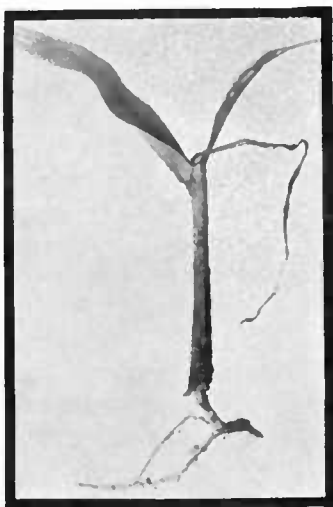


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*The*  
Southern Corn  
Rootworm  
and Farm Practices  
to Control it

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FARMERS'  
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**O**F ALL CORN PESTS in the South one of the most serious is the southern corn rootworm, the larva, or young, of the 12-spotted cucumber beetle. True to its name, it feeds on the roots, but in young corn it also drills a small hole in the stem just above the first circle of roots, boring out the crown and killing the bud. Attacked plants either die outright or are so badly stunted as to be unproductive. Lowland corn suffers the most, and injury is greatest during cool, damp seasons. The adult, or beetle, is also exceedingly destructive; not, however, to corn, but to cucumber, squash, and a great variety of other truck crops and ornamental plants.

Progressive farming methods, as described in this bulletin, will reduce the ravages of this insect. Terraces and margins of fields should be burned over to destroy dead grass, weeds, and rubbish in which the beetles pass the winter. And corn can be planted late enough to avoid serious injury from rootworms, as recommended on page 7 of this bulletin. On lands subject to infestation in northern areas, hybrid varieties of corn that develop profuse, fibrous root systems should be planted. The soil may be enriched by planting legumes so that the corn will have a better chance of recovery from rootworm injury.

# THE SOUTHERN CORN ROOTWORM AND FARM PRACTICES TO CONTROL IT

By PHILIP LUGINBILL, *senior entomologist, Division of Cereal and Forage Insect Investigations, Bureau of Entomology and Plant Quarantine*

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## ECONOMIC IMPORTANCE AND COMMON NAMES

CORN GROWERS in the Southern States suffer damage from the southern corn rootworm (*Diabrotica duodecimpunctata* (F.)) (fig. 1) practically every year. In fact, the rootworm has few competitors as a serious corn pest in the South. During some seasons it is quite a difficult matter to get a stand of corn in the lowlands on account of these "worms." During years of heavy infestation it is necessary to replant corn as many as three times, and even then only a poor stand is obtained. The loss that may be attributed to the ravages of the pest is probably even greater and more far-reaching than is commonly supposed. Very often weather conditions are blamed for the yellowish and sickly appearance of corn and the resulting poor yield of the crop when the true cause is injury done by the southern corn rootworm.



FIGURE 1.—Larva, or grub, of the southern corn rootworm, side view. About  $4\frac{1}{2}$  times natural size.

The southern corn rootworm is commonly known as the "budworm"; in fact, few farmers know it under the former name. It is also sometimes termed "drillworm." These names are more or less descriptive of the injury done to the plant by the grubs. The adult, or parent, is known as the 12-spotted cucumber beetle, from the fact that it has 12 black spots on its back and is often a serious enemy to cucumbers and allied plants.

## GEOGRAPHICAL RANGE OF THIS AND RELATED ROOTWORMS

The southern corn rootworm is found throughout the greater part of the United States, from Maine to Florida and from the Atlantic coast to the Rocky Mountains. It occurs also in Mexico and Canada. It is not recognized, however, as a serious enemy of corn north of Maryland and the southern parts of Ohio, Indiana, and Illinois, south of Georgia, or west of the Mississippi River, with the exception of parts of southeastern Missouri, eastern Arkansas, southeastern Texas, and Louisiana (fig. 2).

A closely allied western insect, the corn rootworm (*Diabrotica longicornis* (Say)) takes its place to some extent in the Middle West and also is found from Maine to the Gulf of Mexico and westward to Minnesota, South Dakota, and New Mexico.

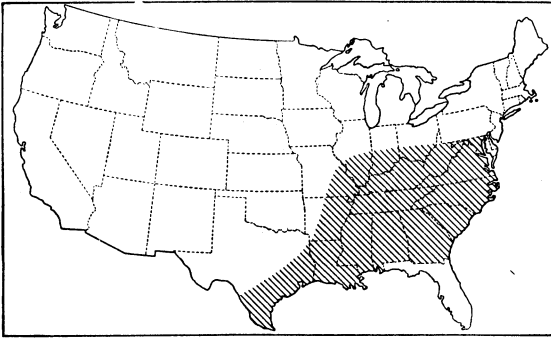


FIGURE 2.—The shaded areas on this outline map of the United States show the region where corn is most seriously injured by the southern corn rootworm.

In the States bordering the Pacific Ocean occurs another closely allied species known as the western spotted cucumber beetle (*Diabrotica soror* LeConte), which in its grub stage is a rootworm attacking various cultivated crops. In southern Texas there is still another species, the banded cucumber beetle (*Diabrotica balteata* LeConte), which sometimes does practically as much damage to corn in that region as does the southern corn rootworm.

### WHEN SERIOUS INFESTATIONS MAY BE EXPECTED

Serious infestations of the rootworm may be expected during seasons of abundant rainfall and cool weather, conditions conducive to the development of this insect. Corn in lowlands is more seriously affected than that in uplands, as this insect prefers to breed in moist soil. Thus it is only during years of heavy infestation that corn in uplands is subject to serious damage.

### INJURY TO CORN BY THE ROOTWORM

The "worm" or larval stage (fig. 1) of this insect is the one most injurious to corn. As the name "corn rootworm" would indicate, it feeds on the roots of corn, but it does not confine its injuries to the roots; indeed, the greatest damage to young corn is that done by the worm in drilling a small hole into the stem directly above the first circle of roots and feeding on the interior, boring out the crown and killing the bud (fig. 3). Plants affected in this way break off at the injured point when an attempt is made to pull them.

## HOW INJURY TO CORN BY THE ROOTWORM CAN BE RECOGNIZED

When young corn has been damaged by this insect the fact can be easily detected. The bud leaves of injured plants, having been cut off from the main plant, dry up and die (see cover page illustration), while the rest of the plant retains its original color for a time. Subsequently the whole plant dies if injured badly. Badly injured plants occasionally give rise to suckers which may produce ears, but these are usually of a poor quality. It is on account of the peculiar injury to the bud that the insect is often called the "budworm," but this name is frequently applied to several other kinds of insect.

When the worms feed on the roots of older plants they cause them to fall over or lodge (fig. 4), or to appear sickly or stunted and send up a number of suckers which are either sterile or will produce grain of an inferior quality.

### DEVELOPMENT OF THE INSECT

The southern corn rootworm has four distinct stages through which it passes in its development. The first is the egg, the second the grub or larva, the third the pupa, or resting stage, and the fourth the adult, parent, or beetle.



FIGURE 3.—Corn plant showing injury by southern corn rootworm to growing point or "bud."

### EGG STAGE

The egg (fig. 5) is oval and about the size of a large pinhead. It is dull yellow when freshly laid but later turns a deeper yellow. Its surface is covered with extremely small, shallow pits which in outline resemble six-sided figures. Eggs are deposited by the female beetle slightly below the surface of the ground among various herbaceous plants. Their number varies greatly. More than 500 may

be laid by one individual and as many as 100 in 1 day. Eggs usually are deposited early in the evening. Sometimes, however, the female may deposit eggs in the daytime, even at midday. The eggs hatch in about 3 weeks very early in the spring and in from 6 to 8 days in midsummer. The length of the egg period depends on the prevailing temperature.

#### GRUB, OR LARVAL STAGE, AND LARVAL FOOD PLANTS

The grub, or larva, when first hatched is slender and yellowish white with a dark-brown head and a dark patch on the top of the last



FIGURE 4.—Corn plants fallen or lodged because of injury to the roots done by the southern corn rootworm.

body segment. It is active at this stage of growth but so small that it is scarcely perceptible to the unaided eye. The full-grown larva usually is deep yellow. The head and patch on the last body segment are somewhat darker than in the newly hatched larva. The mature larva (fig. 1) tapers toward the head end, the last few segments of the body being much wider than the head, which makes them appear

as if swollen. The grub stage lasts from 3 to 4 weeks. Occasionally, however, the insect may live in this stage from 5 to 6 weeks. As the larva increases in size, it molts, or sheds its outgrown skin, twice.

When infested corn is examined the grubs may be found in their tunnels or among the roots, though sometimes they are some distance away from the injured plants, probably migrating to other corn plants in the same row. Usually only one larva is found at one plant, but sometimes, though rarely, there may be two.

In addition to corn, the larvae of this species are known to feed and live on the roots of Johnson grass, southern chess or rescue grass (*Bromus catharticus* Vahl.), wheat, millet, rye, young oats, and alfalfa.

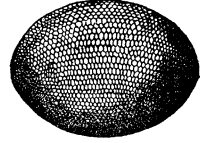


FIGURE 5.—Egg of the southern corn rootworm, magnified about 12 times.

#### PUPA, OR RESTING STAGE

After the larva is full-grown it enters the ground to a depth ranging from a few inches to a half foot or more, depending on the texture of the soil. It then makes a cell somewhat oval in outline and smooths it very evenly on the inside. Presently the larva begins to shorten, and after a few days it sheds its skin and passes into the pupal or resting stage (fig. 6).

In this stage the insect cannot move from place to place and is not destructive. The only part capable of movement is the tip of the abdomen, which is moved about violently when the pupa is disturbed. The pupa is soft, yellowish, about one-fourth of an inch long, and has two very conspicuous spines at the tip of the abdomen.

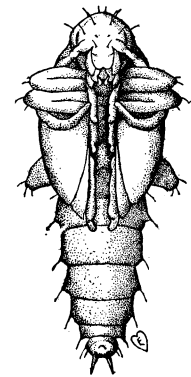


FIGURE 6.—Pupa, or resting stage, of the southern corn rootworm, magnified about eight times.

The pupal stage lasts from 6 to 8 days in summer and from 10 to 13 days in spring and fall. At the end of this period the 12-spotted beetle, or adult, comes forth and works its way through the soil to the surface of the ground.

#### ADULT, OR BEETLE STAGE, AND FOOD HABITS OF THE BEETLE

The adult or beetle (fig. 7), the egg-laying stage of the insect, is about one-fourth inch long, yellowish-green, with a black head and legs and, as previously stated, with 12 black spots on the back. These spots are irregular in outline and generally somewhat separated.

The beetle is very active during warm weather and can be captured only with difficulty. If danger threatens it when feeding, it falls to the ground and crawls away under rubbish or hides under the foliage of small plants. During cool weather it becomes less active, and when the temperature is near freezing it scarcely moves, even when disturbed.

In this stage the insect often does considerable damage to young corn by cutting off the bud leaves, although such plants usually recover. The adult, or beetle, is more injurious to certain truck crops



than to corn, especially to squashes, cucumbers, etc., and on this account is known as the 12-spotted cucumber beetle. It injures these plants by making numerous small holes in the leaves, and if the plants are small and have only a few leaves much harm is done.

In relation to corn the beetle stage is important as being the egg-laying period of the insect, for the female, after having mated, places her eggs in the soil near the corn plants.

### HOW THE INSECT PASSES THE WINTER

The southern corn rootworm passes the winter in the beetle stage, except possibly in southern Florida and Texas. In more northerly

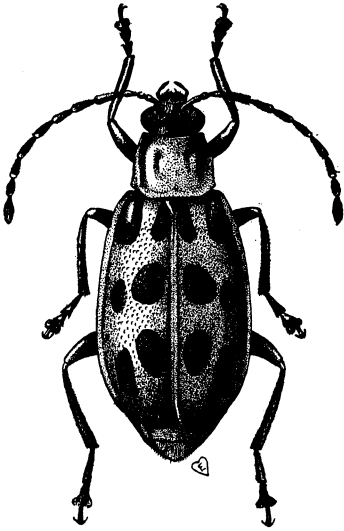


FIGURE 7.—Southern corn rootworm: Adult or 12-spotted cucumber beetle. About eight times natural size.

regions the beetles go into hibernation late in the fall; that is, they crawl under rubbish and to other places that afford them protection from the cold and remain in an inactive condition during the winter. With the return of warm weather they again become active. In the upper margin of this range of infestation the insect apparently dies at the end of each season, and the area is reinfested each year by migrant beetles coming from points farther south. In the more southern States, where temperatures are mild, the beetles do not hibernate in winter, but during cool days and nights hide under rubbish, among dead grasses, or under low-leaved plants and resume activity when the weather again becomes warm. In the South, there are some native plants which remain green throughout the winter, and beetles have been found feeding on them, as well as on alfalfa, rye, oats,

and other crops, during warm days in midwinter.

### NUMBER OF GENERATIONS

This insect has two complete generations annually in the vicinity of Columbia, S. C. Even though the adults of the second generation appear in sufficient time to reproduce the same year they refrain from doing so until the following spring. The beetles of the second generation do not mate until the approach of fall or cooler weather.

Serious injury to young corn in the South is largely done by the larvae of the first generation of the year.

### NATURAL ENEMIES

#### NATIVE BIRDS

A number of our native birds prey upon the adults, or beetles, of the southern corn rootworm. Some of the common ones are the bobwhite, red-headed woodpecker, nighthawk, cardinal, kingbird, and

phoebe. Of these birds the bobwhite deserves special mention. As many as 12 of the beetles have been found in the stomach of one bobwhite.

### INSECTS

The southern corn rootworm has only a few insect enemies, the chief one being a two-winged fly, *Celatoria diabroticae* (Shimer) (fig. 8), which attacks it in the beetle stage. This fly places a maggot, or larva, in the abdomen of the beetle, and the maggot feeds on the vital organs of the host and finally kills it. After the death of the beetle the parasite larva, being then full-grown, enters the ground and forms a tough, leathery case in which it passes into the next or pupal stage. This case, called a puparium, is dark and covered with needle-like spines. From the puparium there emerges in due time the adult, or fly, which starts the cycle over again. This parasite is not very common and thus far has not played a very great role in the destruction of the pest.

### PREVENTIVE AND OTHER CONTROL MEASURES

Various methods, when diligently and thoroughly employed, will aid greatly in preventing injury to corn by the southern corn rootworm. The most important of these methods is timely planting.

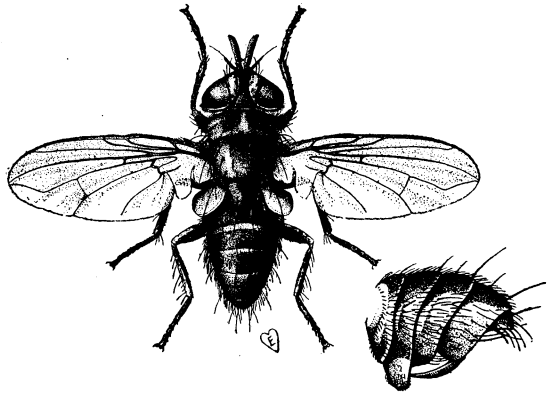


FIGURE 8.—*Celatoria diabroticae*, a fly enemy of the southern corn rootworm. At the right is shown the piercer by means of which the fly deposits a maggot within the adult or beetle of the rootworm. Fly about eight times natural size.

### TIMELY PLANTING FOR LOWLANDS SUBJECT TO INFESTATION<sup>1</sup>

The time at which the corn is planted affects to a large extent its likelihood of escaping rootworm damage. There is a period during which the worms are very active and do much damage. This period varies somewhat with the latitude and to a less extent with the altitude. It is earlier in the extreme South than in the more northerly regions and slightly earlier in the lower than in the upper altitudes. The results of investigations to determine the best planting periods in infested lowlands of the Southeastern States show that the region may be divided into three belts, or zones, each of which has a definite planting period (fig. 9). The first or lower zone includes northern Florida and southern Georgia, and has a safe planting period extending from April 20 to May 1. The second or central zone includes central Georgia and the southern half of South Carolina, and here the safe planting period is from May 1 to May 10. The third or upper

<sup>1</sup> In North Carolina the work upon which these recommendations are based was conducted in cooperation with Z. P. Metcalf, entomologist of the North Carolina Agricultural Experiment Station; in Florida, with J. R. Watson, State entomologist.

zone includes northern Georgia, the northern half of South Carolina, and all of North Carolina. The safe planting period for this zone is from May 10 to May 20. Corn planted in the lowlands in the three regions during the planting periods recommended will not be seriously infested by rootworms, and many of the plants that are infested under these conditions will recover. Corn planted in Georgia, South Caro-

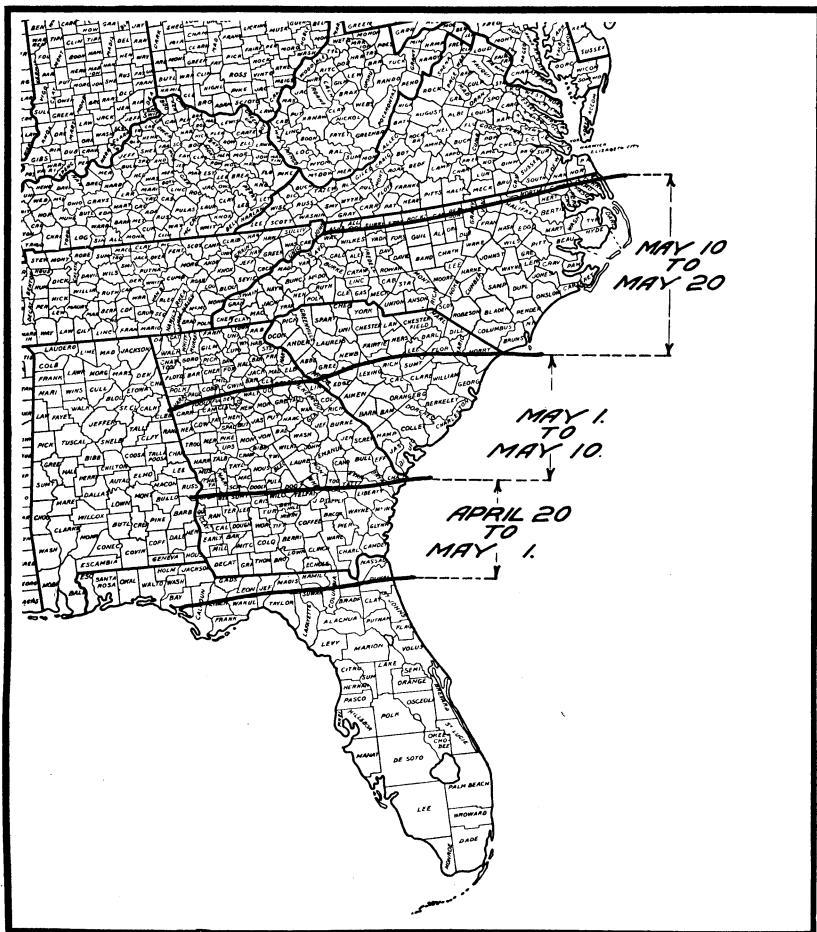


FIGURE 9.—Periods during which corn should be planted in order to escape injury from the southern corn rootworm.

lina, and North Carolina during April usually suffers severe injury. Plantings made very early in the season occasionally escape damage, but on account of the danger from frost it is not advisable to plant low grounds as early as this. Furthermore, it is seldom possible to make an early planting. The soil in the lowlands at this time of year is often too wet to permit plowing and a good preparation of the seed bed.

In each locality the safe planting periods naturally will vary somewhat from year to year, depending on seasonal weather conditions.

During exceptionally early seasons the period may be advanced somewhat, whereas during late seasons it should be delayed. Every farmer, however, by careful observations extending over a period of years, may discover at what date his low ground should be planted so as to minimize the ravages of this pest, taking into account, of course, other important factors in crop production.

Where soil conditions permit, injury to young corn may sometimes be avoided by plowing the land very early in the season, or at least a month before the corn is to be planted. Any rootworms surviving this treatment will reach maturity before the corn is planted, and the resulting beetles will leave the field in search of suitable growing vegetation in which to lay their eggs. The plowed land should be kept barren until planting time in order to prevent the further deposition of eggs by the beetles.

### BURNING OVER WASTE PLACES

Large numbers of beetles may be destroyed by burning over waste places, such as the borders and terraces of fields, in the winter and on cool days. Beetles at that time and on such days congregate in dead grasses, seeking protection from cold. The value of this measure is realized when one considers that the killing of one female in winter is as important as would be the destruction of from 400 to 600 worms in the spring.

### PLANTING HYBRID VARIETIES OF CORN THAT PRODUCE ABUNDANT FIBROUS ROOT SYSTEMS

In the more northerly range of the southern corn rootworm, where injury to corn is mainly the destruction of the roots and subsequent lodging of the stalks, hybrid varieties of corn which develop profuse fibrous root systems suffer less damage than those having a limited supply of coarse roots. The corn grower in this section, before planting lands subject to infestation, should consult the local county agricultural agent or the nearest experiment station regarding the best hybrid varieties of corn to plant in his locality.

### THICK PLANTING

It is a common practice among some of the planters in the Southeastern States who are acquainted with rootworm injury to plant corn thicker in the lowlands than in the uplands. Double the number of grains are dropped in low ground. This offers twice the chance of securing a stand and is to be recommended especially for fields that consist partly of low ground. The upland in such cases may be planted in the regular way. In lowlands of large area this measure loses its value, for if corn is planted thickly some thinning may be necessary and this may mean a loss of labor, time, and money. Under such conditions the best planting periods should be observed as recommended.

### ENRICHING THE SOIL

Soil rich in plant food will produce plants that are more hardy, healthy, and capable of resisting insect attack than soil that is not so supplied. Plants injured by the "budworms" sometimes recover,

and the chances are that a larger percentage will do so in rich than in poor soil. Judicious crop rotation should be practiced wherever possible. Legumes should rank high in the rotation. They will add to the soil the much desired humus as well as store in the soil the valuable nitrogen extracted by these plants from the air.

It has been found that lowlands supplied abundantly with animal fertilizers are more seriously affected by these worms than those not so treated. It is well to use commercial fertilizers in such cases. These do not, as is believed by some, repel the insects, but afford them a less favorable breeding place.

### SUMMARY OF CONTROL MEASURES

(1) To prevent serious injury to corn from the southern corn root-worm, lowlands in southern Georgia and western Florida should be planted between April 20 and May 1; in central Georgia and the southern half of South Carolina, between May 1 and May 10; in northern Georgia, the northern half of South Carolina, and all of North Carolina, between May 10 and May 20. If it is possible to avoid it, plant no corn in the lowlands in this region during April. If possible, plow lowlands early in the season, at least 1 month before planting to corn.

(2) Destroy beetles by burning over field borders and terraces in winter.

(3) Plant low places in fields twice as thickly as the uplands. Thin out later if necessary.

(4) Enrich the soil. Raise leguminous crops; these add humus and nitrogen to the soil.

(5) Plant profusely rooting, hybrid corn varieties in areas where root damage is severe.