The Alfalfa Weevil

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Foreword

This Station is concerned with the alfalfa weevil primarily because the weevil feeds on a crop of great value to dairymen and other farmers. With alfalfa, and other high quality hay and silage, Connecticut farmers now cut their grain bill by growing protein cheaper than they can buy it.

Dr. Quinton's paper is the latest in a long series of reports on problems of the dairy farmer of Connecticut. We are a plant science institute and, hence, do not deal with cows directly. Cows, however, must eat and plants are what they eat.

As early as 1903 Director Jenkins of this Station wrote: "At the present time fruit growing and dairying are the most important features of general farming of the State. . . There will always be a great demand for milk in Connecticut. . . and dairying is likely to continue to have the same relative importance for many years."

Director Jenkins' appreciation of the role of dairying profoundly influenced the course of research at this Station, which has served dairymen, directly and indirectly, for well over a half century.

Analysis of commercial feeding stuffs began in 1895, analysis of milk in 1882, studies of unique and then unknown properties of milk as a food in 1911, and regular assays of vitamin D milk in 1935. Research in genetics gave better varieties of corn, research in soils showed how to keep our old fields productive, studies of the grasses began decades before grassland farming became a byword in the Northeast.

Another area of research lies in studying the biology and control of insect pests on crop plants. Such research has made possible publications like this, the 826th Station Bulletin or Circular in a series intended to put science to work for agriculture and thereby to serve all who use the products of the land.

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THE ALFALFA WEEVIL

RICHARD J. QUINTON

The alfalfa weevil (*Hypera postica* Gyll.) is a native of Europe and Asia. This insect was found in Utah in 1904 and was for a long time limited to states west of the Rocky mountains. In 1952 the weevil was discovered in the East (Poos 1953) and since then has been spreading along the Atlantic coast. In many parts of its range the alfalfa weevil is the most destructive pest of alfalfa.

The insect was first found in Connecticut on May 10, 1957. A survey was conducted immediately by Gerard T. Pfeifer and Elmer Toth of this Station. Small numbers of weevils were found throughout the State. The infestation was most severe along the western border. The highest average larval count found at this time was 2.1 per sweep.

This paper reports the results of observations and studies of the life history and control of the alfalfa weevil.

Host Plants

Essig (1933) found the weevil breeding on only four different species of plants. These were alfalfa (*Medicago sativa*), bur clover (*Medicago hispida*), yellow sweet clover (*Melilotus officinais*), and white sweet clover (*Melilotus alba*). Alfalfa is the only plant which is seriously damaged. All of these plants are native to the original Eurasian habitat of the alfalfa weevil and all have been naturalized in North America. Such plants, even where of limited commercial value, may be important in providing a reserve of plant material upon which the weevil may breed.

Losses Caused by the Weevil

There is no question as to the effect of the weevil when large numbers are present, but where populations are low it is sometimes difficult to evaluate losses caused by this insect. In any case, weevil injury is most serious to the first crop. Feeding on second growth may cause some reduction of this crop. Injury can be found in the field until cold weather. In a newly infested area the weevil often reaches damaging levels by the third season. Nevertheless, records show that the weevil may cause but little damage in parts of an infested area and only occasional moderate or heavy damage in others. Quite likely the weevil will cause injury in Connecticut, and it may be extensive. Whether we will be subject to continuous heavy attack or whether our condition are such that losses will be infrequent or less severe remains to be seen.

Nature of Injury

Both larvae and adults are injurious, although larval feeding causes the greatest damage. After leaving the hatching site the larvae work their way to the tops of the plants where early feeding is confined to leaf buds and terminal growth. Injury of this kind may seriously check plant growth. At this time the larvae are difficult to see as they are small and relatively well concealed. This damage, although inconspicuous, may be readily observed

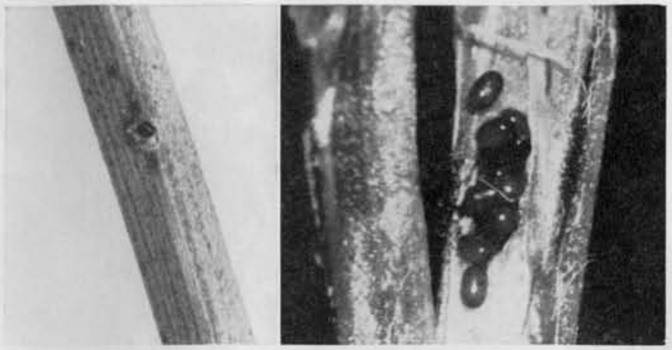

Figure 1. At left, outward appearance of an egg chamber of the alfalfa weevil, about 3 times life size; right, an alfalfa stem opened to show the egg chamber, 5 times life size.

upon close inspection. As the larvae grow larger they begin to feed upon opened leaves, causing a characteristic skeletonizing. At this time the larvae are readily seen, often curled around a leaf or stem. When general feeding has occurred, the infested field takes on a grayish appearance. This is apparent from a distance and is typical of severe larval injury.

Adult weevils may notch main stems and sever side shoots and leaf stems as well as feed upon the leaves. In contrast to larval feeding, the general appearance is ragged. Marginal feeding dominates and slits in the leaf blade are few or absent. Adult females also puncture the stems during oviposition, and Hastings (1953) suggests that such injury could itself reduce first cutting yields.

Life History and Habits

The alfalfa weevil passes through four stages in its development: Egg, larva, pupa (cocoon), and adult. These stages may occur concurrently in

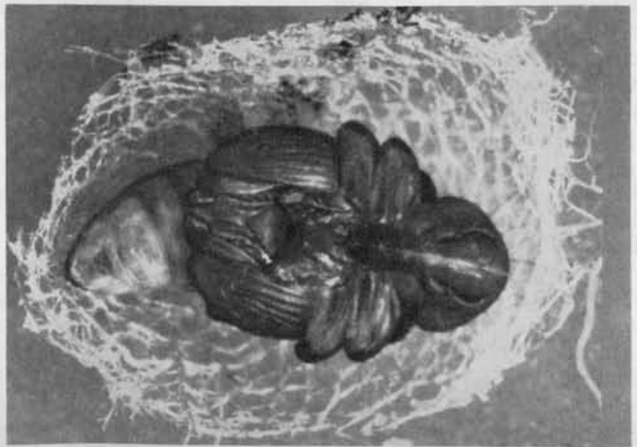

Figure 2. A cocoon opened to show the pupa of the alfalfa weevil (about 7 times life size).

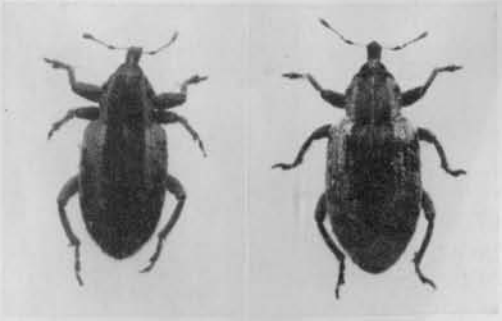

Figure 3. The alfalfa weevil; young adult at the left, older adult at right (about 3 times life size).

the field. Once established in an area, weevils are to be found in greater or lesser numbers each year.

The insect overwinters in the adult stage and also as eggs when these are laid during the fall. Adult weevils become active during early spring when the bulk of the eggs are deposited on alfalfa. At this time, weather profoundly influences the activities of this insect. Warm days foster abundant egg laying. Cool, wet weather, such as occurred during the spring of 1958, greatly extends the period of oviposition and subsequently that of egg hatching and larval development. The incubation period, as shown by Manglitz *et al.* (1957), varies greatly depending on the time when the eggs were laid. With the warmer weather of late spring, hatching time averages about 2 weeks. The larvae reach maturity in 3 or 4 weeks. Cocooning and pupation then occur and in about 10 days the adult insects begin to emerge.

Although it is generally stated that the alfalfa weevil has but one generation a year, a number of workers have considered that there is at least a partial second generation. Snow (1928) showed that some of the beetles of the first generation were ready to lay eggs by October. Later, Yakhontov (1934) demonstrated that within the temperature range of 53.2 to 77 degrees F., a period of about 2 months was required after emergence for maturation of female beetles. These minimum conditions limit the seasonal development of the weevil. Nevertheless, Connecticut conditions do allow sufficient time to permit the development of a partial second generation. Larvae may be readily collected in our fields during October and November. It is possible that these late forms may be stragglers from the overwintering generation, but the abundance of young larvae appearing during this period suggests the presence of a partial second generation. At present, although the existence of a partial second generation may be surmised, its status has yet to be definitely established.

Adult weevils remain relatively inactive during periods of temperature extremes, but may be taken in the field almost any time when the weather is moderate. In frequent collections, the sexes are found in about equal numbers. Mating pairs are commonly observed in early spring and occasionally in late fall. On November 16, 1958, after several hard frosts had occurred, adult weevils were collected in the field. When caged on alfalfa, after being in the warm greenhouse for several hours, these weevils repeatedly crawled to the top of the plants and took off in flight within the cage. This behavior suggests that the spring flight occurs when the weather is first warm enough to stimulate this activity. In this instance the weevils

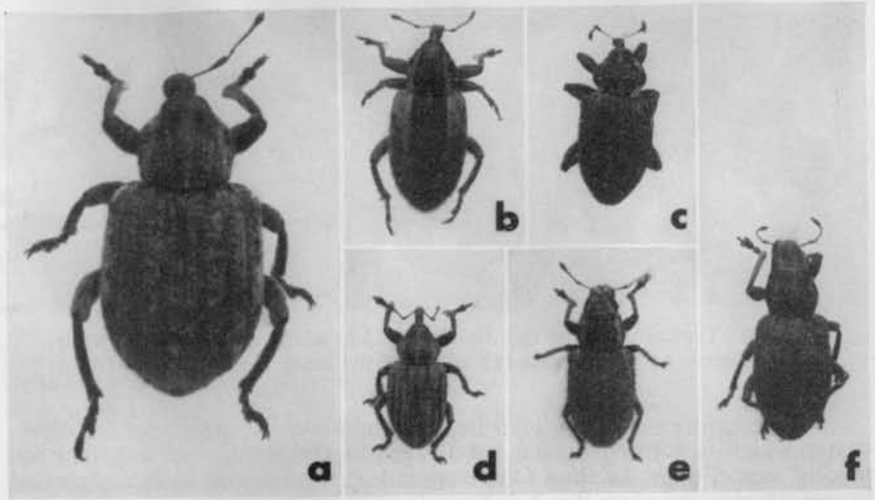

Figure 4. Insect pests of alfalfa and clover, (a) clover leaf weevil, (b) alfalfa weevil, (c) *Hypera meles* (F), (d) lesser clover leaf weevil, (e) clover root curculio, (f) *Sitona flavescens* (Marsh). There are no common names for (c) and (f). All are shown approximately 2 times life size.

had apparently been sufficiently conditioned by cold and physiologically were ready for spring. This is further evinced by the behavior of these weevils in mating and laying an abundance of eggs within 48 hours after being brought into the warm greenhouse. Examination of plants collected in the field at this time failed to reveal any eggs.

Description of Stages

Eggs

Alfalfa weevil eggs are small and oval. They are pale yellow when fresh and become darker in color as they age. They are usually placed in a

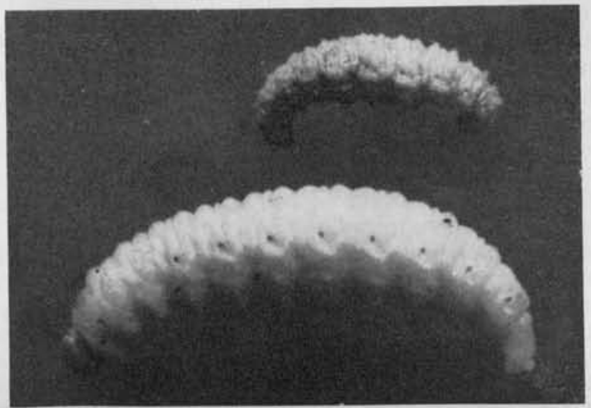

Figure 5. The smaller larva is that of the alfalfa weevil, the larger, the clover leaf weevil larva (about 4 times life size).

Figure 6. Typical injury by (a) *Sitona hispidula* adults on clover, (b) adult alfalfa weevils on alfalfa, and (c) adults of the lesser clover leaf weevil on alfalfa.

cavity which is formed by the female within the stem, and are thus not readily seen. Figure 1a shows the outward appearance of such a chamber. Figure 1b shows a stem that has been opened to reveal the egg cavity. The cavity contains a cluster of eggs, commonly an average of about a dozen. During October and November of 1958, 200 old alfalfa stems and new crown growths were collected at weekly intervals from a field where adult weevils were abundant. Examination of this material revealed that less than 2 per cent contained eggs. As adults taken from this field readily laid eggs in the laboratory, the low incidence of field-collected eggs suggests that fall oviposition is relatively minor under our conditions.

Larvae

The larvae, which are legless throughout their development, pass through four instars before becoming full grown. When first hatched they are less than one-sixteenth of an inch long. At this time their color may vary from grayish-white to a pale dirty yellow, and they have a small black head. As the larvae develop the body color changes to a leaf-green, and older forms are clearly marked with a white stripe which runs down the center of the back. A thinner white line can also be seen on the sides of older larvae. Of especial note is the fact that the head of alfalfa weevil larvae remains blackish or dark brown throughout the growth period. When full grown the larvae are about one-quarter inch long. They are quite active when handled or disturbed.

Pupae

After the larvae are full grown, a cocoon is spun in which the insect pupates. This structure is very distinct. It is roughly spherical and may vary in length from three-sixteenths to five-sixteenths of an inch. It is made of clear white threads formed in an irregular, open weave through which the insect can readily be seen. The cocoons often contain leaf fragments or entire leaves in the enveloping mesh. These structures are found among the surface litter or even attached to foliage in the plants. Figure 2 shows a cocoon from which some of the threads have been removed to show the pupa.

Adults

Adult specimens of the alfalfa weevil exhibit a wide variation in size, color, and marking. In the main they are somewhat less than one-quarter inch long. When young, they are light brown in color with darker brown markings forming a distinct pattern on the upper surface. The thorax bears a dark double-barred pattern separated by a narrow light colored line. A single dark circle also shows on either side of the thorax. The wing covers are marked with an elongated stepwise pattern which is widest at the anterior end. Older individuals are generally darker and, because of the loss of some of the scales which produce the color pattern, may also be less distinctly marked. Typical specimens are shown in Figure 3.

Field Identification

A number of different species of weevils feed upon alfalfa in Connecticut. Among these are several which are sometimes mistaken for the alfalfa weevil. The insects which cause the most confusion are the lesser clover leaf weevil, *Hypera nigrirostis* (F.); the clover leaf weevil, *Hypera punctata* (F.); *Hypera meles* (F.); *Sitona flavescens* (Marsh.); and the clover root curculio, *Sitona hispidula* (F.). Between these insects and the alfalfa weevil, differences in size, color, and habit are sufficient to be useful in field identification.

Adults

An adult alfalfa weevil is shown in Figure 4b. The markings on the back, dark brown contrasting with a lighter brown base, are characteristic. This stepwise pattern clearly identifies the alfalfa weevil, as no other weevil in this group has such markings. The two species of Sitona (Figure 4e and 4f) may be further distinguished by the relative narrowness of the body, the width of the head, and the short, wide beak. The clover leaf weevil (Figure 4a) is almost three-eights of an inch long. The great size and robustness of this insect sets it quite apart. The lesser clover leaf weevil (Figure 4d) is small, only a little more than one-eighth of an inch long. It is also readily distinguished by the greenish color of its wing covers. The remaining species, *Hypera meles* (F), shown in Figure 4c, is somewhat similar to the alfalfa weevil in size and general outline but is usually much darker and lacks the distinguishing marks which the alfalfa weevil bears upon its back.

Larvae

The two species of Sitona can be dismissed from this consideration as their entire larval stages are passed below ground. *H. meles* (F), and *H. nigrirostris* (F), although both include alfalfa among their hosts, are most often found on red clover. Their predominance on this plant plus their particular feeding habits, as noted later, will serve to distinguish them.

The alfalfa weevil and the clover weevil are often difficult to distinguish in the early stages of their development. For any given instar, larvae of the clover leaf weevil are longer and wider than those of the alfalfa weevil, but this distinction is complicated by the fact that the several instars of both insects occur concurrently. Smaller specimens of both insects are similar in color (grayish white to pale yellow), and in both the heads are initially black. As they age, the head of the alfalfa weevil remains black or dark brown while that of the clover leaf weevil becomes light or yellowish brown. The head is a particular point of recognition in size as well as color. The head of the alfalfa weevil is always noticably smaller in relation to the overall body size than that of the clover leaf weevil. The body of both becomes green as they age and both show a white dorsal median line and fainter white lateral lines. Older larvae of the clover leaf weevil frequently show rose-colored areas bordering the median line, a character which occurs only occasionally in the alfalfa weevil. In older specimens, the larger and more robust size of clover leaf weevil larvae easily distinguish them from their smaller relatives. In habit, leaf weevil larvae are also quite sluggish in contrast to those of the alfalfa weevil. The two species which are shown in Figure 5 vary in size but alfalfa weevil larvae are about one-quarter inch long and those of the clover leaf weevil about one-half inch long.

Cocoons

Excepting again the two species of Sitona, which do not form cocoons, the other insects under consideration may be readily identified in the pupal stage. The general characteristics of these cocoons are noted in Table 1.

Figure 7. Alfalfa weevil larvae injury to (a) terminal growth and (b) opened leaves of alfalfa.

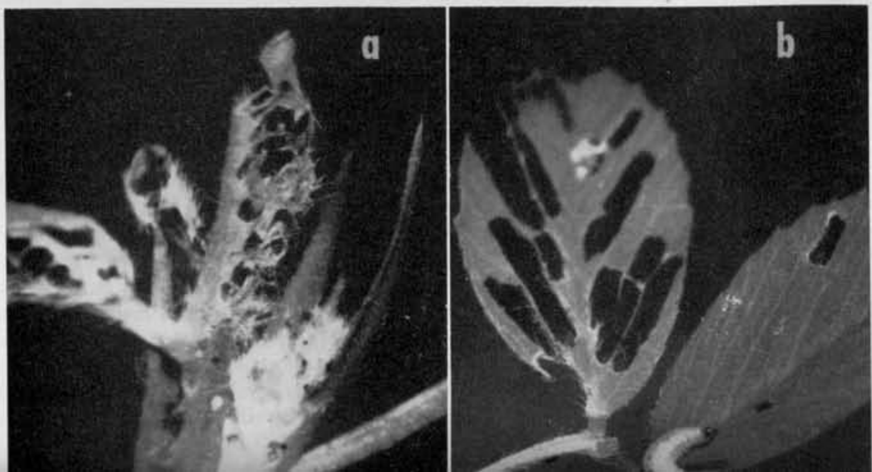

Table 1. Nature and characteristics of cocoons

Insect	Location of cocoon	Relative size	Color	Texture	Nature of mesh
Hypera punctata (F) (clover leaf weevil)	sub-surface	large	amber	hard	regular
Hypera postica Gyll. (alfalfa weevil)	surface or among leaves	medium	white	soft	irregular
Hypera nigrirostris (F) (lesser clover leaf weevil)	fork of stem or crevice of stipule	medium	white	soft	irregular
Hypera meles (F)	surface	medium-small	amber	soft	irregular

As seen in Table 1, color alone is sufficient to identify the clover leaf weevil and *H. meles*. The cocoons of the lesser clover leaf weevil, appearing primarily on red clover in the situation indicated, may also be easily distinguished. Thus the cocoons of the alfalfa weevil, appearing in alfalfa fields a week or so before first cutting, may be readily identified as such.

Feeding Habits

In their feeding, weevils cause foliar injury which is peculiar to the species. The distinct differences for both adults and larvae are discernable in the field. The specimens used in the accompanying illustration were obtained by caging segregated specimens on the host plant. Injured foliage observed in the field will bear, in many instances, the wounds of both adult and larval feeding and possibly those of several species as well. Generally, one species will dominate and the principle nature of the injury coupled with the presence of particular insects will provide identification.

Injury Caused by Adults

Clover Root Curculio. Both species of Sitona feed by standing astride the edge of the leaf blade and cutting notches in the margin. As seen in

Figure 8. Injury caused by (a) small clover leaf weevil larvae and (b) older clover leaf weevil larvae.

Figure 6a, these wounds are roughly semi-circular and fairly shallow. In mixed stands the injury will be most abundant on clover.

Clover Leaf Weevil. This insect also feeds at the margins of the leaves, but being much larger is a grosser feeder. The notches caused by the clover leaf weevil are greater in area and apt to be irregular in outline. The weevils frequently penetrate to the midrib and remove large sections of the leaf blade. The general appearance is coarser than that produced by *Sitona* spp.

Alfalfa Weevil. Adult alfalfa weevils are also marginal feeders. The injury which they cause (Figure 6b) is much more ragged than the others. Alfalfa weevils tend to feed within the boundaries of the smaller veins. Large areas may be removed, but many angular projections are usually produced. These weevils may also feed upon the stems and may cut side shoots or petioles as well.

Lesser Clover Leaf Weevil. The injury caused by this insect is distinct from the others. As seen in Figure 6c marginal feeding is infrequent. Many small circles or elongated holes cut within the leaf blade are typical.

Injury Caused by Larvae

Most of the confusion in identifying larval injury is caused by the alfalfa weevil and the clover leaf weevil. This discussion will be limited to a brief comparison of these two insects.

Alfalfa Weevil. Small larvae of the alfalfa weevil cause initial injury, as shown in Figure 7a, by feeding upon the leaf buds and terminal growth. Later, they feed upon opened leaves, working between the veins on the surface of the leaf blade. At this time they cause the skeletonizing shown in Figure 7b. In feeding they often do not cut entirely through the leaf surface but leave the lower epidermal layer intact. Upon drying, this gives the leaves, and thus the infested fields, the grayish cast so typical of this type of injury.

Clover Leaf Weevil. Early in the spring the smaller larvae typically feed between the appressed young leaves where they cut small round holes (Figure 8a). When the larvae are larger they begin to feed upon opened leaves, eating inward from the margins. They often consume large areas and produce a gross type of injury as shown in Figure 8b.

Time of Control

The various stages of the alfalfa weevil occur concurrently during development of the insects. This complicates and makes the requirements for satisfactory control more difficult. The eggs, laid within the stems, are well protected. So too are the pupae, which are inactive, enclosed in their cocoons, and in many instances covered by surface litter. The adult and larval stages remain the most susceptible and their activity presents several possible times when control measures may be directed against them.

Control of Adults

If all of the adults were killed prior to oviposition in the spring, there would be little injury. Populations which developed would arise from overwintered eggs or from eggs deposited by migrating adults. Large resurgent populations have often been observed in fields following spring treatment. This suggests that extensive oviposition had already occurred on new growth before the treatment removed the adult population, that materials used were not effective or only incompletely so, or that eggs laid in the fall (although representing a small fraction of the total egg population) may at times be considerable. Quite likely a combination of these is involved, but successful spring oviposition seems a major factor and indicates how critical the timing of treatments for adults may be. To be completely effective, a treatment must eliminate the adults before egg laying commences or be residually active against larvae hatching from eggs which have already been deposited.

Control of Larvae

Oviposition takes place over an extended period of time. As a result, egg hatch and larval development also occur over a long period. This limits the degree of plant protection which may be expected as it necessitates delaying treatment until a majority of the eggs have had time to hatch. The method has an advantage in that the developing population can be appraised before a treatment is applied. It is disadvantageous in that extensive larval development and some injury necessarily occurs before application of the control.

The amount of plant injury generally increases in proportion to the extent of egg laying before an insecticide is applied. This was shown by the work of App (1954) and others in controlling adults before oviposition. It was found difficult, however, to time the application with the activity of the weevil. The use of residual materials, applied before the weevils became active, was then considered as a means of eliminating the need for critical timing during the spring. Hasting (1952) found that certain sprays were more effective when applied to bare stubble than when new growth was 4 to 5 inches tall. In general, although a number of materials were found to be initially effective when applied as sprays early in the spring, their residual activity was insufficient to give protection through first cutting. In an effort to extend activity, Muka (1957), Blackburn (1957), and others obtained encouraging results by using granular formulations of insecticides. It was noted, as one example, that granular heptachlor applied as a pre-growth treatment gave protection to first cutting while the same material applied as a spray permitted populations to recover. Similar results have been found in tests conducted at this Station.

1958 Tests

In the work here reported, all sprays were applied with a low-pressure weed sprayer. The machine was equipped with a 30-foot spray boom fitted with 16 flat T-jet nozzles and was operated to deliver approximately 30 gallons of spray material per acre. Granular insecticides were mixed with fine sand, as an extender, and these applied with a hand-operated rotary-

Table 2. Control of alfalfa weevil larvae, formulation and date of applications, 1958

Material	Pounds active per acre	Date applied	Number of alfalfa weevil larvae per 20 net sweeps May 12	May 21	May 28	June 5	June 12
Heptachlor 2½% granular	1.0	18 April	0	0	2.6	4.7	3.0
Heptachlor 2 lb. emulsion	0.25	18 April	0.3	1.6	23.6	85.3	120.0
Heptachlor 2 lb. emulsion	0.25	13 May	...	5.6	11.3	15.7	117.0
Check (untreated)	...	...	4.9	39.2	121.9	143.7	187.4
		LSD 5%	0.6	3.4	8.6	11.4	23.2

type duster. All treatments were replicated three times on randomized plots, 30 by 30 feet, or approximately one forty-eighth of an acre in size.

Table 2 shows a comparison of an early granular treatment with an early and late spray. In the latter instance, plants were 12 to 14 inches tall. Accepted commercial rates of heptachlor application were used in these tests.

These data show that an early treatment directed against the adults is effective in preventing larval development. No significant differences show between the two early treatments on May 21, 33 days after application. By the 39th day the superiority of the granules was evident and this treatment continued to provide control through harvest. The last spray still provided good results on June 5, 22 days after application. A week later the population had risen in these plots until no significant differences showed between the early and late sprays. As used, neither of the spray treatments gave protection through time of cutting.

Sample yields were taken from the plots on June 6 and 13. Larval populations were still increasing at this time. In taking yields a 30-inch sickle-bar mower was used to make a cut across the plot at right angles to the direction of travel of the sprayer. Cuttings from 3 feet at either end of the swath were then discarded and after weeds and grass were removed, the alfalfa was weighed. Table 3 shows the yield data obtained from these 60-square-foot samples.

The effective residual control provided by the granular treatment is reflected in the significant yield increases over the companion spray. Compared with the May 13 spray, the granules were significantly better at the early harvest but not so at the later. The combined yield probably reflects a more realistic appraisal of the relative effectiveness of the treatments, and this shows the granular to be superior to both of the sprays. There was no significant difference between the sprays and the untreated check. The small increase in check yields between the two cuttings at a time when the larval population was also increasing is probably not significant. It suggests, however, that plant growth was offsetting losses caused by the relatively small infestation of weevils. It is not presumed that the maximum yield increase of 18.5 per cent resulted exclusively from control of the alfalfa weevil. The meadow spittlebug, *Philaenus leucopthalmus* (L), was also abundant in these plots. The granular treatment completely controlled the spittlebug while the sprays did not. The yield increases reflect the benefit of controlling both of these pests. These results were obtained with maximum alfalfa weevil larvae populations of 9.4 per sweep. Counts of 30 to 50 larvae per sweep are reported common in heavily infested areas (Manglitz *et al.* 1957). With these higher larval populations effective control of the weevil should result in greater benefits.

Table 3. Effect of alfalfa weevil control on first-cutting yield of alfalfa, 1958

Material	Pounds active per acre	Date applied	Yield in tons of green weight per acre* June 6	June 13	Combined yield	Increase over check, %
Heptachlor 2½% granular	1.0	April 18	10.36	9.90	10.13	18.5
Heptachlor 2 lb. emulsion	0.25	April 18	9.41	7.98	8.69	1.6
Heptachlor 2 lb. emulsion	0.25	May 13	8.61	9.49	9.05	5.8
Check (untreated)	. . .	. . .	8.38	8.71	8.55	. . .
		LSD 5%	0.34	0.76	0.59	. . .

* Dry (hay) weight is approximately ¼ green weight.

Table 4. Residual effect of early treatments on larval control, plant height, and yield of second cutting, 1958

Material	Pounds active per acre	Date applied	Infested tips per 20 stems July 9	Plant height Aug. 1	Yield in tons green wt/acre Aug. 1
Heptachlor 2½% granular	1.0	April 18	0.3	22.7	4.27
Heptachlor 2 lb. emulsion	0.25	April 18	16.7	19.3	3.66
Heptachlor 2 lb. emulsion	0.25	May 13	12.7	20.6	3.66
Check (untreated)	. . .	. . .	17.0	19.4	3.69
		LSD 5%	1.4	0.65	0.26

These same plots were examined during the period of second growth. Some effects of the original treatments could still be noted as shown in Table 4. In this instance the larval counts are measured indirectly by the number of infested tips in the treated area.

This continued effect of the protection provided by the granular treatment is shown in the significantly lower larval populations, greater plant height, and larger yields produced on the second cutting. Differences between the two sprays and the check are relatively small. Occasional significance is indicated, but this may fairly be considered unrelated to the treatments. Residual spray deposits, even if the crop had not been removed, would long since have disappeared. This is indicated by the steady increase of larval populations in these plots as shown in Table 2. It is probable that little larval migration occurred between plots. Therefore, the superiority of the granular treatment would largely be the direct result of the control provided on the first cutting. In addition the granular heptachlor, which was applied under stubble conditions in the spring, would retain some activity. This would provide control against stragglers of the overwintering adult population which, as shown by the presence of young larvae, continued to deposit some eggs at this time.

Summary

The alfalfa weevil (*Hypera postica* Gyll.) appears to be well established in Connecticut. Populations have been increasing and some crop loss may be anticipated. Both adults and larvae feed upon alfalfa, with the larvae causing principal injury to the first crop. Several other weevils, which also feed upon alfalfa, have long been present in our fields. Characteristics of size, color, and habit will serve to distinguish the alfalfa weevil from these other insects. Control of the alfalfa weevil can be obtained by the proper application of insecticides. Granular materials applied prior to new growth in the spring have given good results in these tests. Control of both the alfalfa weevil and the meadow spittlebug resulted and this was reflected in increased yield. This same treatment also protected the second crop.

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