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COLLEGE OF AGRICULTURE AND LIFE SCIENCES
COOPERATIVE EXTENSION
Yuma Agricultural Center

Insect Management on Desert Produce Crops:
Lepidopterous Larvae

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Beet Armyworm, *Spodoptera exigua*

Distribution and Host Range: The beet armyworm is native to Asia and was first found infesting desert vegetable crops around 1916. It is common throughout all desert growing areas. In southwestern Arizona, it is most prevalent from August through November on fall-planted vegetables, and again from April through June on spring-planted melons. However, this pest can be a problem whenever temperatures are warm (> 80° F). Beet armyworm has a wide host range, occurring as a serious pest on all leafy and head lettuce types, cole crops, spinach, celery, cantaloupes and watermelons. The larvae feed on many field crops, including cotton, alfalfa and corn, and adult moths often migrate from these crops onto fall vegetables in late summer. Several summer annual weeds (lambsquarter, nettleleaf goosefoot, pigweed, purslane,) also serve as reproductive hosts.

Description and Seasonal Development: Beet armyworm eggs are generally white in color and laid in egg masses of about 50-100 eggs. Eggs masses are typically placed on the under surface of leaves and covered with white scales from the moths body. This tends to give the egg masses a cottony appearance. As the eggs age, they will darken and hatch in 2 to 3 days under warm fall growing conditions (Plate 1B). Neonate larvae will initially feed in groups near the egg mass and will often spin webs over the foliage where they are feeding (Plate 2B). Larvae will pass through five instars. They are initially pale green or yellow during the first 2 instars, but pale stripes can be observed thereafter. When feeding on leafy vegetables, older larvae (4^{th} and 5^{th} instars) can appear olive green with light colored stripes down the back and a broader stripe along each side (Plate 1C). Mature larvae usually have a dark spot on the side of the body above the second true leg and vary in size, but are usually about 1¼ inches in length (Plate 1D). Large larvae are quite mobile, and a single larva may attack several plants. After larvae reach maturity they typically pupate in the soil. The moth has grayish brown forewings with a pale spot in the front margin, and the hindwings are white with a dark anterior margin (Plate 1A). Moths will begin mating soon after emergence, and oviposition begins within 2-3 days. The moths are nocturnal and a female can lay as many as 500 eggs over a 4 to 10 day period. Under ideal conditions, larvae can complete development in as few as 7-8 days. The complete life cycle (egg to ovipositing adult) on desert vegetables is around 25 days, and the duration of the life cycle varies with temperature and host plant.

Economic Damage: In general, beet armyworm larvae feed on the foliage of leafy vegetables and the fruit of melons. Neonate larvae usually begin feeding immediately on the leaf tissue where they hatched. Large numbers of larvae can skeletonize plant foliage. As larvae mature, they tend to move from plant to plant and eat large irregular holes in foliage or feed on immature fruit.

- Lettuce: On fall planted crops, beet armyworm may severely stunt or kill seedlings by extreme defoliation (Plate 2A). Damage is less serious from thinning to heading stages, but under heavy pressure can result in reduced head size. In head lettuce and romaine grown for hearts, damage is often economic once cupping begins as larvae may feed on the head or heart, rendering it unmarketable. Larvae enter heads from the bottom working their way inward while

feeding along the leaf margins. Damage to leaf lettuce types results from larval feeding on marketable leaves. Contamination of lettuce heads, romaine hearts or leaf lettuce with either live larvae or frass will make it unmarketable (Plate 2C, 2D).

- Cole Crops: Beet armyworms can kill seedlings plants at stand establishment or severely stunt plant growth by feeding on newly developed terminals buds. They will also feed on the newly developing leaves of cabbage heads.
- Celery: Beet armyworms can cause serious damage to celery, particularly older larvae late in the season, by feeding on tender foliage and on the inner surfaces of the petioles (stalks). Damaged petioles make whole plants unmarketable.
- Spinach: Larvae will often feed in the crown of the spinach plant and can severely stunt or kill seedlings. In baby spinach, the potential for damage to leaves and contamination continues right up until harvest. Feeding damage on terminal leaves of spinach can cause cosmetic blemishes and holes as the leaf expands.

Cabbage Looper, *Trichoplusia ni*

Distribution and Host Range: It us unknown where the cabbage looper originated, but it occurs year round in Arizona's central and southwestern desert areas and is a particularly important pest of head lettuce, cole crops and melons. It can present in damaging numbers from September through March on fall-planted vegetables and again from February through June on spring crops. Cabbage looper larvae feed on a wide variety of cultivated plants and weeds; including cotton, celery, squash, sweet peas, basil, a variety of ornamental flowers crops and a number of broadleaf weed species (lambsquarters, wild lettuce, dandelion, and curly dock).

Description and Seasonal Development: Cabbage looper moths lay single, dome shaped eggs on the underside of older leaves, though loose clusters of 5 or more can be commonly found on fall lettuce and cole crops (Plate 4A). The eggs are yellowish-white with longitudinal ridges, and often turn dark in color just prior to hatching. Eggs mature and hatch in about 2-3 days under ideal temperatures (86°F), but require longer periods under cooler weather (5-6 days at 75° F). The larvae are light green in color and have a distinctive white stripe along each side of the body (Plate 4C, 4D). Newly eclosed larvae are somewhat hairy initially, but the number of hairs decreases as the larvae mature. The larvae have two sets of legs in the front of the body and three sets of unjointed prolegs at the rear causing them to move in an arching, looping manner. Cabbage looper pupae appear as greenish to brown pupa in a cocoon of white threads attached to the underside of the leaf or in plant debris. The moth is mottled gray-brown in color and has a small silvery white spot that sometimes resembles a figure 8 near the middle of its front wing (Plate 4B). Females begin depositing their eggs 1-2 days after emergence, and can lay as many as 600 eggs during their life span. Moths are considered semi-nocturnal because feeding and oviposition can occur around dusk. Development time for cabbage loopers varies with temperature and host.

Economic Damage: Cabbage loopers are generally considered leaf feeders, and neonate larvae normally confine their feeding to the lower leaf surfaces. Older larvae chew large ragged holes in leaves and will feed on the netting or outer rind of immature melons. The larvae are voracious feeders and are capable of consuming three times their weight in plant foliage daily and can leave behind large amounts of frass. Larvae may also attract birds to fields where their feeding results in torn leaves and contamination with bird droppings

- Lettuce: Cabbage looper larvae damage plants by eating ragged holes in leaves, and can infest developing heads or romaine hearts (Plate 5A, 6A). Most economic damage occurs after heading, but high populations prior to thinning can kill seedlings or slow growth enough to hinder crop uniformity. Heads are rendered unmarketable at harvest when contaminated with cabbage looper larvae, their feeding damage or frass (Plate 5B).

- Cole Crops: Young plants can be killed or delayed in maturing if feeding damage on leaves is extensive. Feeding on the buds of young plants and developing cabbage heads can result in head deformities. Older plants can tolerate more leaf consumption (Plate 5C), but excessive defoliation can result in delayed maturity. Cabbage looper can be a serious contaminant of fresh market cauliflower and broccoli. In addition, signs of insect feeding and the presence of caterpillars (along with large amounts of unsightly excrement) as contaminants on the heads at harvest can significantly reduce market quality. Economic damage to cabbage results when larvae feeding on wrapper leaves, bore into the developing head (Plate 5D).
- Celery: Loopers feeding during the first one-half of the growing season is not considered important because these leaves and petioles are routinely removed from the plant at harvest. Feeding damage and contamination on petioles within celery hearts prior to harvest can render plants unmarketable.
- Spinach: Direct feeding damage and contamination by looper larve on marketable leaves in baby spinach is not tolerated.

Corn Earworm, *Helicoverpa zea;* **Tobacco Budworm,** *Heliothis virescens*

Distribution and Host Range: The origin of the corn earworm is uncertain, but likely is native to North America. Tobacco budworm is a native species. Both species can be found throughout the desert southwest and are active throughout the year where they are serious pests to head lettuce. They are very similar in appearance and biology, cause the same kind of damage, and their management strategies in desert vegetables are the same. Both species have a fairly broad host range, and can be found developing on cabbage, cantaloupe, collards, corn, cucumber, lettuce, melon, pumpkin, spinach, squash, and watermelon. Other crops injured by these pests include alfalfa, clover, cotton, sorghum, and wheat. Larvae can also be found developing on a number of common weeds including common mallow, groundcherry, horsenettle, lambsquarters, momingglory, pigweed, purslane, ragweed, sunflower, and velvetleaf.

Description and Seasonal Development: Female moths usually lay their eggs singly on the upper surface of leaves. Eggs are pale green when first deposited, but darken before hatching. Deeper ridges and a more hemispherical shape distinguish earworm eggs from those of cabbage loopers. One female moth will lay 500 to 3000 eggs. In general, eggs are preferentially laid in the crown portion of the plant on younger leaves. Eggs hatch in 2 days under ideal temperature (86 F) and up to 10 days under cool temperatures. Upon hatching, larvae move within the plant until they find a suitable feeding site (Plate 7B). Younger larvae of these two species are difficult to distinguish. Older larvae in the third and later instars can be identified under the microscope by comparing the spines on the base of the abdominal tubercles and by looking for a tooth on the inside of the mandible. On tobacco budworm larvae the spines on the tubercles of the first, second, and eighth abdominal segments are about half the height of the tubercles, but in com earworm the spines are absent or up to one-fourth the height of the tubercle. Larvae usually develop distinct stripes on the body as they mature. Overall the color of caterpillars is variable, ranging from brown, green, pink, or sometimes yellow or mostly black (Plate 7B, 7C). Mature larvae drop to the ground and pupate below the surface of the soil. They will pupate in the soil for 10 to 25 days, depending on temperature. Corn earworm moths vary in color but most have light grayish brown front wings with irregular lines and dark areas towards the tip of the wings (Plate 7A). The front wings of the tobacco budworm moth are pale olive in color with three narrow, dark, oblique bands. Moths are active at night and can live for up to 15 days. Female moths begin laying eggs about three days after emergence.

Economic Damage: Some consider corn earworm the most costly crop pest in North America. It often attacks harvested portions of valuable crops such as tomato fruit, cotton bolls or corn ears. On desert vegetables, corn earworm and tobacco budworm are primarily considered a pest of head lettuce.

- Head Lettuce: When early season populations are high, larvae can defoliate seedling stands of lettuce similar to damage caused by beet armyworms. The risk of economic damage is low between thinning and head formation, but larvae will sometimes feed in the plant's crown leaving holes and gouges in the midrib and sometimes killing the growing point. However, *once head formation begins larvae will usually bore into the head 1-2 days upon hatching.* Corn earworm and tobacco budworm are much more likely to bore into lettuce heads than other Lepidoptera larvae, rendering the heads unmarketable (Plate 8A, 8B, 8C). Larvae may enter the head from any point, although they usually burrow in from the top half. If fields are not watched closely, infestations may not be noticed until the head is harvested. Once inside the head, it is almost impossible to control the larvae with insecticides.
- Other Leafy Vegetables: On leaf lettuce, romaine, baby spinach and baby leaf mixes, larvae will feed in the crown of the plant and can severely stunt or kill seedlings similar to beet armyworm. The potential for damage and contamination is possible at harvest.
- Cole Crops: Although corn earworm and tobacco budworm can occasionally be found feeding on foliage of broccoli and cauliflower, they are not considered economic pests in cole crops.

Management of Lepidopterous Larvae Complex

Monitoring/Sampling Pheromone traps can be used to detect adult moth activity, but are not generally thought to be reliable in determining in-field larval infestations. Rather, sampling individual plants is recommended because ovipositing moths frequently migrate from surrounding crops or weeds. Visual sampling for damage and larvae is the most reliable method to detect larval infestations. In leafy vegetables, this generally entails destructively sampling whole plants and carefully looking for signs of recent feeding and the presence of eggs and small larvae. During head formation, sampling should include examining wrapper leaves and dissecting heads. In melon crops, vines can be lifted and shaken to dislodge larvae onto the ground. Also, watermelon and cantaloupes fields that are setting fruit should be carefully monitored for larvae and fresh feeding damage on developing melons.

Fields should be sampled at least 2-3 times per week depending on the crop and the crop stage. Ideally, monitoring for all Lepidoptera pests on vegetables should begin before seedlings emerge. Examine weeds on field borders for larvae and eggs prior to stand establishment. Once seedlings emerge, sample plants randomly across the entire field. Additional samples should be taken from areas of the field most likely to be infested (i.e., field edges near cotton or alfalfa), or areas where larvae have previously been found. Sampling should be done separately for fields with different plant varieties, planting dates, or other unique areas within the field. Sampling frequency should also take into account irrigation schedules, field-labor activities, insecticide applications and re-entry intervals.

Cultural Practices Cultural controls can help suppress Lepidoptera populations over time and space. Disc fields immediately following harvest to kill larvae and pupae. Sanitation along field borders is important; beet armyworms often migrate from weedy field edges into newly planted fields. Delaying produce planting until after nearby cotton is defoliated may help in reducing insect pressure. Cole crop and watermelon transplants should be inspected carefully for larvae and other pests before transplanting.

Natural / Biological Control Lepidopterous larvae in the desert are attacked by numerous natural enemies. Parasitic wasps and tachinid flies are generally thought to be the most effective control agents, but a nuclear polyhedrosis virus will also kill larvae when humidity is high during the summer. *In practice however, these control agents are not adequately effective in preventing Lepidopterous larvae from damaging high value crops such as leafy vegetables or melons.* Biological insecticides, such as *Bacillus thuringiensis* (Bt) can provide short-residual suppression of cabbage looper but only provides marginal control of beet armyworm and corn earworm.

Insecticidal Control Applications of insecticides should be considered during critical crop growth stages when sizable populations of larvae are present or when control of ovipositing moths is desirable. Larvae are generally easier to control while they are still small, and their control prevents excessive less feeding damage. Action thresholds for initiating insecticide sprays for Lepidopterous larvae have been developed, but can vary with crop and market demands. In general, leafy vegetables, particularly grown for fresh-cut bagged salads, have a very low tolerance for damage and insect. Production practices such as irrigation, cultivation, labor crew activity, harvest date projections and pre-harvest intervals for insecticides will often influence chemical choices and spray timing.

The following nominal action thresholds have shown to be effective in preventing economic damage from Lepidopterous larvae in desert crops. Because cabbage looper, beet armyworm and corn earworm/tobacco budworm often occur at the same time, thresholds should take into account all larvae present, regardless of species.

- Leafy vegetables and cole crops: At stand establishment, treat when larvae can be found on more than 1 plant per 100 sampled. Timing insecticide applications when egg masses are beginning to hatch will improve control and prevent damage to small plants. The action threshold after thinning but before heading is 5 larvae infested plants / 50 plants sampled. During head formation, treat if larvae reach 1 / 50 plants. Repeated insecticide treatments may be required to maintain low population levels near harvest.

Correct species identification is useful in determining which insecticides to use for control of Lepidopterous larvae. Insecticides effective against one species may be less effective against another. When multiple Lepidopterous species are present in large numbers, tank mixtures of insecticides may be required. Several insecticide products are available for Lepidopterous larval control. Figures 1-3 lists the most commonly used products for controlling larvae throughout the lettuce, melon and broccoli crop growing cycles.

Products such as Radiant (spinetoram), Proclaim (emamectin benzoate) and Coragen (rynaxypyr) have translaminar activity, cause mortality through both contact and ingestion, and are fast acting and provide quick knockdown control. Intrepid (methoxyfenozide), Avaunt (indoxacarb) and Synapse (flubendiamide) are slower acting products that that act primarily through ingestion. All of these compounds are relatively selective for Lepidopterous larvae and have good residual activity. Application with ground applied equipment will provide the most consistent control. Residual control of larvae with the products will depend on the rate applied, Lepidopteron species present, size of plant, type of application and growing conditions. Older products such as Lannate (methomyl), Orthene (acephate), endosulfan and pyrethroids kill larvae through contact activity and typically provided less residual activity. These compounds are often used in combination with the more selective compounds to provide broad spectrum control of adult moths and other pests that may be present.

Figure 1. Lepidpterous Larvae on Head Lettuce *(products with the same color bars have the same mode of action)*

Alternatives for Lep Larvae Control at Specific Lettuce Crop Stages

Insecticide	IRAC MOA	Pre-plant Soil	Stand establishment		Thinning to Heading				Heading to Harvest		
			Coty-1 leaf	2-4 leaf	5-8 leaf	9-15 leaf	15-20 leaf	Pre - head	Early heading	2-4" head	4-6" head
Radiant	5							•			•
Proclaim	6							•			•
Intrepid	18						•	•	•	•	
Avaunt	22A						•	•	•	•	
Coragen, *Soil / Foliar*	28							•			•
Durivo, *Soil only*	28+4A										
Voliam Xpress	28+3										
Synapse	28							•		•	
Vetica	28+16							•		•	
Lannate	1A		•	•	•	•	•	•	•	•	•
Orthene	1B			•	•	•	•				
Endosulfan	2A			•	•	•	•				
Pyrethroids	3		•	•	•	•	•	•	•	•	•
Bt	11B				•	•	•				

- to be used in combination with a different IRAC mode of action

Always consult the label before applying any pesticides

Figure 3. Lepidopterous Larvae on Broccoli *(products with the same color bars have the same mode of action)*

Alternatives for Whitefly Control at Specific Broccoli Crop Stages

Insecticide	IRAC MOA	Pre-plant Soil	Stand establishment		Thinning to Heading				Heading to Harvest		
			Coty-1 leaf	2-4 leaf	5-10 leaf	10-15 leaf	15-20 leaf	20-25 leaf	Early button	2-4" head	4-6" head
Radiant	**5**							●			●
Proclaim	**6**							●			●
Intrepid	**18**						●	●	●	●	
Avaunt	**22A**						●	●	●	●	
Coragen, *Soil / Foliar*	**28**							●			●
Durivo, *Soil only*	**28+4A**										
Synapse	**28**							●		●	
Vetica	**28+16**							●		●	
Lannate	**1A**		●	●	●	●	●	●	●	●	●
Lorsban	**1B**			●	●	●	●	●	●	●	●
Endosulfan	**2A**			●	●	●	●				
Pyrethroids	**3**		●	●	●	●	●	●	●	●	●
Bt	**11B**				●	●	●	●	●		

● to be used in combination with a different IRAC mode of action

Always consult the label before applying any pesticides

Plate 1. A) Beet armyworm (BAW) moth , B)Neonate BAW hatching from egg mass , C) Third instar BAW larvae feeding on small lettuce plant , D) Fifth instar BAW larva moving on soil, preparing for pupation

Plate 2. A) BAW Feeding damage to lettuce plant at first sidedress, b) Third instar BAW webbing iteslf in broccoli terminal , C) BAW Damage (feeding and frass) on cap leaf of mature lettuce head, D) Fifth instar BAW inside of lettuce head

Plate 4. A) Cabbage looper (CL) eggs, B) CL moth on weed, C) Second instar CL on lettuce plant, D) Fifth instar CL larva just prior to pupation

Plate 5. A) CL and feeding damage to lettuce plant at first sidedress, B) CL feeding damage on mature lettuce head , C) CL and feeding damage on broccoli leaf, D) Fifth instar CL and feeding damage to cabbage

Plate 7. A) Corn earwom (CEW) moth, B) Second instar CEW and feeding damage on mid-rib of lettuce moth feeding, C) Third instar CEW and feeding damage to immature lettuce head

Plate 8. A) CEW feeding damage at base of mature lettuce head , B) CEW feeding damage within mature lettuce head , C) CEW and feeding damage within mature lettuce head