Alfalfa

Alfalfa is the oldest crop grown solely for forage and actual use of it predates recorded history. To the best of our knowledge, the origination of alfalfa is in present day Iran or in mountainous regions of adjacent countries east of the Mediterranean Sea in southwestern Asia. Alfalfa, *Medicago sativa*, is the most important forage crop worldwide. In the US it is grown on approximately 10 million hectares (25 million acres) and has an on-farm value of over $5 billion. Minnesota, and the adjacent states of South Dakota, Iowa, and Wisconsin produce 1/4 of US alfalfa. Alfalfa is unique among field crops in that it represents a relatively long lasting (typically 3-4 years), perennial ecosystem that exists in virtually all parts of the country. Alfalfa is adapted to a wide range of climatic conditions and thrives in cool, humid environments and in most irrigated arid areas. In the Midwest, alfalfa is commonly grown in alfalfa-corn-soybean systems. In the West, it is often grown in alfalfa-sugarbeet systems, and in the East, often in alfalfa-orchard or alfalfa-pasture systems.

Alfalfa supports a diverse arthropod fauna. At least 1,000 species have been reported from alfalfa in the US, with perhaps 100-150 of these causing some degree of injury. Few of these, however, can be described as key pest species, the rest are of only local or sporadic importance, or are incidental herbivores, entomophagous (parasites and predators), or pollinators.

Annual dollar loses due to insect pests in alfalfa runs into the hundreds of millions. Yield reductions in the range of 10-15% are typical estimates (USDA 1965), but are probably low because the question of forage quality has usually not been considered. Alfalfa does not in the usual sense have a market value because production is usually for use as livestock feed by the producer. True value is determined by feed value, e.g., milk production.

With homopterous pests it is often not possible to demonstrate dry weight yield loss (the bulk of the weight being stems), but one can still have significant leaf drop and loss of protein and in vitro dry matter digestibility (IVDMD). Insects may also impair the persistence (e.g., winter kill) and longevity of alfalfa stands.
The key pests include alfalfa weevil, *Hypera postica* (a species that we consider includes Egyptian alfalfa weevil, *H. bruneipennis*), as well as a complex of homopterous pests, the most important of which are potato leafhopper, *Empoasca fabae*, spotted alfalfa aphid, *Therioaphis maculata*, pea aphid, *Acyrthosiphon pisum*, blue alfalfa aphid, *A. kondoi*, threecornered alfalfa hopper *Spissistilus festinus*, and meadow spittlebug, *Philaneus spumarius*. In seed production, serious losses can be caused by mirids, especially *Lygus hesperus*, and *L. elisus*, and the clover seed chalcid, *Bruchophagus roddi* (Eurytomidae). In the South, armyworms, Spodoptera spp., (Leptidoptera: Noctuidae) and webworms, *Loxostege* spp. and *Achyra* spp. (Lepidoptera: Pyralidae) are important pests. The alfalfa snout beetle, *Otiorhynchus ligustici* (Coleoptera: Curculionidae), a serious pest, is thus far limited in distribution to northern New York State and southern Ontario. Blister beetles, *Epicauta* spp. (Coleoptera: Meloidae), do not injure alfalfa, but are of concern because they are poisonous to livestock.

Insecticide use on alfalfa in northern states has generally not been great. Typically, 1-5% of the Minnesota crop is sprayed in any given year. In some parts of the country, because of greater pest pressure, insecticidal treatment is more general and sometimes routine. In Georgia, 85% of alfalfa is treated with insecticides each year. Overall, the crop ranks 18th out of 87 crops in pounds of pesticide (insecticides, herbicides, and fungicides) applied in the U.S. (10.8 million pounds out of 886 million pounds used annually). Much of insecticide applied to forage alfalfa is directed against alfalfa weevil. In recent years, biological control agents and host plant resistance have diminished the impact of this insect and accordingly the need for chemical control.

Alfalfa has several attributes, which make it an excellent candidate for the application of integrated pest management approaches. Cows tend to be tolerant of insect damage and/or insect parts in their diet so there is no reason not to establish realistic economic thresholds. Moreover, alfalfa is for the most part, quite tolerant of moderate pest densities. This permits greater reliance on alternative control methods. Because the crop is semi-permanent, and supports a diverse arthropod fauna, biological control has considerable potential. Biological control agents such as the parasitoids *Aphidius ervi* and *Praon pequodorum*, and generalist predators such as coccinellid beetles, keep pea aphid populations below economic injury levels in much of the United States. Introduced parasitoids are important biological control agents of alfalfa weevil.

Alfalfa offers considerable opportunities for cultural manipulations. The crop is different from many in that it is typically harvested 2-4 times in the northern US, and 6-10 times in the southern US. Harvesting can reduce pest
populations by 95-98%. In Minnesota, delay of first harvest until 1/10th bloom (approximately June 15) allows sufficient time for potato leafhopper oviposition to occur. These eggs (inserted into the stems) are then harvested with the crop, virtually eliminating that generation. Conversely, harvesting alfalfa early, when alfalfa weevil populations are near peak, can eliminate the need for an insecticide application. Burning and mowing have been used to kill overwintering alfalfa weevil eggs. Planting alfalfa in a grass mixture can reduce pressure by both potato leafhopper and alfalfa weevil. Grazing tolerant alfalfa varieties have been developed that enable cattle to continuously graze alfalfa. In future, grazing may become a viable cultural management practice.

Host plant resistance to spotted alfalfa aphid, is common in alfalfa cultivars, thanks to efforts by plant breeders. Development of alfalfa cultivars with resistance to alfalfa weevil proved one of the most difficult breeding problems ever undertaken in alfalfa. Researchers at the USDA Beltsville Laboratory undertook a program of recurrent selection. Over 2 million seedlings were exposed to massive weevil infestations. From this material, selections were made that eventually to the cultivar, Team, were released in 1969. Team has partial resistance to weevil. This resistance is based on tolerance and some degree of antibiosis. In areas where Team is well adapted it has been credited with contributing significantly to reductions in weevil pest pressure. Germplasm releases with glandular-haired trichomes derived from crosses with wild Medicago species, e.g., KS 224 and KS108GH5, possess resistance to potato leafhopper and alfalfa weevil. "Hairy" alfalfa varieties derived from these lines should be available soon.

The alfalfa weevil and its natural enemies

The Alfalfa weevil was first discovered in the US in 1904 near Salt Lake City. It is assumed it was probably introduced from southern Europe. For the next 50 years, alfalfa weevil gradually expanded its range until it occupied most of the region west of the 100th meridian. A second introduction, which for many years was considered to be a closely related but different species, the Egyptian alfalfa weevil, invaded Arizona and southern California in 1939. That insect apparently has remained confined to the hot valley regions of the Southwest. In 1952, alfalfa weevil was discovered near Baltimore and from there spread rapidly throughout the eastern, southern, and midwestern states. The eastern population weevil proved much more aggressive than the western weevil and caused major economic losses. In the southeastern United States alfalfa was virtually eliminated as an agricultural crop. In 1970, alfalfa weevil (eastern population) was discovered in Minnesota and within 3 years had moved across the state. Minnesota populations have, however, remained at subeconomic levels. The eastern and western populations have now merged west of the Mississippi River.
and alfalfa weevil occurs in all 48 contiguous states.

Until recently, eastern alfalfa weevil and western alfalfa weevil were considered to represent distinct "strains" of *H. postica*, while Egyptian alfalfa weevil was considered to be a different species, *H. brunneipennis*. The eastern and western populations are not completely isolated, but differ in details of biology, e.g., the eastern weevil returns from summer aestivation sites to the alfalfa in the fall whereas the western weevil does not return until spring. Entomologists now recognize that eastern alfalfa weevil is actually more closely related to the Egyptian alfalfa weevil than it is to the western alfalfa weevil. Comparison of isoenzymes (Hsiao) tends to support this view.

In the old world, alfalfa weevil is a species having a remarkable range of distribution, occurring from Scandinavia to Egypt and Iran, therefore, it is not surprising that distinct biotypes exist. Even within the populations there is considerable biological plasticity, e.g., in the south, the alfalfa weevil may reach sexual maturity and begin egg laying in the fall, whereas in the north, egg laying is confined to the spring. This makes the alfalfa weevil much more difficult to control in the southern portion of its range.

Biological control of the weevil was first attempted in 1911 with the introduction of the ichneumonid parasite, *Bathyplectes curculionis* from Italy. The parasite proved moderately effective in cooler climates, but has been less successful in hot climates, e.g., San Joaquin valley. *B. Curculionis* also attacks Egyptian alfalfa weevil, but initial introductions were ineffective, presumably due to the hot weather of habitats favored by Egyptian alfalfa weevil and encapsulation of the parasites eggs by that host. Introduction of a new strain of *B. curculionis* from Iran was attempted to overcome these limitations, but success was not achieved until the introduction of a second species, *B. anurus*.

Similarly in the eastern US, the alfalfa weevil tends to encapsulate *B. curculionis* reducing the parasites effectiveness. Attempts have been made to establish additional parasitic species against the eastern alfalfa weevil and at least 5 of these are now widely distributed: *B. anurus*, *Oomyzus incertus*, *Microctonus aethiopoides* and *M. colesi* and *Patasson luna*. Recently, the egg predator *Peridesmia discus* has been recovered; years after the initial releases were made.

In areas where 3 or more parasites are established, alfalfa weevil is seldom of economic importance, even in areas once requiring multiple applications of insecticide. Often as *B. anurus* has become established, it has
tended to displace *B. curculionis* and *O. incertus*. This process is most likely in situations where the fungal pathogen *Zoophthora phytonomi* causes epizootics killing large numbers of alfalfa weevils. *Bathyplectes anurus* has an advantage when fungal epizootics occur because it attacks alfalfa weevil larvae slightly earlier in the season than does *B. curculionis* and appreciably earlier than *O. incertus*. Thus, *B. anurus* is more likely to have completed its development before host larvae begin to die. Also, *B. anurus* has only one generation per year whereas *B. curculionis* and *O. incertus* tend to be multivoltine. *Bathyplectes curculionis* has been in Minnesota since arrival of the alfalfa weevil in 1970, but *B. anurus* has only been established since 1991. To date, there is no evidence that *B. anurus* has displaced *B. curculionis* in Minnesota, but *B. anurus* now predominates in Iowa.

*Zoophthora phytonomi* was first identified from alfalfa weevil larvae in Ontario in 1973. The pathogen, is similar, but is presumed different from that occurring in the cloverleaf weevil, *Hypera punctata*. The pathogen is now the key natural mortality factor in much of eastern Canada and the eastern and southern US.

The alfalfa weevil is one of the primary insect defoliators of alfalfa. Thought to be of Asian origin, the alfalfa weevil was introduced into the United States from southern Europe. First discovered in 1904 in Utah, it is now present in all 48-mainland states. Annually, insect pests of alfalfa, including the alfalfa weevil and potato leafhopper, cause hundreds of millions of dollars in losses. Though difficult to estimate, these same insects are estimated to reduce yields by 10 to 15% annually (forage quality not taken into account). Introduced biological control agents and natural enemies have reduced alfalfa weevil populations in many areas, though it continues to be a sporadic pest of alfalfa.

**Description**

Alfalfa weevil adults are small (1/4 inch) brown snout beetles that have a distinctive dark, narrow stripe that extends down their back. Adult weevils insert yellow oval eggs into alfalfa stems. Following egg hatch, small legless yellowish-green larvae, each with a white stripe along the middle of the back, emerge. A fainter white stripe is also present on each side of the more prominent central stripe. Each larva has a very conspicuous black head and is approximately 3/8 inch when mature. Transformation to the adult stage is passed in a loosely woven white cocoon, about the size of a pea, to which leaves may be attached.

The alfalfa weevil can be confused with the cloverleaf weevil that is another pest of alfalfa. Larvae of both these species are similar, but have distinct differences in appearance. The cloverleaf weevil is green with a white
stripe down the center of its back, but the white stripe is bordered with smudges of pink or red; the head of the cloverleaf weevil is tan. Adult cloverleaf weevils are about two times larger than the alfalfa weevil (5/16 inch long); light brown, with a wide dark brown stripe on the back.

**Life Cycle**

Some initial egg laying during November may take place before the onset of cold weather. During the winter, when temperatures permit, adults may deposit some eggs. Female weevils insert eggs in clusters of 2 to 25 inside alfalfa stems. Larvae become noticeable in April and readily observable in early June. The green larvae feed for roughly 3 to 4 weeks depending on the quality of the alfalfa and the temperature. Larvae molt or shed their skins three times. Following the last larval in star, cocoons are spun on plants or in curled up leaves that have fallen to the ground. The pupal stage requires 1 to 2 weeks for completion. Upon their emergence from cocoons, adults feed for a week or two, and then move to sheltered areas to spend an inactive summer. It is quite likely that at any given point in time during the summer, most, if not all, alfalfa weevil life stages can be found. Older adult weevils may continue their egg-laying activities, while at the same time, larvae, cocoons, and newly emerged adults may also be observed. Upon the arrival of colder weather, adult weevils seek out the crowns of alfalfa plants, or the protection of wooded areas or vegetation provided in ditch banks or fencerows to over winter.

**Injury**

Both adults and larvae feed on alfalfa foliage, but the larvae cause the majority of the damage. Larvae feed initially on the inside of terminal leaves and later move to foliage on the lower portion of the plant. Early season larval damage (first and second instars) shows up as pinholes in leaf terminals. Leaves are made bare as larvae increase in size. Third and fourth instars defoliate plants by feeding between the veins, and also on the buds and growing tips. Adults generally feed on the leaf margins that create a feathery appearance of the foliage. Injured leaves dry very quickly giving the field a grayish to whitish cast.
Alfalfa weevils have the ability to severely damage the first cutting of hay. In southern areas, significant egg laying may take place during the fall, predisposing some alfalfa fields to early larval damage the following spring.

Cloverleaf weevils and alfalfa weevils also feed and behave differently. Alfalfa weevils feed during the day, actively feeding on the foliage, starting near the leaf tips. Cloverleaf weevils feed at night, usually on the lower leaves. They can be found on the ground, near the crowns during the day.

**Scouting Procedure**

Growers should always examine stubble following the first harvest, because of the potential for larval and adult feeding on new tender growth. Fields should be scouted in a U-shaped pattern. Care should be taken to take samples from representative portions of the field avoiding field edges. At least 30 stems should be chosen from the U-shaped swath throughout the field. When randomly collecting the stems, avoid looking directly at a stem to be chosen. All stems should be placed in a bucket with care taken not to dislodge larvae upon the ground before they can be counted. The following observations should be made of the collected stems: (1) stage of plant development, (2) presence or absence of damage to foliage, (3) number of larvae per stem. In order to make the last observation, beat the stems along the sides of the bucket and count the larvae that have fallen off the stems. The number of larvae per stem and the percentage of stems with leaf tip damage can be calculated.

When 25 to 50% of leaf tips have been skeletonized and if there are three or more weevil larvae per stem, a management decision must soon be made. This decision need not only mean choosing an insecticide. If an insecticide is selected as a management tactic, do not apply it during bloom because of potential harm to nontarget insects such as honeybees. Consider harvesting the first hay crop as early as possible. Regrowth should be monitored very carefully for any sign of weevil damage. Alfalfa weevil adults and larvae have the potential to prevent or slow regrowth by feeding on the new shoots; adults also feed on sides of the stems (bark feeding). Control may be warranted after a cutting when larvae and adults are feeding on more than 50% of the crowns and regrowth is prevented for 3 to 6 days.
Management

Alfalfa weevil activity can be predicted with the use of degree-days. Beginning January 1, the accumulations of degree-days (base 48°F), can be used to estimate alfalfa weevil activity. Larvae begin to hatch around 300 degree-days. We recommend beginning scouting after the accumulation of 250 to 300 degree-days. The first larval peak is estimated to occur after the accumulation of 325 degree-days and the second larval peak after 575 degree-days.

<table>
<thead>
<tr>
<th>Degree Days (following January 1)</th>
<th>Stage</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>Egg hatch</td>
<td></td>
</tr>
<tr>
<td>301-438</td>
<td>1st-2nd instar</td>
<td>Light leaf feeding</td>
</tr>
<tr>
<td>439-595</td>
<td>3rd-4th instar</td>
<td>Major leaf feeding</td>
</tr>
<tr>
<td>596-810</td>
<td>Pupa-adult</td>
<td>Mating &amp; egg laying</td>
</tr>
</tbody>
</table>

Alfalfa weevil populations may be regulated by naturally occurring pathogens. As you scout your alfalfa fields, keep alert for brown or discolored larvae on leaves at the top of plants. A fungus, Zoophthora phytonomi, may have infected these larvae. The fungus reduces larval populations during the summer, subsequently resulting in a smaller overwintering population of adult weevils. A warm and humid environment favors Zoophthora phytonomi. With above average rainfall or humidity levels above 90%, an environment may be present in which the fungus can develop and cause a dramatic decline in alfalfa weevil populations.

Parasitic wasps also help keep alfalfa weevil populations in check. Bathylplectes anurus and B. curculionis are two parasitic wasps that have been introduced into the United States. Both wasps are very small, about 1/8 inch, and deposit eggs in weevil larvae. Adult female wasps lay their eggs in weevil larvae. The parasitoid larva, following hatch, kills the weevil as it completes its cocoon. A brown cocoon with a white band is formed by the parasitoid. The parasitoid cocoon may be found in the cocoons of the alfalfa weevil, and these parasitoid cocoons appear to "jump" several centimeters when disturbed.

Early harvesting is a very effective tool for the management of the alfalfa weevil. Harvesting the crop early, when alfalfa weevil populations are high, can dramatically reduce weevil densities. This helps to remove food and shelter from larvae and also increases their exposure to harmful rays from the sun. Reports indicate that harvesting can reduce pest populations by 95-98%. The windrows of hay also create a suitable environment that allows for the development and spread of the fungus Zoophthora phytonomi.
There are several insecticides registered for the control of alfalfa weevil. In recent years insecticide use in alfalfa has decreased. Biological and cultural control practices often keep alfalfa pests below economic levels. Monitoring of alfalfa fields for insect pests and crop development will help determine the need for management strategies.

**Spotted Alfalfa Aphid**

The mature aphid is about 1/16 inch long, and is either winged or wingless. It is yellow and has several rows of black or brown spots on its back and on the underside of its body. The young, or nymphs, resemble the adults, but are smaller and have no wings. When magnified, they appear spiny. Usually, spotted alfalfa aphids are most abundant on the lower part of the plant.

A sugary secretion of aphids, called honeydew, is often apparent in moderately to heavily infested fields. A black, sooty mold may develop on the honeydew. Apparently this aphid feeds almost exclusively on alfalfa and does not attack any of our other forage crops. However, two other species of aphids closely resemble it—the yellow clover aphid on red clover and the sweet clover aphid on sweet clover. These two do not become established on alfalfa. Therefore, an aphid fitting this description on alfalfa is likely to be the spotted alfalfa aphid, while that found on red, alsike, or sweet clover is not the spotted alfalfa aphid.

**Life Cycle**

Spotted alfalfa aphids winter primarily in the adult stage in the crown of the alfalfa plant, feeding whenever the weather permits. They begin to produce young early in the spring. Since no male spotted alfalfa aphids have been observed in the United States to date, every spotted alfalfa aphid is assumed to be a female capable of giving birth to living young, at the rate of 1 to 6 a day under optimum conditions.

Each adult may produce 25 to 100 young in her life span. Depending on temperatures, it takes 1 to 4 weeks for a nymph to mature; thus, there may be 15 to 30 generations each year. This pest was first found in the United States in 1954, spreading since into 32 states. It flies readily from field to field; it can migrate long distances in strong winds.
Damage

In the early stages of an infestation, the plants begin to wilt; healthy green plants begin to yellow and turn brown. This damage usually appears first in a small area that gradually enlarges, causing many plants to die. Thus, old stands are seriously thinned and the life of the crop is shortened. Death or serious damage to established stands occurs most often when moisture is scarce.

Moderate to heavy infestations of the spotted aphid seriously reduce hay quality and yields. New alfalfa seedlings are killed rapidly. The honeydew secreted by the aphids may become so thick that cutter bars on mowers gum up and have to be washed. Balers may have to be washed to keep them operating. In severe cases, tractor tires become covered with the sticky material and must be washed. A sooty mold that develops on the honeydew seriously affects the quality of the hay. One aphid per seedling will produce enough young in 7 to 10 lays to kill the tiny plant. An infestation of 20 aphids per stem in old stands of alfalfa may develop into a very serious infestation within 1 to 2 weeks.

Control

Natural or biological control is quite important. Several species of lady beetles and their young feed on aphids. It has been said that a lady beetle is capable of eating a teaspoonful of aphids in one day. The young of the green lacewing, or aphids lions, as well as the larvae of flower flies, also feed extensively on aphids. Several other insects also prey on these pests. Species of wasps, specific parasites of the spotted alfalfa aphid, have been imported from the insect's native home and are now becoming established in the United States. Whether some of our native parasitic insects will attack this pest remains to be seen. Naturally occurring fungus diseases of aphids may help to control it. Winter weather, as it affects the ability of the aphid to overwinter, is important in determining how numerous this pest will be. Rainstorms during the growing season may also have an effect. Humidity may be a factor since the insect appears to thrive best under dry conditions and moderate temperatures. Unfortunately, these natural factors are often not able to cope with heavy infestations of this pest before serious damage or loss of stand occurs. In these cases, chemical control will be helpful. Since these aphids migrate readily, chemical control operations must be a community endeavor. In applying chemical control measures, however, always evaluate the populations of beneficial insects. If they seem to be numerous,
the use of chemicals may be unwise. On the other hand, if such pests are scarce or absent, chemical control may be advantageous.

Blue Alfalfa Aphid

The blue alfalfa aphid resembles the pea aphid, but does not have dark bands encircling the base of each antennal segment. Light infestations have been recorded from most counties of Kansas, but serious damage has not been observed so far. Heavy infestations that seem to be pea aphids, particularly on pea aphid-resistant varieties, should be identified by an entomologist. Stunting of plant growth is evident at lower infestation densities than with pea aphid feeding. For instance, 20 blue alfalfa aphids per stem on 10-inch-tall alfalfa, or 50 blue alfalfa aphids on 20-inch-tall alfalfa, may justify insecticide treatment.

Data on efficacy of insecticides for blue alfalfa aphid control in Kansas is limited. The following chemicals list either blue alfalfa aphid or aphids on the label.

Chlorpyrifos 4E (numerous products)

0.5 to 1.0 lb. a.i./acre (1 to 2 pints per acre); PHI is 14 to 21 days.

Cyfluthrin (Baythroid 2)

0.044 lb. a.i./acre (2.8 fl. oz./acre); labeled for suppression. PHI is 7 days.

Dimethoate (Dimethoate or Dimate)

0.25 to 0.5 lb. a.i./acre; PHI is 10 days.

Gamma-cyhalothrin (Proaxis)

0.01 to 0.015 lb. a.i./acre (2.56 to 3.84 fl. oz/acre); PHI is 1 day for forage and 7 days for hay.

Lambda-cyhalothrin (numerous products)
0.02 to 0.03 lb. a.i./acre (2.56 to 3.84 fl. oz./acre); PHI is 1 day for forage and 7 days for hay.

Malathion

1 to 1.25 lb. a.i./acre; PHI from 0 to 7 days depending on product and/or rates.

Methyl Parathion (Cheminova Methyl 4EC)

0.25 to 0.5 lb. a.i./acre; PHI is 15 days.

Permethrin (Pounce 3.2EC, Ambush 2E)

0.05 to 0.2 lb. a.i./acre. Control may not be adequate under heavy aphid infestations. PHI is 0 to 14 days.

Zeta-cypermethrin (Mustang MAX)

0.014 to 0.025 lb. a.i./acre (2.24 to 4.0 fl. oz./acre); PHI is 3 days for cutting or grazing or 7 days for seed.

Distribution

California entomologists discovered the blue alfalfa aphid, Acyrthosiphon kondoi Shinji, in 1975. Since then it has become widespread in that state and has become established in Arizona, Nevada, New Mexico, and at least as far east as Kansas and Oklahoma.

Description

The blue alfalfa aphid looks very much like the pea aphid. However, the blue alfalfa aphid is smaller, more blue-green, and has a waxy appearance. In contrast, the pea aphid is lighter green and shinier. The third antennal segment of the blue alfalfa aphid is uniformly brown; that of the pea aphid has a narrow dark band at the tip. The thoracic area on the winged forms of the blue alfalfa aphid is dark brown as opposed to light brown on the pea aphid.

Life History

The blue alfalfa aphid overwinters in the egg stage in the Midwest. The tiny black eggs are glued to the stems and fallen leaves of alfalfa and clover in the fall. Hatching occurs in
the early spring, and the young nymphs feed on new growth of alfalfa or clover. They molt four times before becoming adults. After one or two generations on alfalfa, a large proportion of the next generation will develop wings. These winged females disperse with the aid of the wind into adjacent alfalfa fields where they start new colonies, producing nymphs parthenogenetically. The entire life cycle takes about 7 to 10 days at an average temperature of 70°F, and since each female can produce 50 to 100 nymphs, large populations can result. Blue alfalfa aphid populations decrease rapidly when the daily high temperature reaches 85° to 90°F.

**Damage**

The blue alfalfa aphid prefers to feed on the tender succulent parts of the alfalfa plant. These aphids cluster on the terminal growth, but as populations increase, they will spread over the entire plant. Heavily infested alfalfa is characterized by severe stunting of the stems, which have shortened internodes and smaller leaves. Leaf curling and eventual leaf drop are also common symptoms in severely infested fields. Large blue alfalfa aphid populations have delayed cutting schedules or have caused the loss of a full cutting.

**Scouting Methods**

Randomly select complete stems throughout the field and count the number of blue alfalfa aphids per stem and all parasitized (mummified) or diseased (brown and flattened) aphids. Continue this procedure until you have sampled at least 20 to 30 stems. Calculate the average number of healthy aphids per stem and the average of diseased or parasitized aphids per stem. Then measure each stem and calculate the average stem length. Twenty blue alfalfa aphids per stem on 10-inch alfalfa or 50 blue alfalfa aphids on 20-inch alfalfa would be cause for alarm if diseased and parasitized aphids were scarce.

**Alfalfa Caterpillar**

The yellowish-orange or whitish butterflies of the alfalfa caterpillar lay eggs on the short, new growth alfalfa that is less than 6 inches tall. Eggs hatch into green caterpillars in 3 to 7 days. Full-grown caterpillars are about 1.5 inches long and are distinguished from other common caterpillars on alfalfa by their velvety green bodies and white lines along their sides.

Caterpillar populations usually result from a flight of butterflies into the field when the alfalfa is less than 6 inches tall. Extremely large numbers of adults migrating between fields are often present from June to September in the Central Valley and from May to October in the Imperial Valley. Factors contributing to
economic populations are slow and uneven growth of the crop, lack of parasites, and hot, dry weather. There are four to seven generations a year of alfalfa caterpillar, and each generation is closely synchronized with the hay-cutting cycle so that the caterpillar pupates before cutting occurs.

**Damage**

Alfalfa caterpillars consume entire leaves. The larger larvae are most destructive. In contrast to armyworms, alfalfa caterpillars do not make the leaves into skeletons, but will consume the midrib.

**Management**

The most important way to control the alfalfa caterpillar is to preserve and encourage its natural enemies by avoiding unnecessary insecticide applications for aphids or weevils in late spring or by using nonselective insecticides against caterpillar pests in summer.

**Biological Control**

An important parasite of the alfalfa caterpillar is *Cotesia medicaginis*, a dark brown to black wasp about 0.25 inches long. This wasp stings very small alfalfa caterpillars and lays an egg inside. The egg hatches and the wasp larva consume the body contents of the caterpillar. A parasitized caterpillar dies before it reaches 0.5 inch in length. It is recognized by being lighter than normal in color, somewhat shiny rather than velvety on the surface, and swollen toward the rear. Grasping the caterpillar at each end of the swelling and pulling it apart will expose the shiny, white parasite. It is important to determine the amount of parasitism because the economic threshold takes parasitism into account.

**Cultural Control**

Border-strip harvesting is a useful method for preserving the natural enemies of both the alfalfa caterpillar and aphids because it helps retain parasite larvae in the field. Early harvesting of fields infested with economic levels of alfalfa caterpillars kills a large number of caterpillars, preserves crop yields, and avoids reducing the natural enemy population. Time this cutting to avoid serious damage, yet obtain satisfactory yield.

**Organically Acceptable Methods**

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Biological and cultural controls, as well as sprays of *Bacillus thuringiensis*, are acceptable for use on an organically certified crop.

**Monitoring and Treatment Decisions**

In early summer start sweeping fields with adequate plant height 2 to 3 times per week to monitor for caterpillars. If cutting is not practical or not scheduled soon after monitoring, treat if there is an average of ten or more nonparasitized alfalfa caterpillars per sweep, fifteen or more nonparasitized armyworms per sweep, or 10 or more nonparasitized alfalfa caterpillars and armyworms combined per sweep.

**Beet Armyworm**

The adult beet armyworm is a small, mottled gray- or dusky-winged moth. The moths fly mostly at night but may be seen flying up as you walk through the field. Females deposit pale greenish or pinkish, striated eggs on the upper side of the alfalfa leaves in small or large masses covered with white cottony material. The eggs hatch in a few days, and the tiny caterpillars begin feeding on the plant. Heavy feeding on the tips of plant stalks can cause flagging, as terminal leaves turn white. The smooth-skinned caterpillars become full grown in about 2 to 3 weeks and are about 1.25 inches long. They may be olive green to almost black in color down the middle of the back with a yellow stripe on each side of the body.

Armyworms are common pests in the Central Valley and desert valleys from June through September. There are at least 5 generations a year in the low desert and four in the Central Valley. The final generation may overwinter as large larvae or pupae.

**Damage**

Armyworms skeletonize foliage, leaving veins largely intact. First and second instar larvae tend to feed in clusters around the egg mass from which they hatch. This frequently causes a tattered appearance to the terminals. This whitish appearance caused by the feeding is known as "whitecaps" and is very visible across a field. As the larvae mature and move to more stems, the areas of "whitecaps" tend to coalesce and the entire field takes on a tattered look.

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Management

Populations of armyworms are frequently controlled by natural enemies and are more or less cyclic, occurring in large numbers only every few years. Early harvest, border cutting, and biological control are important components in avoiding damage from armyworms.

Biological Control

Natural enemies can provide good control of armyworms in many fields. Predators include big-eyed bugs, spiders, minute pirate bugs, damsel bugs, and lacewings. The parasitic wasp, *Hyposoter exiguae*, is the most important of at least 10 parasites attacking this pest. Sample for parasitism by pulling the heads from older caterpillars and squeezing the body contents out toward the head end. *Hyposoter* larvae are a light, translucent green color. Viral diseases of armyworms are also important natural control agents. Diseased caterpillars first appear yellowish and limp. After death they hang from plants as shapeless, dark tubes oozing the disintegrated body contents.

Cultural Control

Border-strip harvesting is a useful method for preserving natural enemies because it helps retain parasite larvae in the field. Early cutting will give satisfactory control if the infestation appears late in the cutting cycle.

Organically Acceptable Methods

Biological and cultural controls, as well as sprays of *Bacillus thuringiensis*, are acceptable for use on an organically certified crop.

Monitoring and Treatment Decisions

In early summer start sweeping fields, with adequate plant height, 2 to 3 times per week to monitor for caterpillars and continue through fall. Divide each field into 4 sections and take 5 sweeps per section with a 15-inch diameter sweep net, for a total of 20 sweeps.

Alfalfa Blister Beetles

Blister beetles are narrow and elongate and the covering over the wings is soft and flexible. They may be solid colored (black or gray)
or striped (usually orange or yellow and black) and are among the largest beetles likely to be found in a sweep net sample in alfalfa.

**Damage**

Blister beetles do not cause widespread feeding damage to alfalfa, however, they contain a chemical, cantharidin that is toxic to livestock. Cantharidin is contained in the hemolymph (blood) of the beetles and may contaminate forage directly when transfer of the hemolymph from crushed beetles onto forage incorporates beetles killed during harvest into baled hay or indirectly. As the name implies, handling these insects may result in blisters, similar to a burn, on the hands or fingers. Blister beetles have been a serious problem in alfalfa in the northern United States, the Midwest, and the south for many years, but until recently have not been a problem in California.

Alfalfa contaminated with blister beetles in the southern Owens Valley has been linked to the death of several dairy cows. At this point, it is not known if blister beetles are widespread or confined to the Owens Valley. Likewise, it is not known if the problem is likely to spread and hence become a common occurrence in California alfalfa. In the meantime, growers and PCAs are advised to be on the lookout for blister beetles and to contact their farm advisor for advice if these insects are found.

**Management**

There are no known predators or parasites that effectively control blister beetles. Blister beetles are attracted to blooming alfalfa. Therefore, to reduce the incidence of blister beetles in alfalfa, cut hay before bloom. If beetles are found, remove the conditioner wheels from the swather in order to prevent crushing beetles. Also, these beetles are found on the edge of the field or congregated in groups within the field. Skip such areas when cutting or pick up the bales for these areas separately and isolate them from the rest of the field. No treatment thresholds have been established for blister beetles.

**Alfalfa Clover Root Curculio**

Adults of the clover root curculio are slightly smaller than alfalfa weevil adults and are a mottled gray-brown with no distinct patterns. The life cycle is similar to alfalfa weevil in that the adults leave the alfalfa fields and spend the summer in protected areas.

The clover root curculio is a recognized alfalfa pest in the eastern half of the US, but information on this pest in California is extremely limited.
Clover root curculio is apparently more common in sandy soils than in the heavier soils.

**Damage**

The white, grub like larvae of the clover root curculio feed on alfalfa roots and leave gouges in the taproot. They are most likely to be found in June. This damage has been shown to be detrimental to alfalfa yield and stand longevity in the eastern United States. The feeding also promotes root rot diseases by providing entry points for fungi.

**Management**

There are no thresholds or control measures for this pest.

**Alfalfa Ground Mealy bug**

Ground mealybug is a small, whitish insect found on the roots of alfalfa and other crops. It is restricted to the heavier soils of the Sacramento Valley and is not found in the San Joaquin or Imperial Valleys.

The ground mealybug has slender, waxy filaments that form a sort of netting over some individuals. The ground mealybug also secretes a small amount of wax, which can give the soil a somewhat bluish appearance when the mealybugs are abundant. There are three generations per year with populations peaking in the early winter, spring and mid-summer periods. The eggs, nymphs and adults all occur in the soil.

**Damage**

The ground mealybug feeds on alfalfa roots and can cause severe damage. Feeding interacts with stressful environmental conditions resulting in greatly reduced plant growth that is particularly evident during summer. Infestations in alfalfa fields generally occur in "circular" patches and spread slowly.

**Management**

There are no thresholds or control measures for this pest. Crop rotation may help, but this pest appears to survive on several crop plant and weed species. Because there is differential survival across species, rotation to a less preferred host may aid in management. In a greenhouse study, greatest survival was on potato, tomato, safflower, and alfalfa, followed by cotton, cantaloupe, dry land rice, sugar beets, and wheat. There was only
slight survival on field corn and kidney beans. However, there were no plant species without some level of survival.

Alfalfa Sampling with a Sweep net

Sampling with a sweep net is a common practice for many alfalfa pests when alfalfa plants are at least 6- to 10-inches tall. (For shorter regrowth, do not rely on sweep net sampling to determine population levels). Sweep net sampling is also used for estimating lady beetle populations. A 15-inch diameter sweep net is the standard sampling tool used in alfalfa. The manner in which this sweep net is used can greatly influence its effectiveness for collecting insects in alfalfa and, consequently, treatment decisions based on the number of insects caught. Therefore, standard methods have been developed for sampling so results from different individuals are comparable.

To use a sweep net, swing it in a 180° arc such that the net rim strikes the top 6 to 8 inches of alfalfa growth. Hold the net slightly less than vertical so the bottom edge strikes the alfalfa before the top edge. This will facilitate getting the insects into the net. Each 180° arc counts as one sweep. A common practice is to take a sweep from right to left, walk a step, and take another sweep, left to right.

After taking the desired 5 sweeps, quickly pull the net through the air to force all insects into the bottom of the net bag and grasp the net bag with a hand at about the mid-point. Slowly invert the net bag while releasing your grasp on the bag allowing the insects to escape and count the numbers of key species. Many slow-moving insects, such as weevil larvae, aphids, and caterpillars can be counted by turning the net onto a white pan or even the hood of a vehicle. Divide totals by 5 to get the average number of insects per sweep. To get a good representation of insect numbers in the alfalfa field, take sweep net samples in four different areas of the field.

If the numbers are so large that counting in the field is difficult, the bag contents can be placed into a plastic or paper bag and the counting done after cooling the sample to slow down the insect movement. Pest management decisions, however, are generally made before such high numbers occur. Collect samples from all portions of the field but avoid unusual parts of the field, such as field edges. The exception to this is when sampling leafhoppers, which tend to be concentrated initially on the field margins. The table below details specific sweeping guidelines for each pest.
### Guidelines for sweep net sampling

<table>
<thead>
<tr>
<th></th>
<th>Alfalfa caterpillars and armyworms</th>
<th>Egyptian alfalfa weevil and alfalfa weevil</th>
<th>Leafhoppers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>When to start</strong></td>
<td>In early summer (June) when plants reach adequate height.</td>
<td>In early January or later, depending on location. Sweep fields after weevil larvae appear (as evidenced by chewed leaves). (If plants are too short to sweep, monitor terminals for damage.)</td>
<td>In July to August at the first sign of injury (wedge-shaped leaf burn at the tip of leaves).</td>
</tr>
<tr>
<td><strong>How often</strong></td>
<td>Twice a week</td>
<td>Twice a week</td>
<td>Weekly until numbers approach the threshold.</td>
</tr>
<tr>
<td><strong>Divide field</strong></td>
<td>4 sections; 5 sweeps/section (20 sweeps total)</td>
<td>4 sections; 5 sweeps/section (20 sweeps total)</td>
<td>4 to 6 sections; 10 sweeps/section</td>
</tr>
<tr>
<td><strong>Special instructions</strong></td>
<td>Identify type of caterpillar. Count armyworms 0.5 inch or longer. •Record the number of healthy and parasitized (pull apart caterpillars and look for a parasite larva) •Keep records on monitoring form</td>
<td>Continue to monitor weekly during spring or after a treatment: •Central Valley through June •Southern deserts until March •Intermountain areas until mid-June. •Keep records on monitoring form.</td>
<td>Count number of adults and nymphs. •Be sure to include field edges when sampling. •Keep records on monitoring form.</td>
</tr>
<tr>
<td><strong>Treatment thresholds</strong></td>
<td>If cutting is not scheduled soon after monitoring, treat when there is an average of: •10 or more nonparasitized alfalfa caterpillars per sweep •15 or more nonparasitized armyworms per sweep •or 10 or more per sweep of both species that are nonparasitized</td>
<td>For sweep net sampling, treat when weevil larval count reaches an average of 20 larvae/sweep.</td>
<td>If alfalfa is 2 or more weeks from harvest, apply treatments if counts reach 5 leafhoppers/sweep (adults and nymphs). For fields scheduled to be harvested in 10 days to 2 weeks, treat if counts reach 10 leafhoppers/sweep.</td>
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</tbody>
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