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L. O. HOWARD, Entomologist and Chief of Bureau.

METHODS OF CONTROLLING TOBACCO INSECTS.

BY

A. C. MORGAN,
Agent and Expert.

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METHODS OF CONTROLLING TOBACCO INSECTS.

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INTRODUCTION.

Investigation by the Bureau of Entomology of the United States Department of Agriculture of insects affecting tobacco has been in progress in the "dark tobacco" districts of Kentucky and Tennessee since July, 1907.

In the work in Tennessee the Bureau of Entomology has had the hearty cooperation of the Tennessee agricultural experiment station and of its director, Prof. H. A. Morgan. During the summers of 1908 and 1909 Professor Morgan assigned a student, Mr. D. C. Parman, of the University of Tennessee, as an assistant to the Federal agent in charge of the tobacco-insect investigations. The writer wishes to express his thanks to Professor Morgan for the personal advice received from him and for this valuable cooperation.

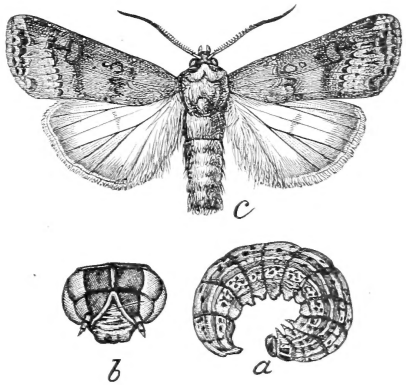

FIG. 1.—*Agrotis ypsilon*, one of the tobacco cutworms: *a*, Larva; *b*, head of same; *c*, adult. Natural size. (From Howard.)

In this investigation all insects found affecting tobacco have been studied, but particular attention has been given to the different species of cutworms, to the tobacco flea-beetle (*Epitrix parvula* Fab.), and to the tobacco hornworms (*Phlegethontius sexta* Joh. and *P. quinquemaculata* Haw.). In this particular circular only the insects mentioned above are considered. Although the investigation has not been completed,

it is thought that a description of remedies already in use, with the addition of those discovered during the investigation, may be of value to the growers.

It should be stated that the remedies herein treated will apply not only to Kentucky and Tennessee, but should apply equally as well to all tobacco-growing States which do not border on the Gulf.

CUTWORMS.

Tobacco is frequently very seriously injured by various species of cutworms, of which two common species are illustrated in figures 1 and 2. It is the common experience of all farmers that cutworms are the most abundant and injurious on land that has been left uncultivated for some time previous to being planted to a certain crop. Where tobacco follows clover serious injury from these pests is likely to result. On the other hand, if winter grain precedes tobacco very little injury is likely to occur. However, if tobacco is to follow a clover sod it is a simple matter to rid the soil of these "worms." If it is possible to do so, the sod should be plowed under in the fall or winter and be kept free of vegetation by disking or harrowing. Thus by keeping the field free of vegetation the cutworms will be starved to death before the time for setting the tobacco. When sod land is plowed only a short time before setting the tobacco, a trap bait may be used to rid the field of the worms. In Farmers' Bulletin No. 120[a] Dr. L. O. Howard recommends thoroughly spraying a patch of weeds or clover with Paris green, then cutting it and dropping it in little bunches here and there throughout the field. Another trap bait that meets with wide favor is also recommended by Doctor Howard.[b] It

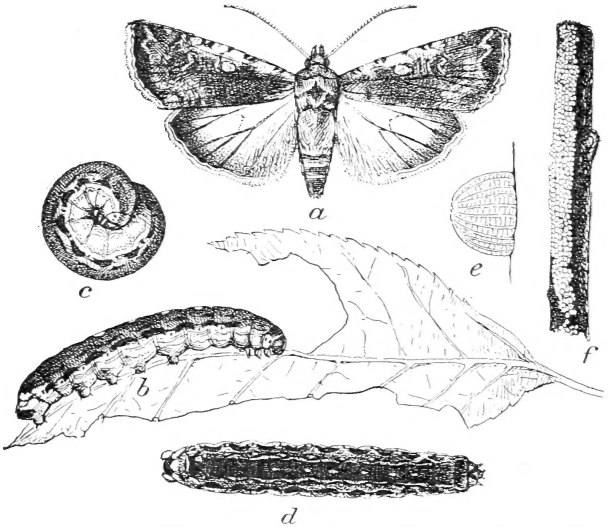

FIG. 2.—A tobacco cutworm (*Peridroma margaritosa*): *a*, Moth; *b*, normal form of larva, side view; *c*, same, in curved position; *d*, dark form of larva, from above; *e*, egg, from side; *f*, egg mass on twig. All natural size except *e*, which is greatly enlarged. (From Howard.)

[a] Farmers' Bulletin No. 120, United States Department of Agriculture, p. 23, 1900.
[b] Loc. cit.

consists of 1 pound of Paris green mixed with 50 to 75 pounds of bran, sweetened with molasses and moistened with water to make a mash. This should be dropped about the field three or four days before the plants are set, or two or three teaspoonfuls should be dropped about each hill after the plants are set. The cutworms are very fond of the sweetened mash and will generally eat it in preference to the plants. If seed beds should become infested with cutworms, the bran mash may be drilled through the bed and the ravages of the worms will be stopped. When trap baits are used great care should be exercised in keeping all live stock and barnyard fowls out of the field until the poisoned materials have been worked into the soil.

In the spring of 1908 the writer applied an arsenate of lead spray (made at the rate of 1 pound of arsenate of lead in paste form to 12 gallons of water) to a plant bed that was seriously infested with cutworms, with the result that all the cutworms were killed before they had done any appreciable additional injury to the plants.

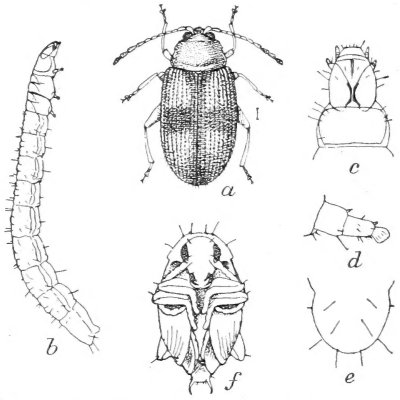

FIG. 3.—The tobacco flea-beetle (*Epitrix parvula*): *a*, Adult beetle; *b*, larva, side view; *c*, head of larva; *d*, hind leg of same; *e*, anal segment of same; *f*, pupa. *a*, *b*, *f*, Enlarged about 15 times; *c*, *d*, *e*, more enlarged. (From Chittenden.)

THE TOBACCO FLEA-BEETLE.

(*Epitrix parvula* Fab.)

The tobacco flea-beetle (*Epitrix parvula* Fab.) (fig. 3) is known also by the common names of "tobacco flea" and "flea-beetle." It may be found, from setting time until frost, in more or less injurious numbers in every tobacco field in the United States. The most injurious outbreak on record occurred in the "dark tobacco" districts of Kentucky and Tennessee in the spring of 1907. Nearly all plant beds, except those tightly canvased, were devastated. Practically all the first sowing was destroyed and in many cases the second and third also. In consequence the acreage was reduced 15 to 20 per cent, and owing to the fact that the crop as a whole was set much later than usual an additional loss resulted. Late-set tobacco does not produce the same number of pounds as the early-set tobacco, and because of the lateness of harvesting and the near approach of cool weather this tobacco frequently cures poorly and is graded lower than tobacco that is harvested earlier in the season. The loss in Kentucky and Tennessee in 1907 was not far from $2,000,000.

The tobacco flea-beetle passes the winter in the adult stage in piles of dead leaves or dead grass in the woods, or in fence corners and

similar localities. The beetles begin to emerge from hibernation in Kentucky and Tennessee in March, generally about the time the young tobacco plants are appearing in the plant beds. The young and tender plants furnish a favorite food for the beetles, and unless the beds are well protected by canvas considerable damage is sure to result. The flea-beetle also seriously injures tobacco in the field. The writer has observed fields where numbers of plants were killed by its ravages. The young leaves were riddled with holes (fig. 4) and new foliage was completely devoured as fast as it appeared.

The tobacco flea-beetle occurs upon many species of solanaceous plants, as it has been found feeding upon tomato, potato, horse nettle, ground cherry, and "jimson weed" (*Datura stramonium*). It lays its eggs on or near the base of the stems of these plants and also upon the stems of young tobacco plants. The principal injury to tobacco is occasioned by the feeding of the adults upon the foliage, although

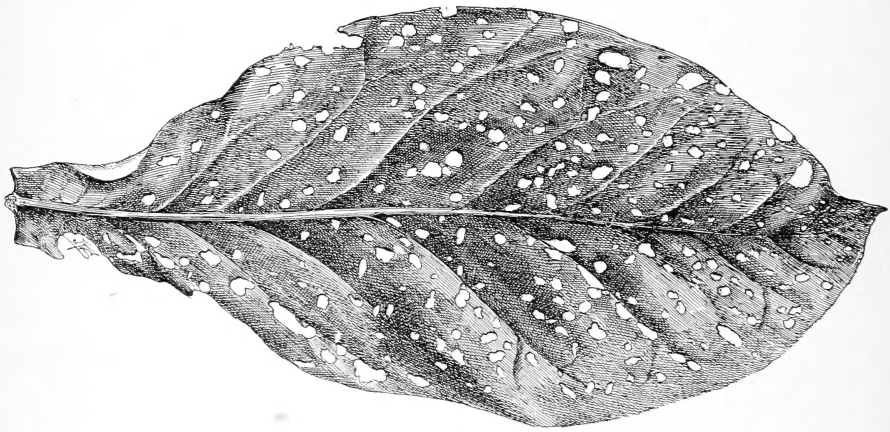

FIG. 4.—Leaf of young tobacco plant, showing work of the tobacco flea-beetle. (Original.)

the larvæ occasionally do considerable damage to the young plants by feeding upon the roots and stems.[a]

PREVENTIVE MEASURES.

Properly canvased beds escaped uninjured in 1907. Only whole, strong canvas should be used, with boards or straight logs for the sides of the bed, banking up the earth 3 or 4 inches against the sides so that no holes are left beneath the logs, and fastening the canvas closely and securely to the sides. Beds canvased in this way will not suffer from flea-beetle attack.

[a] The biology of this insect has been carefully worked out by Dr. F. H. Chittenden in Bulletin No. 10, of this office, pp. 79–82, and in Bulletin No. 19, pp. 85–87.

REMEDIAL MEASURES.

Even though flea-beetles do gain access to the plant beds in great numbers they can be controlled economically. Nearly all the severe loss of 1907 could have been averted had the growers known the proper remedy to apply. The writer has found the following insecticide very efficient in killing the beetles and not at all injurious to the plants:

Arsenate of lead (in paste form, or ½ pound powdered form)	pound	1
Water	gallons	12 to 16

Mix the arsenate of lead thoroughly in a small quantity of water, pour into the tank, and add sufficient water to make the desired quantity; then apply to the bed with a spray pump until every leaf is thoroughly dampened. Two very good spray pumps are illustrated in figures 5 and 6. If a heavy rain falls soon after the application is made it may be necessary to make a second application; but it must be remembered that arsenate of lead will stick to the foliage much longer than Paris green, and will not be greatly dissipated by a light shower. After the plants have grown considerably it will be necessary to spray the bed again if flea-beetles are still numerous, for the new foliage will, of course, not be protected by the first application.

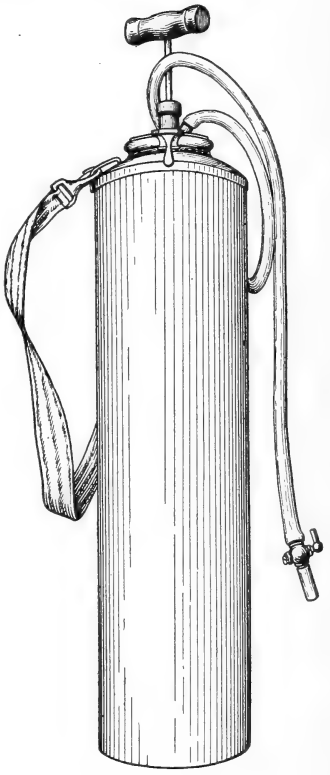

FIG. 5.—Compressed-air spray pump.

If flea-beetles are very numerous at the time of setting tobacco, the plants can be protected for several days by dipping the *tops*, just before setting, in the arsenate of lead spray recommended for use upon the plant bed. If plants are not dipped at setting time and if the flea-beetles appear in the fields in injurious numbers, apply the arsenate of lead, in the strength recommended above, with a knapsack sprayer (fig. 6). With this sprayer one man can spray from 5 to 6 acres of young tobacco in a day at a cost of from 25 to 35 cents an acre for arsenate of lead.

Tobacco growers as a rule pay too little attention to protecting their plant beds from insect attack. The result is that more of the

crop has to be set late than would be the case if the beds were protected. The grower should always be prepared to fight the flea-beetle, for often prompt attention to insect attack upon the plant bed will enable him to save his bed and thus be prepared to set all his crop early.

An early-set crop of tobacco has two very important advantages over a late-set crop. The first is the production of a better grade and of more pounds to the acre, as mentioned above. The second advantage is often more important than the first. An early-set crop will frequently mature in time to be cut before the August "shower" of tobacco worms is large enough to do it serious injury. This point will be explained more fully in the following discussion of the tobacco hornworms.

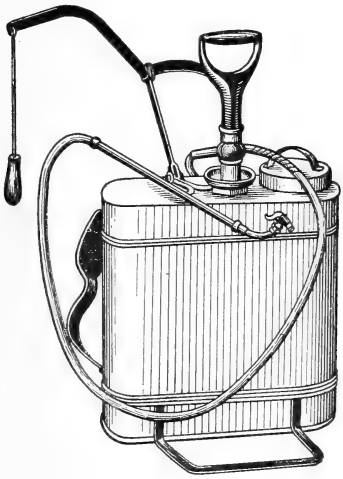

FIG. 6.—Knapsack spray pump.

THE TOBACCO HORNWORMS.

(*Phlegethontius sexta* Joh. and *Phlegethontius quinquemaculata* Haw.)

In the "dark tobacco" districts of Kentucky and Tennessee the hornworms are the most injurious tobacco insects, and they are important enemies of this crop in every district in the United States where it is grown. There are two species, the northern tobacco worm (*Phlegethontius quinquemaculata* Haw.) and the southern tobacco worm (*Phlegethontius sexta* Joh.) (fig. 7). The northern tobacco worm is called also the "Spanish worm" in Tennessee and Kentucky. This "worm," or larva, is in general darker than the southern tobacco worm, but the easiest way of distinguishing the two species is by the white markings on the sides of the body. The northern worm has 8 V-shaped markings on each side of the body, each of which incloses a spiracle, or breathing pore. The southern worm has 7 oblique lines on each side of the body, each of which passes in front of a spiracle.

DISTRIBUTION.

In general, as the common names indicate, the northern worm is most numerous in the north and the southern worm is most numerous in the south. The northern species is found as far south as Florida, though it is rare, and the southern species has been collected in Canada. At Washington, D. C., on the authority of Dr. F. H. Chittenden, the northern species predominates, while in Tennessee

the southern species is much the most abundant. These two species are so nearly alike in their work, life history, and seasonal history that the remedial measures which apply to one will apply equally well to the other. The life history and seasonal history notes given in this article are from observations upon the southern species (*Phlegethontius sexta* Joh.).

LIFE HISTORY AND SEASONAL HISTORY.

This circular does not propose to describe in detail the life history and seasonal history of the tobacco worms, but to give only such data

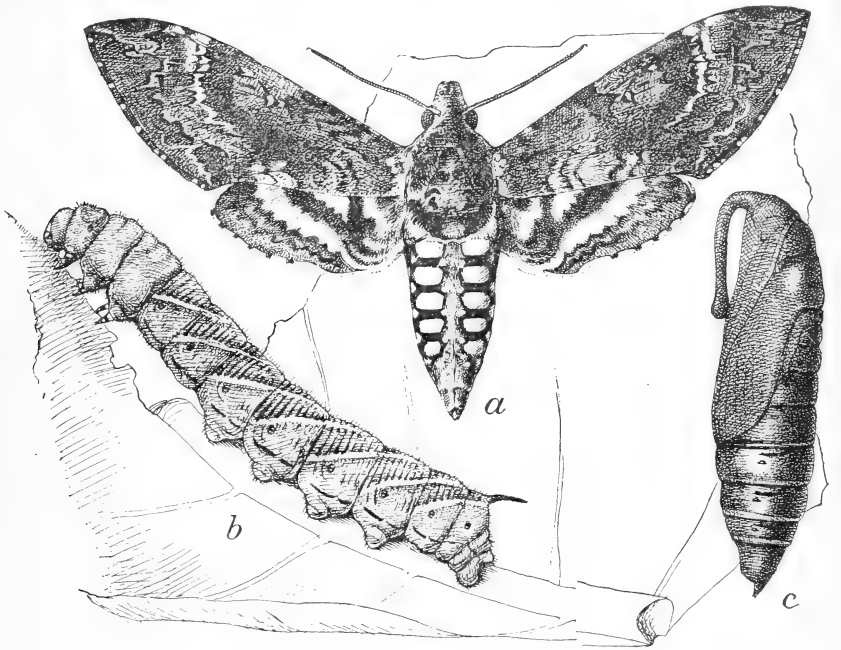

FIG. 7.—The Southern tobacco hornworm (*Phlegethontius sexta*): *a*, Adult; *b*, larva; *c*, pupa. (From Howard.)

as are necessary for the proper understanding of the reasons for recommending certain methods of control.

The tobacco moths begin to emerge from hibernation about June 1, and in a few days more they begin to deposit eggs. By reference to Table I it will be seen that the eggs hatch in about 4 days, and that the "worms," or larvæ, in from 19 to 20 days, pass through five stages of growth. They then enter the soil to pupate (fig. 8). Those that pupate not later than the last week of July will emerge in about three weeks as adult moths of the second generation, and will commence

depositing eggs in 3 or 4 days. Those that pupate after the 10th of August will usually hibernate, and will not emerge as adult moths until the following year. It is not until the third stage of growth—

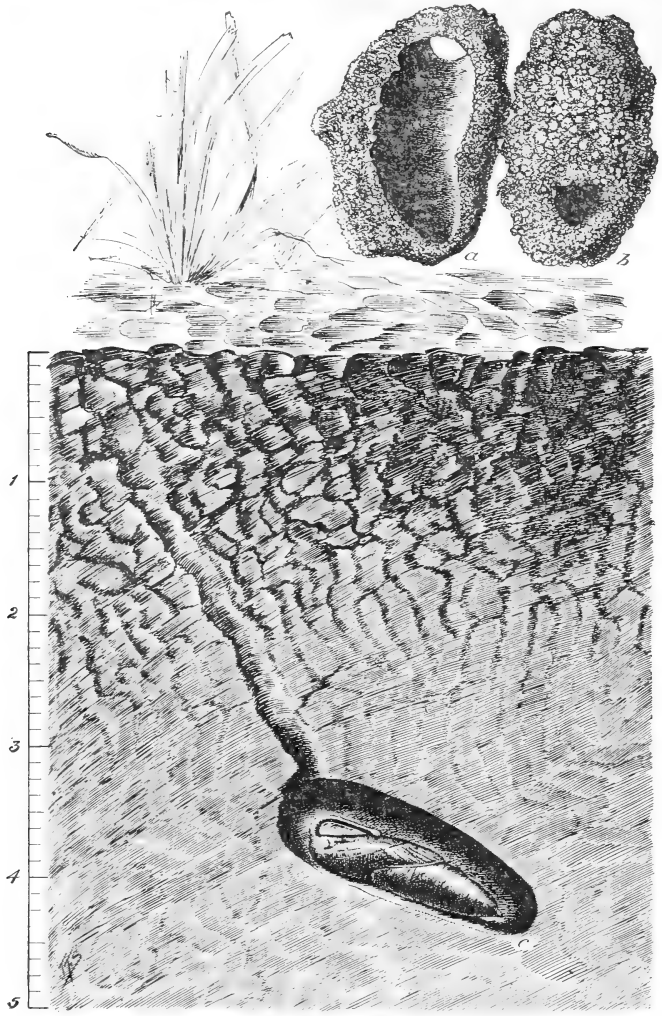

FIG. 8.—Hibernation of Southern tobacco hornworm: *c*, Pupa in hibernating cell in soil, at the depth at which pupation usually takes place in the stiffer soils; *a*, cross section of pupal cell viewed from below; *b*, pupal cell showing entrance hole of larva or "worm." Two-thirds natural size. (Original.)

that is, about 10 to 12 days after the eggs are deposited—that the larvæ injure tobacco seriously. In the fourth (fig. 9) and fifth stages one larva will ruin a small leaf of tobacco in a single day.

TABLE I.—*Average length of different stages in life history of the southern tobacco hornworm (Phlegethontius sexta).*

Emergence of moth to oviposition.	Incubation period.	Instars, or stages, in growth of larva.					Total larval period.	Pupal period.	Total life cycle.
		First.	Second.	Third.	Fourth.	Fifth.			
Days. 4	*Days.* 4	*Days.* 3	*Days.* 3	*Days.* 3	*Days.* 4—	*Days.* 6.5	*Days.* 19.5	*Days.* 21	*Days.* 48

The tobacco moths, as has already been stated, begin to emerge from hibernation about June 1, or slightly earlier, and the *emergence continues until the middle of August or later.* From Table I we see that 48 days after the emergence of the moths from hibernation the moths of the second generation will become adult, and that in 4 days more they will begin to deposit eggs. These eggs will hatch in 4 days, and in 6 or 7 days more—that is, in about two months from the emergence of the first moths from hibernation—the larvæ of the second generation will pass into the third instar, the instar in which they begin to injure tobacco seriously. For example, let us take 4 moths that have emerged from hibernation on the following dates: June 1, June 15, July 1, and July 15. The second generation of tobacco worms, the progeny of these moths, will begin to injure tobacco seriously about August 1, August 15, September 1, and September 15, respectively.

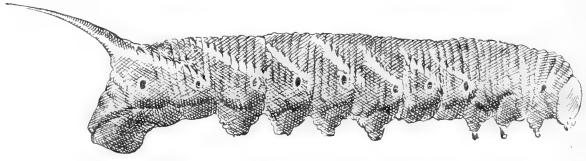

FIG. 9.—The Southern tobacco hornworm: Larva, fourth instar. Natural size. (Original.)

Although moths of both the first and second generations are depositing eggs during late July and in August, we will show later that by far the greater percentage of them has just emerged from hibernation, and belongs, therefore, to the first generation. This fact has a very important bearing upon the recommendation of fall plowing.

Tobacco worms begin to enter the soil to pass the winter (i. e., hibernate) about the middle of August, and continue doing so until frost. Usually they penetrate the soil to a depth of from 3 to 6 inches. Several observations upon "second bottom" soils of the Cumberland River have shown the average depth to be 4 inches; that is, to nearly the greatest depth to which the land was plowed in pre-

NOTE.—For the purposes of this article the date of oviposition may be considered as taking place at any time from June 1 to July 15, for there will not be a second generation from eggs deposited after the latter date.

paring it for the tobacco crop. After the larvæ, or "worms," have reached this depth they twist and turn many times, finally forming by this action oval cells, in which in a few days they transform to the hibernating form, or pupæ (fig. 8). The cells protect the pupæ much better from changes in the weather conditions than if the soil were lying in close contact to them. The insects remain as pupæ in the cells during the winter and, as has been stated, begin to emerge about the 1st of the following June as adult moths ready to deposit eggs upon tobacco.

EMERGENCE OF THE SOUTHERN TOBACCO HORNWORM FROM HIBERNATION.

Careful records of the emergence from hibernation of the moths of the southern tobacco worm (*Phlegethontius sexta*) were kept during the seasons of 1908 and 1909 with very interesting results. In 1908 the emergence began about the last of May and continued until August 13. In 1909 the emergence began June 1 and continued until August 22, a period of 83 days. The records of 1908 were from an emergence of 58 moths. The records of 1909 were taken from an emergence of 1,667 moths, and are, therefore, of more value than the records of 1908. The most interesting part of the data is the fact that in both years a large percentage of the moths issued after midsummer. Table II shows the most important data obtained from the emergence records.

TABLE II.—*Record of emergence of tobacco moths from hibernation.*

Period of emergence.	Emergence during period.	Period of emergence.	Emergence during period.
1908.[a]	*Per cent.*	1909.[b]	*Per cent.*
June 1 to July 15	34.5	June 1 to July 15	22.7
July 16 to August 13	65.5	July 16 to August 22	77.3
July 21 to July 31	52	July 29 to August 9	50
July 21 to August 13	63.8	July 29 to August 22	59

[a] Emergence began about June 1.

[b] Emergence began June 1.

From Table II it will be seen that there was a large wave of emergence in 1908 in the 11 days from July 21 to July 31, inclusive, and that 52 per cent of the total emergence took place during that period. The record further shows that after July 15, 5 per cent of the total emergence took place. In 1909 the results were very similar. The large wave of emergence took place during the 11 days from July 29 to August 9, inclusive, and 77.3 per cent of the emergence occurred after July 15.

REMEDIAL MEASURES.

It has been the belief that the larger percentage of the tobacco worms that appear in late July and in August and September are of the second generation. This is not true, for nearly all the worms

that appear before the middle of July are killed by hand worming, and we have already shown by means of the life-history records that it will be two months from the emergence of the hibernating generation before the "worms," or larvæ, of the second generation will be large enough to injure tobacco seriously.

The statement has been frequently made to the writer, and personal observation has convinced him of its truth, that no difficulty is experienced in keeping tobacco free of worms by hand worming until the middle of July or later. Therefore, if tobacco is not injured by worms until after the middle of July, the conclusion is that until that date very few large tobacco worms have escaped hand worming and that the second generation from those that have escaped will be a very small one. *By far the greater portion of tobacco worms that appear in late July and in August are the offspring of moths that have emerged from hibernation;* for the second generation of worms, the offspring from those worms that mature after July 15 will not be of sufficient size to injure tobacco seriously until about September 15. If tobacco has been set early the crop will be ready for the barn by this date and will, therefore, escape the second generation of worms.

FALL AND WINTER PLOWING.

Numerous experiments in 1907, 1908, and 1909 have demonstrated that as a rule only about one-fourth of the tobacco worms that hibernate are able to survive the winter and become adult. A part of the mortality is due to parasites, but a greater part of it is due to the unfavorable weather. The hibernating period is, therefore, a very critical period in the seasonal history of the tobacco worm, and many of those that do survive this period must be greatly weakened. Hence, any artificial disturbance of natural conditions will produce an additional mortality. As has been stated, the hibernation period is passed in the pupal stage in an oval cell (fig. 8), about 4 inches below the surface of the soil.

The most simple method of disturbing the pupæ during hibernation is to disk or plow the land. Both methods were tried. It was found that the disk would reach only from 5 to 10 per cent of the cells, and that therefore little benefit could be derived from that treatment. *The experiments in plowing the land killed more than half the pupæ that would otherwise have passed the winter successfully.* The ground should be plowed to the same depth as it was in preparing it for tobacco, for many of the tobacco worms will go down to the hard soil to form the hibernating cell, that is, to the greatest depth to which the soil has been broken. Plowing will throw the pupæ and the cells up to or near to the surface, will break the cells in nearly all cases, and will place the pupæ in close contact with the earth, in

which condition they are most susceptible to changes in temperature and to other climatological changes.

A week or ten days should elapse between the time of cutting the tobacco and the plowing of the land, in order to give all larvæ that are in the soil time to change to the more helpless pupal stage. Plowing should be done as soon thereafter as possible, so that the pupæ will be exposed as long as possible to unfavorable conditions.

It is the practice in many localities of Kentucky and Tennessee to disk the land that has been in tobacco in preparation for the wheat that is usually sowed after the tobacco crop has been harvested. In some localities it is thought that disking tobacco land is a better preparation than plowing, for the reason that plowing loosens up the soil too deeply and that the wheat will freeze out more easily. Undoubtedly this may be true for some soils, that is, soils that contain little clay and do not, therefore, run together very compactly. There is, however, a large proportion of clayey soils in the Tennessee and Kentucky tobacco regions in which wheat should not freeze out easily. In fact, many farmers always plow their tobacco land in preparing it for wheat because they believe they obtain a better yield. Whether it is wise or not to plow tobacco land for wheat is a question that each farmer must decide for himself. But it is certain that plowing will cause the death of more than half the pupæ, while disking will kill very few. Upon the looser soils it would, perhaps, be better to change the rotation and to sow some crop other than wheat after tobacco.

COMBATING TOBACCO HORNWORMS UPON GROWING TOBACCO.

If tobacco is planted early the hand worming, necessary to kill all worms that appear before the large emergence wave in late July (Table II), can be made incidental to other processes in the growing of tobacco, and will require very little additional time and labor. Usually, in addition to the cultivation with farm implements, tobacco will receive the following attention: Two hoeings, hilling, priming, and topping, and much of the early tobacco will be suckered. During these necessary operations it is very easy to discover and to kill the few tobacco worms that have appeared, but when the large wave of emergence appears, hand worming will be found very costly, and in some localities impossible because of the scarcity of labor.

When tobacco worms are numerous it will require an outlay of at least $8 to $10 an acre to hand-pick the worms, and frequently the outlay will exceed $10 an acre.

Use of Paris green.—After the appearance of the July and August "shower of worms" an application of Paris green with a dust gun (fig. 10) will be found to be the most economical means of combat. In Tennessee and Kentucky Paris green is generally applied without

a carrier, but the writer prefers to mix it with twice its weight of finely powdered air-slaked lime, for when the application is made without a carrier the cloud of dust from the nozzle of the dust gun is so thin that it is impossible to determine whether the application is being made evenly. On the other hand, if the Paris green is mixed with about twice its weight of lime, the cloud of dust from the nozzle will always show whether the gun is working properly, and a clogging of the tubes can be discerned instantly. *Apply the dust early in the morning when the dew is upon the plants and when there is no breeze.*

FIG. 10.—Applying Paris green to tobacco with a dust gun. (Original.)

Use a dust gun that has a strong fan power, and apply to only one row at a time. Great care should be taken to make the application even and thorough. No definite date can be given for making the first application. The time will depend upon the appearance of the young tobacco worms, and it may be the last week in July or not until about the middle of August. In 1908 and 1909 some of the early planted tobacco at Clarksville, Tenn., did not require poisoning, and in 1909 some of it required almost no worming. The first appli-

cation should be made within three or four days after the eggs begin to hatch. A thorough application of from three-fourths of a pound to 1 pound to the acre should be sufficient to kill the young larvæ. Do not wait until the worms become half grown before making the application, for in addition to being very much harder to kill than the young ones, they will do considerable damage to the leaves before they are killed. In dry weather a thorough application will remain effective for a week or ten days, but if there is a rain the application should be repeated immediately. The number of applications and the dosage will be influenced by weather conditions—whether wet or dry—by the numbers of young worms that appear, and by the earliness or lateness of the crop. By watching the effect of an application it can be easily determined whether it is losing its effectiveness and whether another application is necessary. The presence of a few large worms does not necessarily mean that the poison is ineffective. Some worms will escape the most careful applications, and these should be hand picked. The strength of the later applications upon tobacco that is nearly grown may be increased to 1, 1½, or even 2 pounds to the acre.

Caution.—Do not apply Paris green until two or three days have elapsed after suckering, for if a light rain should wash the Paris green into the fresh wounds made by breaking out the sucker, the caustic effect of the free arsenic may cause the leaves to drop off; also, do not apply a heavy dose of Paris green to tobacco when it is beginning to "grain," for the leaves are then more susceptible to "Paris green burn" than they are a few days previous to "graining."

Spraying tobacco versus dusting.—In this circular we have recommended dusting tobacco instead of spraying for two reasons: First, the labor of spraying is very much greater than that required to apply the dust. When tobacco is nearly full grown, that is, has begun to lap in the row, it will require from 120 to 150 gallons of water to spray an acre. Therefore, to apply the spray to 1 acre a 5-gallon knapsack sprayer must be refilled from 24 to 30 times. Second, the Paris green is not kept in suspension very easily in a knapsack sprayer and the last of the spray from the tank is likely to contain more than its proportion of the Paris green and thus cause injury to the plant. Furthermore, if great care is not used in applying the spray, a part of the plant is very likely to be drenched and the Paris green will be collected along the midribs and in the axils of the leaves in sufficient quantity to cause serious injury. It is not denied that a more even and thorough application can be made in spray form, but with negro labor, and with most white labor, we do not believe it will be made as satisfactorily as in the dust form.

Arsenic left upon tobacco.—There is fear among growers that if arsenicals are used a sufficient amount of arsenic may be left

upon the cured tobacco to injure the user. This fear is groundless. Prof. H. Garman,[a] state entomologist of Kentucky, reports the results of several experiments to determine the amount of arsenic left upon treated tobacco. Paris green was used at the rate of 1 pound to 160 gallons of water. The experimental row that received the greatest amount of Paris green received 8 sprayings with a total

FIG. 11.—Applying Paris green to tobacco with a knapsack spray pump. (Original.)

of $4\frac{1}{3}$ pounds to the acre. The last spraying was made August 22, and the tobacco was cut September 4. Analysis of this tobacco showed 0.651 grain arsenious oxide to the pound. In the several experiments performed by Professor Garman only one experiment gave more than one grain of arsenious oxide to the pound of dried tobacco, and the tobacco in this experiment was sprayed the day it

[a] Bul. 63, Ky. Agr. Exp. Sta., pp. 69–74.

was cut. Professor Garman concludes that very little danger may be apprehended from the arsenic left upon tobacco. In 1909 the writer made several experiments to determine the amount of arsenic left upon tobacco. To make the test severe, arsenate of lead was used because this arsenical adheres to tobacco much longer than does Paris green. August 13 the experimental plat received a spraying at the rate of 5 pounds to the acre, and on August 18 a second spraying at the rate of 4 pounds to the acre. Arsenate of lead in dust form was used, hence the two dosages, amounting to 9 pounds, were almost exactly equivalent in the amount of combined arsenic to Professor Garman's dosage of 4⅓ pounds of Paris green. The tobacco was cut September 8. The analysis, made by the Miscellaneous Division of the Bureau of Chemistry, showed an average of 0.347 grain arsenious oxide per pound. Heavier dosages of powdered arsenate of lead left only 0.501 and 0.531 grain arsenious oxide per pound. A fatal dose of arsenic for an adult is about two-thirds of a grain, and this, of course, has to be taken into the stomach. Since tobacco is not taken into the stomach, and since so little arsenic will be taken into the mouth at any one time, it is not believed that there is the slightest danger in using tobacco that has been poisoned with either Paris green or arsenate of lead; in fact, the writer is personally acquainted with tobacco growers who have been applying Paris green to their tobacco for from six to eight years and who have been chewing and smoking the cured tobacco without injurious effects.

POISONING THE TOBACCO MOTHS.

The custom of poisoning "jimson" blooms with arsenide of cobalt (flystone) to kill the tobacco moths when they feed has long been recommended and has been practiced in nearly every tobacco region, but unfortunately the custom has fallen into disuse. This method of combating tobacco moths should be revived, for the killing of one female moth at "jimson" blooms will be equivalent to the killing of several hundred worms later.

The following is the formula for this poison:

Arsenide of cobalt (flystone)	ounce..	1
Water	pint..	1

Sweeten, just before using, with molasses or honey. Place a few drops in each bloom late in the afternoon.

SUMMARY.

CUTWORMS.

1. Plow sod land in the fall in preparing it for tobacco and keep down all vegetation during the winter and spring. This will starve the cutworms.

2. If sod land has not been treated as recommended above, use the poisoned bait four or five days before setting tobacco, or drop the bait about each hill directly after setting tobacco.

FLEA-BEETLES.

3. Canvas seed beds tightly with strong whole canvas and thus prevent entry of the beetles.
4. Spray infested beds with arsenate of lead at the rate of 1 pound paste form (or ½ pound powdered form) to 12 gallons of water.
5. If flea-beetles are very numerous at setting time dip the *tops* of the plants in the arsenate of lead recommended in No. 4.
6. If flea-beetles continue to injure plants after setting, spray with arsenate of lead at the strength given above.

TOBACCO HORNWORMS.

7. Nearly all the destructive late July and August "shower" of worms is the direct offspring of tobacco moths that have issued from hibernation during late July and early August.
8. Over 60 per cent of the hibernating generation of moths emerge from hibernation late in July and in August.
9. Fall plowing of land that was in tobacco during the year will destroy more than half of the hibernating generation and will thereby reduce proportionately the number of tobacco worms that will appear the next year late in July and in August.
10. Poison worms upon tobacco plants by dusting with Paris green.
11. Poison tobacco moths by placing a few drops of arsenide of cobalt (flystone) solution in "jimson" blooms.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *April 18, 1910.*

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