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High Tunnel Pest Management - Caterpillars

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What You Should Know

- In Utah high tunnel production (Fig. 1), there are a variety of caterpillar pests (larvae of moth and butterfly species) that cause economic damage to crops.
- Common caterpillar pest species found in Utah include hornworms, tomato fruit worms, imported cabbage worms, diamondback moths, cabbage loopers, armyworms, and cutworms.
- Various weed species growing inside or outside high tunnels can attract and harbor caterpillar pests.
- Managing caterpillar pests in high tunnels involves various mechanical, chemical, biological, and cultural control practices.

Along with many weeds, the following caterpillar pests in several insect families can affect many high tunnel crops.

- Sphingidae (sphinx moths): **tobacco hornworm** *(Manduca sexta)* and tomato hornworm *(Manduca quinquemaculata)*.
- Pieridae (whites and sulphur butterflies): **imported cabbageworm** *(Pieris rapae)*.
- Plutellidae: **diamondback moth** *(Plutella xylostella)*.
- Noctuidae (owlet moths): **tomato fruitworm** (more commonly referred to as the corn earworm) *(Helicoverpa zea)*, **cabbage loopers** *(Trichoplusia ni)*, **cutworms**, and **armyworms**.

There are many species of cutworms and armyworms that can feed on crops in high tunnels. Common cutworm species in Utah include the army cutworm *(Euxoa auxiliaris)*, black cutworm *(Agrotis ipsilon)*, glossy cutworm *(Apamea devastator)*, pale western cutworm *(Agrotis orthogonia)*, and variegated cutworm *(Peridroma saucia)*.

Common armyworm species include beet armyworm *(Spodoptera exigua)*, bertha armyworm *(Mamestra configurata)*, fall armyworm (Spodoptera frugiperda), and western yellow-striped armyworm *(Spodoptera praefica)*.

Fig. 1. High tunnels used for vegetable production in Utah.

HOSTS

Hornworms feed primarily on tomatoes, peppers, potatoes, and eggplants, which are commonly grown in high tunnels. Weed species that attract hornworms include those in the nightshade family.

Tomato fruitworm is predominately a problem in field sweet corn, but inside high tunnels, they can feed on cabbage, eggplant, pepper, bean, tomato, and leafy greens. Weed hosts include common mallow, lambsquarters, pigweed, purslane, ragweed, and sunflowers.

Imported cabbageworm, **diamondback moth**, and **cabbage looper** all attack crops in the Brassicaceae family (broccoli, Brussels sprouts, cabbage, cauliflower, collards, horseradish, kale, kohlrabi, kale, radish, and turnips). Many weed hosts are also in this plant family.

Cutworms prefer nearly all vegetables, alfalfa, grains, and turf grasses. Alternate weed host examples include curly dock, lambsquarters, and pigweed.

Host crops for **armyworms** include alfalfa, asparagus, bean, beet, Brassicas, leafy greens, cucurbits, pepper, potato, tomato, and many other vegetables. Alternate hosts include grassy weeds and various herbaceous ornamentals.

DESCRIPTION

Tomato hornworm larva (Fig. 2) is green with eight white "V" markings along its back, lining up toward the head. At the end of its abdomen is a notable horn. At the adult stage, it's known as the five-spotted hawkmoth and has a wingspan of up to 13 cm. The wings are gray and brown with large front wings and small hind wings marked with a zigzag pattern. The moth's abdomen is brown and white with a row of five yellow spots along each side.

Tobacco hornworm larva (Fig. 3) appear simlilar to tomato hornworms, but are marked with thin white lines and a darker red horn in later instars. It eventually transforms into the Carolina sphinx moth. It has a wingspan up to 10 cm. The wings are narrow with a gray, brown, and white pattern. On the abdomen are six yellow spots along each side. Both five-spotted hawkmoth and Carolina sphinx moth have long, coiled, tube-like mouthparts, which are used to extract nectar. They typically fly in the evening, hovering over flowers. While in flight, they may be mistaken as hummingbirds.

All hornworm eggs are spherical in shape and 1.5 mm in diameter, ranging in color from white to a light green. The pupa (cocoon) is 5-8 cm long and dark brown. A noticeable feature is the "handle" structure in which the moth's mouthparts will develop.

Tomato fruitworm adults (Fig. 4) lay eggs that are pale green and 0.5 mm long. Larvae develop through 6 instars. Their color ranges from orange to light brown with a white net-like pattern. Pupae measure 17-22 mm long. Adult moths are brown with a 32-45 mm wingspan.

Imported cabbageworm adults (Fig. 5) lay bullet-shaped eggs that are 1 mm long. Larvae develop through 5 instars and grow up to 4 cm long. They are green with thick, yellow stripes. They have blunt ends and have dense short hairs. The pupae (chrysalis) 2 cm long (colored yellow, gray, and green), with a sharply angled, keel-like projection evident dorsally on the thorax. The adult butterfly is white; females have two dark spots, and males have one dark spot. Adults have a wingspan of 5 cm.

Diamondback moths (Fig. 6) lay round, yellow eggs that are 0.4 mm wide. Larvae develop through 4 instars, growing to 1.25 cm long (plain green/gray color). The pupae is a loose mesh cocoon of 1 cm. Adult moths are grayish-brown with white/cream diamonds and a wingspan of 1.5 cm.

Cabbage looper (Fig. 7) eggs are dome-shaped and light yellow. Larvae develop through 5 instars. Smooth and pale to dark green, they are thin with white or light-yellow stripes and tapered at the head. The pupa is a fuzzy cocoon of 3 cm. Adult moths are grayish-brown with eight silver marks and a wingspan of 4 cm.

Fig. 2. Tomato Hornworm *(Manduca quinquemaculata)*.

Fig. 3. Tobacco Hornworm *(Manduca sexta)*.

Fig. 4. Tomato Fruitworm *(Helicoverpa zea)*.

Fig. 5. Imported Cabbageworm *(Pieris rapae)*.

Fig. 6. Diamondback Moth *(Plutella xylostella)*.

Cutworm larvae range from a dull, gray color to brown. They notably curl into a "C" when disturbed. Adult moths range from brown to gray with various patterns. Their wingspan reaches 1.5 inches (Figs. 8-12).

Adult **armyworm** moths are typically mottled gray and brown with light-colored markings. Wingspan among the various species ranges from 25-40 mm long. The larvae have a large range of colors from tan to green to almost black (Figs. 13-15).

Fig. 7. Cabbage Looper *(Trichoplusia ni)*.

Fig. 8. Army Cutworm *(Euxoa auxiliaris)*.

Fig. 9. Black Cutworm *(Agotis ipsilon)*.

Fig. 10. Glossy Cutworm *(Crymodes devastator)*.

Fig. 11. Western Pale Cutworm *(Agrotis orthogonia)*.

Fig. 12. Variegated Cutworm *(Peridroma saucia)*.

Fig. 13. Beet Armyworm *(Spodoptera exigua)*.

Fig. 14. Fall Armyworm *(Spoddoptera frugiperda)*.

Fig. 15. Western Yellow-Striped Armyworm *(Spodoptera praefica)*.

LIFE HISTORY

Hornworms overwinter in the ground as pupae. They are first seen as adult moths in mid-spring. This adult stage usually lasts 2 to 3 weeks. During this time, females of both tomato and tobacco hornworms lay clusters of thousands of eggs on either the upper or underside of leaves. When hatched, the hornworm larvae start feeding immediately and grow through 5-6 instars throughout the summer. The larva then drops to the soil near the base of the plant, burrows 4-6 inches down, and pupates. The second generation of adults emerge about 2 weeks later.

Imported cabbageworms overwinter in their pupation stage. When adult butterflies emerge, they are active during the day, moving amongst crops and flowering weeds. Females will produce 300-400 eggs on lower leaf surfaces. When larvae hatch, they develop through 5 instars. Generations during the warm months will last 3-6 weeks.

Diamondback moths pupate in loose silk cocoons formed on lower and outer leaves. Pupation ranges from 5-15 days. When adults emerge, they live about 12 to 16 days. For 10 days, females will deposit eggs singly or in small groups of 2-8. When hatched, larvae develop through 4 instars.

Cabbage loopers overwinter in the pupal stage on leaves, plant debris, or in the soil. Adults emerge in the springs and are primarily active at night. They will lay eggs singly and in clusters. The life cycle requires 18-25 days at around 70-90 degrees.

Cutworms overwinter in the larval stage and can be seen as early as January into April. They are most active and cause significant damage during the spring and early summer months. In Utah, there are two overlapping generations of the black and variegated cutworms. There is only one generation of the army, pale western, and glassy cutworms in a year. Cutworm infestations tend to be sporadic.

Armyworms overwinter in the pupal stage in the soil and can have 1-3 generations a year in Utah. They are typically a concern from mid-July through September.

CROP INJURY

Hornworm larvae have chewing mouthparts and primarily feed on the host plant's foliage. In their final instar and high populations, they can cause significant economic damage to crops. Hornworms will begin consuming the upper leaves first and slowly move down to lower leaves. Loss of foliage may decrease fruit production and increase the risk of sun-scalded fruit.

Larvae also feed on fruits, blossoms, and stems when foliage runs out or populations are high. In tomato and pepper, **tomato fruitworms** create tunnels in fruits, reducing their quality and marketability. They may also chew holes in leaves, stems, and flowers, reducing fruit yield and quality.

Imported cabbageworms, **diamondback moths**, and **cabbage loopers** chew holes in leaves and may cause serious defoliation. Feeding begins on outer leaves, but as the caterpillars mature, their feeding intensifies, and they often move into the developing heads, creating tunnels. Larvae can leave frass (fecal material) which contaminates leaves and lowers production quality.

Cutworms get their name due to them "clipping off" young seedlings at the soil surface with their chewing mouthparts. Later in the season, they may damage fruit and foliage.

Armyworm larvae have chewing mouthparts in which they can cause irregular holes, shredded leaves, or skeletonized foliage. Armyworms may also bore into heads of leafy vegetables or chew the stems, flower buds, and upper plant roots.

MONITORING

Monitoring for caterpillar pests is important, especially in high tunnels. Regularly inspect a selection of plants for feeding damage on newer foliage. Shake a portion of the plant over paper or cardboard to dislodge any larvae. Scout plantings for eggs and larvae on the undersides of leaves, especially on the innermost leaves (Fig. 16). Feeding damage and excrement are also signs of an infestation. Examine at least 10% of the crop, checking the random interior and edges of the high tunnel. Also, look for white butterflies (adults of imported cabbageworm) flying during the day among plants.

Traps are a good way to identify when adult moths or butterflies have arrived in an area and can indicate their relative numbers. If you find injured plants, dig about 1-inch deep around the base of plants to check for live cutworms.

Fig. 16. Monitor for for signs and symptoms of caterpillar pests regularly inside of high tunnels.

Fig. 17. Insect netting or shade cloth is a physical exclusion method that an be placed on high tunnels during the warm months to prevent moths and butterly species from entering the structure.

MANAGEMENT

When properly managed, high tunnels can have a decreased incidence of caterpillar pests. The wall structure of high tunnels can help prevent insect pests from accessing crops (Fig. 17). The diffused light might also cause orientation problems during adult flight. A high tunnel creates a change in a microclimate that may be less favorable to pests or more favorable to natural enemies.

- When planting in high tunnels, consider **interplanting**. Interplanting crops with unrelated plants lowers larval populations and increases beneficial wasps' larval parasitism and predation. Predatory and parasitic wasps are attracted to the varied resources provided by a diversity of plants, including nectar and pollen in flowers and diverse insect prey.

- When bringing in transplants to a high tunnel, **inspect transplants** carefully to ensure they are free of caterpillar eggs and larvae.

- **Handpick and destroy larvae.** Plant early or use early maturing varieties. Mature plants can tolerate feeding damage better than young seedlings.

- **Remove plant debris both inside and outside the high tunnel** at the end of the growing season, as it may serve as an overwintering site for various growth stages of caterpillar pests.

- **Plant tolerant varieties**. Mustard, turnip, and kohlrabi are among the more tolerant Brassicas to the diamondback moth. Glossy-green Brassica varieties that lack the normal waxy, grayish-green bloom are somewhat resistant because larvae spend more time searching, and less time feeding, on the glossy leaves.

- **Tilling soil** in spring or fall in the high tunnel can disrupt and destroy overwintering pupae and reduce their population for the following season (Fig. 18). Tilling nearby cornfields at the end of the season can decrease the survival of tomato fruitworm pupae.

- Weeds growing inside or outside high tunnels can provide food sources for caterpillar pests (Fig. 19). **Removing cool-season weeds** can help starve young caterpillars. Lambsquarters and wild mustards are attractive plants for egg-laying.

Fig. 18. Tilling soil in the high tunnel can destroy overwinter pupae stages of various caterpillar pests.

Fig. 19. High tunnel with weeds growing in pathways.

BIOLOGICAL CONTROL

Beneficial insects are a major contributor to natural biological control. Lady beetles (Coccinellidae) and green lacewings (Chrysopidae) (Fig. 20) prey on eggs. Paper wasps (Vespidae) (Fig. 21) will feed on many small caterpillars in gardens including early instar hornworm larvae. General predators such as shield bugs, ambush bugs, and vespid wasps also attack caterpillars, as do many birds.

The braconid wasp *Cotesia congregata* (Fig. 22) specifically parasitizes **hornworms**. If you find a parasitized hornworm, let it be. This will allow the wasp life cycle to continue.

Parasitoids of the **imported cabbageworm** include the braconid wasp *Cotesia glomerata* (Fig. 23), a gregarious wasp, *Cotesia rubecula* (Fig. 24), a solitary wasp, and *Apanteles glomeratus*, which attacks early instars. *Trichogramma* spp. are egg parasitoids and *Pteromalus puparum* (Fig. 25) is a pupal parasitoid.

Natural enemies that can provide effective control of the **diamondback moth** include parasitoid wasps such as ichneumonids *Diadegma insulare* (Fig. 26) and *Diadromus subtilicornis* (Fig. 27), the braconid *Microplitis plutellae* (Fig. 28), and *Trichogramma pretiosum*, which attack eggs. Generalist insect predators such as ground beetles, true bugs, syrphid fly larvae, lacewing larvae, paper wasps, and spiders also play a role in reducing diamondback moth numbers.

Some **cabbage looper** parasitoid wasps include the egg parasites *Trichogramma pretiosum* and *Copidosoma truncatellum* (Fig. 29), and the larval parasites *Hyposoter exiguae* (Fig. 30) and *Microplitis brassicae* braconid. The endoparasitic tachinid fly *Voria ruralis* (Fig. 31) is another important natural enemy.

Tomato fruitworm in all life stages have some natural parasites and predators, but their numbers are typically inadequate to provide control. *Trichogramma* wasps parasitize corn earworm eggs.

Many predators, parasites, and diseases attack **armyworms** and **cutworms**, but because armyworms and cutworms dwell beneath the soil surface, few of these natural enemies are effective in controlling their populations. *Bacillus thuringiensis* (Bt) products can effectively control young armyworm and cutworm larvae.

Fig. 20. Lacewing Larvae.


Fig. 21. Northern Paper Wasp.


Fig. 22. *Cotesia Congregata.*


Fig. 23. *Cotesia Glomerata.*


Fig. 24. *Cotesia Rubecula.*


Fig. 25. *Pteromalus Puparum.*


Fig. 26. *Diadegma Insulare.*


Fig. 27. *Diadromus Subtilicornis.*


Fig. 28. *Microplitiis Plutellae.*


Fig. 29. *Copidosoma Truncatellum.*


Fig. 30. *Hyosoter Exiguae.*


Fig. 31. *Voria Ruralis.*

CHEMICAL CONTROL

Table 1. Effective Home and Commercial Pesticides to Control Caterpillar Pests Within High Tunnels

Control Agent	Hornworms	Imported cabbageworm	Diamondback moth	Cabbage looper	Tomato fruitworm	Armyworms	Cutworms
Commercial Use							
Carbaryl (Sevin SL)	X	X	X		X	X	X
Malathion (Malathion)		X	X	X			X
Pyrethrins (Pyganic)	X	X	X	X	X	X	X
Pyrethrins + azadirachtin (Azera)	X	X	X	X	X	X	X
Spinosad (Entrust)	X	X	X	X	X	X	X
Bacillus thuringiensis (DiPel ES)	X			X	X	X	X
Methoxyfenozide (Intrepid)	X	X	X	X	X	X	X
Burkholderia spp (Venerate CG)	X	X	X	X	X	X	X
Chroimobacterium subtsugae (Grandevo)	X	X	X	X	X	X	X
Azadirachtin (Aza-Direct)						X	X
Home Use							
Zeta-Cypermethrin (Garden Tech Sevin)	X	X	X	X	X	X	X
Cyfluthrin (BioAdvanced Vegetable and Garden Insect Spray)		X	X	X	X	X	X
Spinosad (Natural Guard Spinosad Spray)		X	X	X		X	
Bacillus thuringiensis (Bonide Thuricide)	X			X		X	
Permethrin (Bonide Eight)		X	X	X	X	X	X
Pyrethrins (Monterey Bug Buster-O)	X	X	X	X	X	X	
Pyrethrins + insecticidal soap (Safer Brand Tomato & Vegetable Insect Killer)		X	X	X	X	X	X

Note: All brands are registered trademarks. The brands listed in this table are not all-inclusive, but are meant to provide examples of products for these crops in Utah. Always check the label for the **specific crop** you are treating, application and safety information, and protection and preharvest intervals.

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