

Alfalfa Weevil Management in Kansas:

II. Non-chemical controls

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Recommendations developed at Kansas State University emphasize integrated management strategies for controlling insect problems. Cultural, biological, and other non-chemical strategies are important components of this philosophy. This publication expands on the non-chemical information in MF-846, <i>Alfalfa Weevil Management in Kansas</i>, and MF-809, <i>Alfalfa Insect Management</i>. THE PEST AND DAMAGE Damage: Feeding by larvae removes leaf tissue from the tops of plants, giving the field an appearance of being frosted. Reduced amounts of alfalfa leaf tissue lowers feeding value by decreasing protein and energy contents of the hay. After feeding is finished, larvae drop to the ground where they spin loosely woven white cocoons among the leaf litter. Several days later adult weevils emerge from the cocoons. Adults rarely become an economic problem unless large numbers occur just after the first cutting is removed from the field. Adults may delay regrowth by “barking” the stems, forcing new growth to develop from below ground or within the crown. Losses consist of defoliation, reduced growth, and delayed maturity which result in reduced yield and/or quality. At stem densities of 30 to 35 per square foot, alfalfa weevil larvae will consume about 170 pounds of hay per acre for each additional larva present on a stem that feeds for its entire life cycle. Under very heavy weevil feeding pressure, damaged plants may be at the pre-bud stage of development when they should be in full bloom.	Protein concentration of hay does not always change in a consistent manner following weevil attack. However, total protein yield produced per field often declines. Length of productive stand life may be greatly reduced if high weevil pressure is allowed to persist. Weevil feeding allows more light to penetrate the canopy, resulting in increased weed competition, further stressing the surviving plants. DIRECT AND CARRYOVER LOSSES Direct losses of one ton per acre have been measured during the first cutting as a result of severe weevil feeding. Carryover losses are caused by the failure of plants to adequately recharge stored carbohydrates in the crown and root tissues before top growth is removed. The plants may be unable to rapidly regrow following cutting because they do not have adequate stored energy reserves to draw upon. Thus, the hay may be of lower quantity and quality because weevil feeding removes protein with the foliage. Carryover losses may be severe—even if the crop receives no further stress. One study reported severe weevil pressure during the first cutting, reduced yields in the second cutting by 9/10 ton per acre, by 6/10 ton per acre in the third cutting, and by 1/4 ton per acre in the fourth cutting. In this study, the total seasonal loss caused by weevil larvae feeding unchecked in the first cutting amounted to 2.75 tons per acre. A producer should manage for the entire season when making decisions	regarding larvae present during the first cutting. MANAGEMENT OPTIONS Many approaches to alfalfa weevil management have been attempted over the years. These include flaming, flooding, crushing of eggs and larvae, disking or harrowing, grazing or pasturing, early harvest, biological control with tiny parasitic wasps and diseases, changing the time of seeding to avoid egg laying, host plant resistance, and many types of insecticides. <i>Why should non-chemical controls be considered?</i> Experience has shown that best management results from a combination of control tactics. Total reliance on insecticides is costly and often leads to increased insecticide resistance. Insecticides also can leave toxic residues in the harvested crop. Regardless of the reasons, most alfalfa producers would probably prefer to have a variety of alternatives to choose from rather than relying solely on chemical control measures. FLAMING AND BURNING Flaming or the use of fire has been investigated since the 1920s. Kerosene, straw, and more recently propane have been used as fuel to burn the surface residues, destroying weevil eggs. Results of flaming have varied greatly. A 1971 University of Maryland study indicated that flaming dormant alfalfa <i>sometimes</i> gave control of weevil larvae. Flamed and insecticide-treated plots resulted in approximately equal yields. However, flaming stands of new seedlings reduced stem density and lowered
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vigor of surviving plants, sometimes resulting in lowered hay yields. Alfalfa that is dormant or has at most two to three inches of new growth has usually been used in these studies. Flaming of alfalfa when new growth was present reduced weevil control effectiveness and lowered harvested yields. Flaming dormant alfalfa, combined with early harvest, produced plants with lower fiber and higher protein content. The use of herbicides before flaming to dry weed growth did not increase weevil control. Weevil control with fire has usually been proportional to the intensity of the burn. Slower ground speeds and hotter flames have usually given a greater reduction of weevil larvae. Tractor-mounted flamers typically have been used at ground speeds of less than four miles per hour. A 45 to 60 percent reduction in weevil densities can be achieved through flaming. Research to improve flamer design has reduced fuel requirements from 75 gallons to approximately 17 gallons of propane per acre. Flaming dormant alfalfa gave more protection against very early season alfalfa weevil infestations than did foliar applications of insecticides. This result is perhaps not as surprising as it first seems since flaming destroys many eggs, whereas insecticides are largely active against larvae which must emerge from eggs before they can be controlled. A 1988 southeast Kansas study of burning stubble showed significant reductions in populations of alfalfa weevil larvae. Eventually the burned field had to be sprayed with an insecticide because weevil pressure was very heavy. However, nearby fields had to be sprayed twice with insecticides if they had not been burned previously. Note that burning itself may have some undesirable effects on the stand, may also reduce wildlife cover and can lead to increased soil erosion.	GRAZING Grazing of dormant alfalfa by livestock has been used for decades to reduce alfalfa weevil problems. A 1988 study conducted in California concluded that fall grazing should not reduce alfalfa yield if timed properly. A New Mexico study indicated that grazing can temporarily reduce alfalfa weevil populations. The population reduction is probably related to stocking rate, plus timing and duration of grazing. Cattle were limited by fences to selected areas of fields in a recent Oklahoma study. This experiment was undertaken after fall regrowth of about 10 to 14 inches in height was killed by cold weather. Grazing started in December and continued until February when livestock were removed before new growth developed. Cattle reduced the density of weevil eggs by over 60 percent. The impact of grazing on a beneficial parasitic wasp also was determined in this study. Cattle hooves killed 2 to 12 percent of the overwintering wasps. The authors concluded that the benefits of grazing greatly outweighed the detrimental effects of parasite mortality caused by the cattle. Many factors should be considered before undertaking grazing of alfalfa. Green alfalfa may cause cattle to bloat. Intensive stocking may cause crown damage which can reduce stand longevity and expose plant tissues to pathogens and diseases. Grazing may entail other expenses, such as additional fencing and watering facilities. DISKING, HARROWING, AND CRUSHING Shallow disking did not reduce alfalfa weevil larval populations in a 1981 New Mexico study. Harrowing and disking is not recommended by most researchers because of the alfalfa crown damage which occurs. Crown damage allows entry of	disease organisms that cause early plant death and stand loss. Crushing with rollers or vehicles has increased mortality of overwintering eggs. Evidence of this can be observed where vehicle pathways cross alfalfa fields during the dormant season. Reduced weevil damage may be observed where the vehicle tires have passed. ALFALFA AS AN ANNUAL CROP Altering the time of seeding also may have value in limiting weevil damage. Spring-seeded fields may sometimes escape economically important infestations of alfalfa weevil larvae. A recent study was conducted in Indiana, Kentucky, and Tennessee to determine if alfalfa could be managed as a spring-seeded annual and thereby avoid problems by disrupting the weevil life cycle. In this study, non-winter hardy alfalfa was planted in the spring. In one trial, the spring-seeded alfalfa was virtually uninfested while traditionally-managed perennial alfalfa in the second year of growth had about four larvae per stem. This population was about 100-fold higher than in the spring-seeded plots. Several limitations to this study were noted, however. Annual re-establishment of alfalfa is risky and relatively expensive. Much of the non-winter hardy alfalfa did survive the winter. This provided an overwintering site for larvae. Some areas developed very dense populations the next spring. Winter survival resulted in the producer having to conduct an extra field operation to destroy the alfalfa so another crop could be planted. Requirements for success include planting non-dormant alfalfa cultivars that winterkill and/or destroying any alfalfa that survives the winter. Fall disking of this field reduced the opportunity for alfalfa and alfalfa weevil larvae to overwinter — but even with the disking, a
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high percentage of larvae was present the next spring. The researchers concluded that alfalfa could be used as a spring-seeded annual crop with some benefits derived from disrupting the weevil life cycle. Weevils were less of a problem in spring-seeded alfalfa because the crop was either too small to be attractive to egg-laying adults or because the crop emerged after the migration of weevils into the fields had ceased. Any eggs laid in the non-winter hardy alfalfa would be lost when the alfalfa died. This cultural approach could be useful during some years at Tennessee latitudes. BIOLOGICAL CONTROL Several biological control agents have been investigated for their potential in controlling alfalfa weevil larvae. These include: parasitic wasps known as parasitoids, various predators, and insect-specific diseases. Although many insect predators may be present in alfalfa fields, for the most part their activity does not coincide with that of the alfalfa weevil. PARASITOIDS A number of alfalfa weevil parasitoids (small wasps) have become firmly established in the northeastern United States. These parasitoids have suppressed local populations of the alfalfa weevil. Release projects are underway to evaluate establishment of parasitoids in many parts of the U.S. Several of these wasps, capable of attacking weevil larvae and adults, have been released in Kansas. The wasp lays an egg inside weevil larvae or adults. A wasp larva emerges from the egg and feeds on the body fluids of the weevil larva. Although the weevil larva may continue to survive for a period of time, the amount of feeding damage that occurs is reduced greatly. Two wasp species attack and kill the weevil before it emerges from the cocoon. Parasitism in the field can be	determined by the presence of a small brown object with a white belt inside the weevil cocoon. Eventually, a tiny adult wasp will emerge from the brown, white-belted parasitoid cocoon. Evaluating parasitoid effectiveness is not easy. First, weevil larvae, pupae, and/or adults must be collected. The insects must be separated from all plant material, then dissected or maintained alive until the parasitoids emerge. Eventually, the percent parasitization or mortality can be estimated. However, this estimate is made after crop damage already has occurred. <i>Bathyplectes curculionis</i> is one of the larval parasitoids that develops internally. Not only does the parasitoid attack the weevil larvae but the weevil larvae may counter this attack. Parasitoid eggs within the weevil larva can be encapsulated. This interferes with breathing and feeding of the developing wasp which then dies. In effect, this encapsulation reduces the effectiveness of the parasitoid by 15 to 40 percent about the time the peak weevil larvae population is achieved. This example illustrates how complex biological control systems can become. Another wasp species, in addition to killing weevil larvae, renders adults sterile. Many releases of weevil parasites have been made in Kansas in an attempt to introduce more effective biological control measures. Some of these wasps have been recovered throughout the state, but often in very low numbers. To date, the reasons why a given parasite was or was not effective have not been established. There is speculation that the dry conditions of Kansas may limit the effectiveness of some released biological agents. Additionally, very hot conditions also may reduce parasitoid establish-	ment, as can limits on alternative food sources for adult parasitoids. Another problem may be high insecticidal use which eliminates adult parasitoids before they can effectively reproduce. The transfer of parasitoids from a field where they have been effective to an uninfested field requires much knowledge of parasite and host biology and behavior. Improper timing of releases often results in a complete waste of time and money. Before a parasitoid is released, several factors must be considered. Foremost is that insects cannot be introduced into Kansas without permission of the Animal and Plant Health Inspection Service at the federal level and without similar permission from the State Board of Agriculture. These regulations prevent the introduction of potentially harmful species. Examples of well meaning biological control programs that have failed are well documented. Determination that an insect may have some undesirable qualities can only be established through careful research and study by specialists familiar with the organisms. Another potential problem is the possible unintentional release of hyperparasitoids. These are also very tiny wasps that directly attack the weevil parasitoid rather than the weevil itself. Several other requirements are necessary for a successful parasitoid release. In general, a moderate population of weevils should be present. Low weevil populations should be allowed to persist as food or reproductive resources for the beneficial insects. The appropriate stage of the host also must be available. No insecticides should be used in that area for a minimum of four weeks and one year often has been recommended. Other problems may include incompatibility of some parasitoid species for both eastern and western strains of the alfalfa weevil. Insufficient research has been conducted on this subject.
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Time may be required for successful establishment of any biological control agent. Even when conditions are optimal, not all parasitoids have become well dispersed or established. Release of some species on an annual basis appears to be necessary. DISEASES Insect diseases also play a role in suppressing alfalfa weevil populations. A fungal disease can devastate weevil populations a few days after it is first detected in a field. Larvae, prepupae, and pupae can be killed. Infections usually are detected about the time the weevil larval population peaks in the field. Unfortunately, this event usually occurs about the time weevil populations have reached or already exceeded an economically damaging population. Infection is most obvious when the population of weevil larvae is declining. One study indicated that at least 1.5 larvae per stem are needed to trigger the "epizootic" which devastates the population. This fungal disease is highly influenced by rainfall (free water) and temperature. Affected weevil larvae appear limp, may darken and then change colors and harden as the fungal spores appear on the surface of the body. This fungal agent may help keep larval populations from re-surging rapidly and limit the ability of the alfalfa weevil to become a season-long pest.	Fungal diseases may actually interfere with other biological control agents by destroying the hosts that these species depend upon for reproduction. Thus, much care should go into a decision to release a new biological control agent because it may disrupt the efficacy or efficiency with which other population controlling organisms depend. HOST PLANT RESISTANCE Host plant resistance is based on improving the ability of the plant to resist severe damage from the pest. Resistance can be summarized as the ability to survive or thrive in spite of what is considered to be a significant pest attack. Resistance mechanisms can be very diverse and complex. Several host plant resistance mechanisms have been proposed for alfalfa weevil control. Small stem diameters, solid stems, and other factors are thought to limit the amount of egg laying that may occur. Other hypothesized plant factors include direct mortality caused by toxic compounds, alfalfa cultivars that lack necessary dietary components for weevil larvae to complete their development, and structures which may lead to the entrapment of tiny weevil larvae. Several alfalfa varieties have shown some tolerance to alfalfa weevil. <i>Team, Arc, Cimarron, Gladiator, Liberty, Perry, and Weevilchek</i> are weevil-tolerant cultivars. This type	from weevil damage. Because of their range in dormancy ratings, all these varieties may not be suited to Kansas conditions. Current levels of resistance are most effective under low to moderate populations. A relatively new concept in alfalfa host plant resistance is the breeding of varieties which have sticky glandular hairs on the leaf and stem surfaces. These hairs form a barrier against upward movement of tiny larvae. The sticky hairs are similar to flypaper in effect and can prevent tiny larvae from moving from the point of egg laying to the top of the plant. Larvae become entrapped in the sticky glandular hairs, lose contact with the stem surface, and starve or die from desiccation. This resistance mechanism also appears to be effective against other alfalfa pests in some situations. Although germplasm containing the glandular-haired traits has been released to private industry, this approach to alfalfa weevil management is not yet available commercially. In summary, integrating several control strategies can be valuable for managing the alfalfa weevil. The overall integrated program might include winter grazing, the planting of stress-tolerant alfalfa cultivars, judicious use of chemical insecticides, and, where possible, taking advantage of available biological control agents.
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