Integrated Approach for Managing Clover Root Curculio

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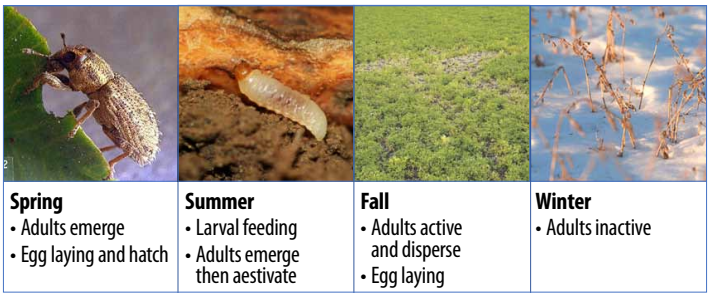
An insect pest often overlooked but causes significant losses to an alfalfa stand is the clover root curculio (CRC; *Sitona hispidulus*). This is also a serious red clover and white clover pest and can cause minor soybean damage. Originally from Europe and Asia, it has spread across North America. On alfalfa, CRC damage causes losses in yield and crude protein, reduces nitrogen fixation, and results in premature stand decline from directly killing plants and from winter heaving and winter kill of plants with weakened root systems. There are currently no resistant cultivars, no labeled insecticides, and few management methods to reduce damage. A concerted integrated approach is needed to address this pest problem, which appears to be causing increased stand loss.

Figure 1. Life stages of the clover root curculio.



Spring	Summer	Fall	Winter
• Adults emerge • Egg laying and hatch	• Larval feeding • Adults emerge then aestivate	• Adults active and disperse • Egg laying	• Adults inactive

CRC Life Cycle & Impact on Alfalfa. Adult CRC are small, narrow-bodied dark-brown to black beetles with short broad snouts. Adults emerge from soil in spring, mate, and lay eggs on the soil surface. During this period they feed on foliage, causing semi-circular notches on leaf margins. However, it is the larvae hatching from eggs that cause economic plant damage. The first two larval instars (stages) feed on root nodules, disrupting nitrogen fixation. The third, fourth, and fifth instars feed on fibrous, lateral, and tap roots causing root pruning and forming large tunnels in lateral roots and tap roots that can girdle roots. Scarring from tunneling can cover 35% or more of the root surface and disrupts water and nutrient flow. Stand losses from CRC are notably greater during periods of water stress. Wounds caused by feeding are pathogen entry points that cause additional damage and can kill the plant. Larvae may also introduce pathogens into roots. More than 30 pathogens have been identified. In fall, adults emerge and disperse to nearby clover and alfalfa fields where some egg laying occurs. CRC can kill alfalfa seedlings by severing roots if planted in fall near an older field with a large pest population. The only management method available is rotation to a non-legume when the stand deteriorates below an acceptable plant density.

Is CRC an Emerging Pest Problem? Practically every alfalfa stand in the U.S. has some level of CRC damage. In the summer of 2020, numerous observations of severe CRC damage were reported from the western states. Plants evaluated by ARS scientists in St. Paul, MN, arrived from Idaho and Washington alfalfa fields. They had extensive scarring from CRC covering most of the root system; farmers reported stand decline and significant yield losses as well as failure of new seedings. Did pest populations increase over time or did specific environmental conditions lead to a sudden population boom? Too little is known about this pest to speculate about the cause of the problem observed this summer. However, steps can be taken to improve management of CRC.

Developing an Integrated Pest Management Plan for CRC. The lack of reliable means of measuring CRC infestations in fields makes it very difficult to determine economic losses, develop economic thresholds, or develop degree day models to predict insect activity. Thus, a high priority for research is to develop methods for estimating insect populations in the field. Currently, determining populations requires a large number of soil samples due to uneven distribution of insects and time-consuming sieving to isolate eggs and larvae. Sweep nets for capturing adults are useful only for short periods of time when adults are active. Pheromone-baited traps are a standard tool for studying population dynamics of other crop pests and have been developed for other species of *Sitona*. Development of pheromone traps should have high research priority. Accurate pest monitoring tools will enable researchers to make better estimates of stand and yield loss due to CRC. From stand loss studies done with the alfalfa snout beetle, another root-feeding pest, one estimate of loss from CRC is $140/ha ($365/ac) in a 4-cut, 3-year system. Data on stand and yield losses from CRC damage in different parts of the U.S. are needed to support development of management options.

The use of resistant cultivars is the most common means of managing insect pests and diseases in alfalfa. The last published studies of host resistance to CRC, done in the 1980s, failed to identify resistant alfalfa germplasm. Since then, thousands of new wild accessions have been collected but remain untested for resistance to this pest. To facilitate screening, artificial rearing of CRC is needed to provide uniform pest pressure and accelerate testing under controlled conditions as opposed to testing under field conditions in which insect pressure cannot be predicted and plant damage may be caused by multiple factors. Identifying plants producing compounds such as saponins that inhibit feeding may also accelerate progress. A straightforward way to develop resistant plants is to engineer them to express a protein toxic to CRC. The genes encoding insecticidal proteins from the soil bacterium *Bacillus thuringiensis* (Bt) have been used in genetically modified (GMO) crops for very effective control of root and foliar pests. Although this technology comes at a high cost for development, it could provide significant benefits for alfalfa farmers.

Figure 2. Damage to alfalfa roots from clover root curculio.

Larvae cause lesions near the crown and feed on fibrous roots and nodules.	Feeding damage causes tunneling on tap root and girdling of the root tip.	Extensive scarring of the root surface by larvae lead to fungal pathogen infection.

There are no registered insecticides to control or reduce the numbers of CRC larvae in infested fields. Use of insecticides in some regions of the U.S. would upset biological control of alfalfa weevil and aphids. Research is needed on alternative chemistries as well as adjustments to application patterns and timing that could reduce non-target effects of insecticides. Seed treatments would be useful in protecting new seedings from CRC. An alternative to insecticides is the use of biocontrol organisms to manage pest populations. Entomopathogenic fungi and nematodes have been identified that kill CRC larvae and adults. These biocontrol agents can be long-lived in soil, protecting the crop for the life of the stand. Certain nematodes have been successful in lab and field trials for CRC management and nematodes are an effective control for alfalfa snout beetle. Further testing of biocontrol agents in diverse environments and pairing with alfalfa varieties with moderate levels of resistance or tolerance to CRC warrant further investigation.