for the eggs that are introduced from the seed beds to hatch, and for the young larvæ (young budworms) to reach the bud and do considerable damage. For the best results the buds must be treated twice a week until topping has been completed.

The best mixture which has been employed in experiments under actual field conditions is 1 pound of arsenate of lead and 75 pounds of corn meal (approximately 6 heaping teaspoonfuls to 1 peck of corn meal). Bolted or sifted meal is preferable to the unsifted product. In the preparation of this mixture care should be taken to obtain an even distribution of the poison throughout the corn meal. For this purpose mechanical mixers have been employed where large quantities are necessary. These, however, are not essential, for with a little care the mixture can be prepared quite as well by hand.

Caution.—Calcium arsenate should *not* be used as a substitute for arsenate of lead in the budworm poison mixture.

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