The clover root curculio (CRC, *Sitona hispidulus* F.) is an important agricultural pest in forage crops. Adult beetles feed on foliage while the more damaging larval stage feeds on roots. Heavy larval feeding has been associated with reduced stand establishment, disruption of nutrient and water uptake, susceptibility to soilborne pathogens, decreased winter plant survival, delayed green-up, and reductions in forage quality and yield. Due to the hidden nature of eggs and larvae in the soil, CRC has been overlooked and damage is often misdiagnosed as nutrient deficiencies or pathogens.

Historically, applications of chlorinated hydrocarbons, carbamates, and organophosphates targeted other alfalfa pests like alfalfa weevil. These chemistries, with long-lasting residual activity, were able to keep CRC populations below damaging thresholds. Since the reduction in use of these products, as well as the regulatory phase-out of several important soil fumigants, CRC populations have incidentally increased.

Adult CRC are grey-brown and approximately 1/8 to 3/16 inch long. Adults have a short and broad snout with chewing mouthparts as well as semi-erect hairs on their wing covers (Fig. 1). Eggs are found at or 1 inch below the soil surface. They are white when first laid, and turn black after 2-3 days (Fig. 2). The smooth, shiny, ovoid eggs are difficult to see in the field because of their small size (< 1/32 inch).

Larvae are white, legless grubs with brown heads and chewing mouthparts (Fig. 3). Darker areas of the digestive system may be visible. There are five larval stages that feed on the roots and all are small (1/32 – 1/4 inch long).

Pupae are found near the soil surface. They are small (1/8 inch long) and off-white to yellow (Fig. 4).

Alfalfa weevil (*Hypera postica*) adults have a dark brown stripe down their back, have a longer snout, and may be larger (3/16 inch) than CRC. Eggs are also oval-shaped but are yellow, and laid in the stem. Alfalfa weevil larvae feed on leaves and are yellowish-green to light-green. Larvae also have a white dorsal stripe and a dark brown to black head (Fig. 5).
Pea leaf weevil (*Sitona lineatus*) is similar in size and shape to CRC but lacks erect hairs. The adult is brown with alternating light and dark stripes running down the length of its body. Pea leaf weevil larvae are difficult to distinguish from CRC larvae, but they tend to prefer different hosts than CRC.

Larvae of other soil insects associated with alfalfa roots include: wireworms, predatory beetles, and fungus gnats (Fig. 7). Wireworm larvae are yellow and have hardened bodies with small legs. Predatory beetle larvae have legs, large chewing mouthparts, a flattened body and “tail-like” structures. Fungus gnat larvae are legless and white to cream colored with a very small head.

Generally, CRC prefer clover species (*Trifolium* spp.) over alfalfa and related legumes, although preference depends on the host species and plant growth stage (Table 1). The most historically important clovers in North America, the red (*Trifolium pretense*), white (*Trifolium repens*), and alsike clover (*Trifolium hybridum*) are all suitable hosts for CRC adults and immatures. Since the U.S. has increased alfalfa production, CRC is more common on alfalfa. CRC has been reported on soybean when planted next to heavily infested alfalfa fields.

### LIFE CYCLE

CRC has one generation per year. Adults emerge mid-summer and feed on host plant foliage. During the hottest part of the season (August-September), adults will undergo a period of dormancy in which they will not be as active (Fig. 8.). After this period, feeding resumes and mating occurs. In Utah, mated females lay most of their eggs at the soil surface from August to October until temperatures are too low for activity in winter. In contrast to eastern U.S. populations where CRC overwinter as adults and lay eggs in early spring, the majority of CRC in the West overwinter as eggs with few adults surviving to spring. Once temperatures have increased in spring, surviving adults lay eggs once more before they die. The overwintered and newly laid eggs hatch in April and the first-stage larvae crawl into the soil in search of host root nodules. As the larvae develop, they will feed on increasingly larger roots, eventually feeding on and scarring the taproot. In Northern Utah, larval populations peak around early June (Fig. 8.). CRC then pupates for 15-25 days until adult emergence.

Adult feeding forms semicircular notches on leaf edges or symmetrically paired holes centered at the midrib (Fig. 9). Field damage from adult feeding is typically negligible, but early feeding on seedlings reduces stand establishment (i.e., seedling densities).

### HOST PLANTS

**Table 1.** Host plants of CRC. Primary hosts support CRC adult feeding and oviposition (egg-laying) and allow for complete development of CRC larvae. Uncommon hosts are plants where CRC infrequently feed, lay fewer eggs, or cannot develop to adults.

<table>
<thead>
<tr>
<th>Primary Hosts</th>
<th>Uncommon Hosts</th>
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<tbody>
<tr>
<td>white clover</td>
<td>common lespedeza</td>
</tr>
<tr>
<td>red clover</td>
<td>black medic</td>
</tr>
<tr>
<td>alsike clover</td>
<td>trefoils</td>
</tr>
<tr>
<td>sweet clover</td>
<td>crown vetch</td>
</tr>
<tr>
<td>alfalfa</td>
<td>large yellow vetch</td>
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</tbody>
</table>

### CROP INJURY

Adult feeding forms semicircular notches on leaf edges or symmetrically paired holes centered at the midrib (Fig. 9). Field damage from adult feeding is typically negligible, but early feeding on seedlings reduces stand establishment (i.e., seedling densities).
Direct injury occurs from larval feeding on all parts of the root. Early-stage larvae feed almost exclusively on nitrogen-fixing root nodules (Fig. 10). Larval emergence in spring is synchronized with peak nodule production making it difficult to find larvae hidden inside the nodules. Mid-stage larvae feed on the lateral and fibrous roots which can result in heavy damage where larvae completely sever or girdle roots, interrupting water and nutrient movement or killing root apices. The weakened root system from CRC damage has been associated with winter heaving, where freezing and water expansion forces roots out of the soil, causing plant mortality. Taproot damage from larger late-stage larvae occurs rapidly and is concentrated in the top 10 inches on the root system and crown (Fig. 11). As alfalfa stands age, severe damage occurring at shallow soil depth accumulates. Consequently, symptoms of damage are typically not noticed until the second year.

Indirect injury occurs when larval feeding predisposes plants to infection by pathogens such as *Fusarium*, *Verticillium*, and others. These opportunistic pathogens take advantage of the root wounds and plant stress caused by CRC, and may actually be inadvertently carried from plant to plant by larvae.

**CULTURAL CONTROL**

Due to the lack of insecticides for the damaging larval stage, cultural control methods are an important part of CRC management plans. Current cultural control methods include crop rotation, planting date modification, nutrient and moisture management, and the use of resistant varieties.

**Crop rotation** toward a non-leguminous, non-host crop that is unsuitable for CRC feeding and development (e.g. grasses, row crops) will limit CRC damage and temporarily disrupt populations before rotation back to alfalfa. Furthermore, planting new alfalfa stands away from severely infected fields can reduce CRC migration. Lastly, since CRC damage is additive, it is recommended that alfalfa stands be promptly removed at the end of their economically productive lifespan (before the 5th year).

**Planting dates** for new fields should occur during the spring. Well-established plants can tolerate more damage and the roots of spring-sown alfalfa have a more robust root system that can better withstand larval feeding during the first year of damage.

**Irrigation and fertilization** should be monitored and managed appropriately to limit the effects of CRC damage, since healthy plants may withstand a certain level of stress from root damage. Root-damaged plants are less able to obtain soil water, and drought conditions compound the problem. Plants grown at optimal irrigation levels are better able to tolerate CRC larval damage, however, over-watered soils can lead to higher incidences of secondary-plant pathogens and reduced nitrogen fixation. Regularly monitor soil health through diagnostic soil testing to identify nutrient deficiencies and predict fertilizer requirements.
Resistant varieties are not yet commercially available for chewing insects such as CRC or alfalfa weevil, but research is ongoing to develop varieties effective against CRC. Disease-resistant varieties are available to reduce instances of root rot associated with CRC root damage.

**BIOLOGICAL CONTROL**

Beneficial arthropods such as ground beetles, rove beetles, and wolf spiders seem to be among the most important predators of CRC adults and eggs. Although our knowledge is limited on managing these biological control agents for CRC, reducing unnecessary broad-spectrum insecticides is an important first step.

Various parasitic wasps that attack CRC eggs and adults in Europe were introduced to the U.S. and Canada in mid to late 1900s. These introductions failed to establish, and their current status in western U.S. legume fields is unknown.

Different types of entomopathogens (insect-specific microbial pathogens) have been used against CRC. The most widely-found fungus naturally infecting CRC is *Beauveria bassiana*, though it is unknown to what extent this pathogen affects CRC populations. Nematodes have also been tested for use against CRC larvae. Field-applied *Heterorhabditis bacteriophora* (Oswego strain) may be able to reach stable populations, persist for multiple years, and reduce adult emergence and root damage. However, the efficacy of this nematode in managing CRC in Utah is unknown.

**CHEMICAL CONTROL**

Currently, several insecticides are registered for use against CRC adults, but none are labeled for larval management. The use of broad-spectrum products registered for CRC adults (Besiege, Declare, Cobalt, Warrior II) are not recommended for established fields due to their ability to reduce densities of beneficial predators and parasites of the alfalfa weevil and other important alfalfa pests. Additionally, it is unclear how adult reductions impact larval densities. Insecticides with systemic activity or applications of insecticides that permeate the soil (e.g., fumigation, chemigation) have not yet been investigated for CRC larval control.

**ADDITIONAL RESOURCES**


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