Integrated Pest Management

- Pest management
  - One of the keys to successful crop production
  - Many pests can be devastating to horticultural and agronomic crops
    - Disease pests
    - Insect pests
    - Weed pests
  - Without effective control measures many crops cannot be grown in a profitable manner

Melon Fruit Fly

Tomato Fruitworm

- One definition that is often used:
- "IPM is a concept that uses multiple approachs for minimizing pest damage, empowering farmers, increasing the income and production of the farmer, and restoring a balance to the ecosystem."
- IPM promotes prevention over remediation and advocates integration of at least two or more strategies to achieve long-term solutions for pest control."

- IPM is a ***systems*** **approach to controlling pests**
- **Every decision is made only after considering its impact on pest management.**
  - **For example, if we are choosing a cucumber variety, we might consider selecting varieties that carry natural resistance to powdery and downy mildew, and anthracnose**
  - **Thus, we opt to grow cucumbers that often eliminates the need to spray to control these common diseases of cucumbers**

Understand the Pest

- **To make IPM work we must understand the pest.**
  - **Knowledge of the pest's life cycle, where it lives and what it eats helps us devise strategies to interrupt its activities by altering management practices rather than by using pesticides.**
  - **For example, Cucumber Beetles overwinter as unmated adults in bordering vegetation close to cucurbit fields, and plant debris. Cucumber beetles become active in spring when temperatures reach about 16ºC and feed on alternate host plants until cucurbit plants appear in vegetable fields.**
  - **Trapping the adults early in the season will prevent egg-laying and provides a season-long solution for this pest without needing to apply pesticides.**

- **The Action Threshold**
  - **It is also important to know that all pests don't have to be controlled.**
  - **The term "action threshold" is used to describe the population level of pest presence that requires control.**
  - **With plant diseases, action thresholds are frequently the first occurrence of disease symptoms or the occurrence of climatic conditions (usually temperature and humidity levels) that favor development of the disease.**
  - **With insects and weeds, the action threshold is usually linked to the presence of some critical population level or the appearance of feeding damage on a critical number of the plants in the field.**

- **Action thresholds vary from pest to pest.**
  - **For cucumber plants, the action threshold for Cucumber beetles is only an average of 1 adult per plant.**
  - **Yield reductions are likely if 1 or more beetles are found per plant and a higher economic value will result than the cost of control.**
  - **Thus, if 1 or more beetles are found per plant, then some type of action must be taken to control the pest**

Integrated Pest Management

- Effective and environmentally sensitive approach to pest management
  - relies on a combination of common-sense practices
  - IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment
  - This information combined with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment (minimize pesticide use).

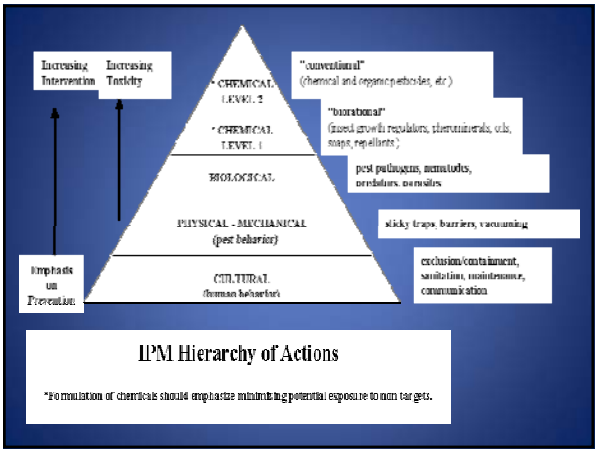
Integrated Pest Management

- The IPM approach can be easily applied to agricultural crop production.
- IPM takes advantage of all appropriate pest management options including, but not limited to, the lower use of pesticides.
- IPM is a more sustainable approach to managing pests.

IPM emphasizes the integration of many pest suppression technologies:

- **Biological control--beneficial organisms that manage pests (e.g., lady beetles for control of soft-bodied insects such as aphids).**
- **Cultural control--crop rotation, sanitation, and other practices that reduce pest problems. Mechanical and physical controls--for example, traps, cultivation, and temperature modification.**
- **Chemical control--judicious or limited use of pesticides and other chemicals.**
- **Genetic control (host plant resistance)--traditional selective breeding and newer biotechnology that produce pest-resistant crop varieties.**

IPM is not a single pest control method but, rather, a series of pest management evaluations, decisions and controls.



In practicing IPM, growers who are aware of the potential for pest infestation follow a four-tiered approach. The four steps include:

1) Set Action Thresholds

- Before taking any pest control action, the point at which pest populations or environmental conditions become economically damaging must be determined. Seeing just a single pest does not always mean that control is needed. The level at which pests will become an economic threat is critical to guide future pest control decisions.

2) Monitor and Identify Pests

- Not all insects, weeds, and other living organisms require control
- Many organisms are harmless, and some are even beneficial
- IPM programs work to monitor for pests and identify them accurately, so that appropriate control decisions can be made in conjunction with action thresholds
- This monitoring and identification removes the possibility that pesticides will be used when they are not really needed or that the wrong kind of pesticide will be used

3) Prevention

- As a first line of pest control, IPM programs work to manage the crop to prevent pests from becoming a threat
- In horticultural crops, this can mean using cultural methods, such as rotating between different crops, selecting pest-resistant varieties, staking , mulching and planting disease-resistant rootstocks
  - These control methods can be very effective and cost-efficient and present little to no risk to people or the environment

3) Control

- Once monitoring, identification, and action thresholds indicate that pest control is required, and preventive methods are no longer effective or available, IPM programs then evaluate the proper control method both for effectiveness and risk
- Effective, less *risky* pest controls are chosen first, including highly targeted chemicals, such as pheromones to disrupt pest mating, or mechanical control, such as trapping or weeding
- If further monitoring, identifications and action thresholds indicate that less risky controls are not working, then additional pest control methods would be employed, such as targeted spraying of pesticides. Broadcast spraying of non-specific pesticides is a last resort.

Clients will learn about pest identification, and IPM methods and tactics for several important horticultural crops

Horticultural crops-

-Approaches for pest control using IPM tactics

-Focus on:

- Hot chile peppers
-Tomatoes
-Sweet Corn

Integrated Pest Management for Chile Peppers

Dr. Alan Walters

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- Pepper (*Capsicum sp.) is one of the most* varied and widely used foods in the world
- From the various colors and tastes, peppers are an important spice commodity and an integral part of many cuisines.

- Chile Peppers are warm-season vegetable crops with optimal day temps of 24 to 29°C and night temps of 10 to 16°C
- Although tolerant to temps of about 38°C such extreme conditions can reduce effective pollination, fruit set and yield
- Most cultivated peppers require around 75 days from transplanting to first harvest and can be harvested for several weeks before production wanes
- Important domestic and export crop for Afghanistan
  - However, several important pests hinder production

Phytophthora blight of pepper

Integrated Pest Management for Chile Peppers

Insect Pests

- A wide variety of insect pests can cause significant damage to pepper plantings
  - Beet armyworm
  - Flea beetles
  - Tomato fruitworm (discussed in tomato IPM)
  - Tomato (potato) psyllid
  - Twospotted spider mite
  - Western yellowstriped armyworm
  - Whiteflies
  - Green peach aphid
  - Leafminer
  - Thrips

Green Peach Aphid
Scientific name: *Myzus persicae*

Green peach aphid

- Among the most common aphid species found on peppers.
- Generally pale green, although at times individuals may be present that are pinkish; during cool weather, individuals are usually more deeply pigmented.
- Winged forms the green peach aphid have a distinct dark patch near the tip of the abdomen; wingless forms lack this dark patch.

- **DAMAGE**
- The green peach aphid transmits a number of destructive viruses in pepper including pepper potyviruses and cucumber mosaic cucumovirus.
- It can also damage the plant by sucking plant sap.
- Extensive feeding causes plants to turn yellow and the leaves to curl downward and inward from the edges.
- Honeydew produced by the aphids can be a problem, especially on fresh market peppers.

MANAGEMENT

- **Biological and cultural controls** can be useful for limiting damage
  - removing old crop debris from the field will reduce sources of virus and thereby its transmission by aphids, and using reflective mulches early in the season will repel aphids from young plants.
- Heavy infestations on seedling and young plants may require treatment with insecticides.
- **Biological Control**
- The green peach aphid is attacked by a number of common predators, including lacewings, lady beetles, syrphid flies, and parasites, including many species of parasitic wasps and is susceptible to the fungus disease, *Entomophthora* spp., that commonly attacks aphids.
- Aphid sampling should always include an evaluation of the presence and activity of natural enemies.

Cultural Control

- Field sanitation, especially removal of infected crop debris immediately after harvest and destruction of alternate host plants
- The spread of the virus within a geographical area can be reduced by not planting peppers near other pepper fields.
- Studies have shown, however, that aluminum foil or silver reflective plastic mulches were effective in repelling aphids from plants.

Monitoring and Treatment Decisions

- Treatment of aphids to prevent or reduce the incidence of viruses.
- Treatment thresholds for green peach aphid:
  - Economic thresholds: before fruit formation: > **2** aphids per leaf and once fruit are present: **4** aphids per leaf
- High populations can do extensive damage, particularly on seedlings or young plants and may require insecticides
- Insecticides:
  - IMIDACLOPRID (Admire Pro)
  - INSECTICIDAL SOAP (M-Pede)
    - Only gives partial control (about 50%) and may cause phytotoxicity and apply when aphids first appear or when damage first occurs.
    - Spray to wet all infested plant surfaces.
    - Repeat at weekly to biweekly intervals.

Pepper Diseases

- Alfalfa mosaic virus
- Bacterial spot
- Cucumovirus mosaic
- Curly top (discussed for tomato)
- Pepper potyvirus mosaic diseases
- Pepper tobamovirus diseases
- Phytophthora root and crown rot
- Powdery mildew
- Tomato spotted wilt virus (discussed for tomato)
- Verticillium/Fusarium wilt

Phytophthora root and crown rot
Pathogens: *Phytophthora capsici*

A pepper field infected with Phytophthora root rot.

Aboveground symptoms of Phytophthora root and crown rot include rapid wilting and death of affected pepper plants.

- Close examination of the roots and stems of affected plants is necessary to confirm the cause of disease.
- The disease can develop at any stage of pepper plant growth.
- Tap roots and smaller lateral roots are water-soaked, very dark brown discoloration of cortical and xylem tissue.

- Very few lateral roots remain on diseased plants and the tap roots may also be shorter compared to those of healthy plants.
- The most striking difference between healthy and diseased plants is the total amount of root tissue.
- Stems are usually infected at the soil line.
  - Stem lesions are first dark green and watersoaked, turning dry and brown.
  - The lesions may girdle the stem and result in wilting of plants above the lesions and subsequent death.

Phytophthora capsici

- The fungus can survive on and in seed and in soil.
- The fungus also produces thick-walled oospores that can survive prolonged periods of adverse conditions.
- Contaminated seed and transplants, or soilborne inoculum are sources of primary infections.
- Irrigation water often disseminates fungal propagules from infested areas to other parts of the field.
- Thus, irrigation (such as flood irrigation) can significantly increase the incidence and severity of root and crown rot in pepper. Increased frequency and duration of irrigation favor disease development.

Phytophthora capsici

- Water, temperature, and soil texture are the major factors affecting the development of root and crown rot.
- The presence of water is essential and soil saturation for as little as 5 to 6 hours can result in infection, and susceptible varieties can become severely diseased in as little as 5 days.
- The disease is severe in fine-textured (clay) soils that drain slowly and in highly compacted soils.
- Infections that occur late in the season may reduce vigor and yield of plants without killing them.
  - However, the foliage wilts during the hottest time of day, exposing fruit to sunburn.

MANAGEMENT

- *Phytophthora* fungi survive in soil as oospores for several years.
- Factors that influence the development of root and crown rot in peppers in a given season include varietal susceptibility, amount and frequency of irrigation, and soil compaction and drainage.
- Crop rotation, proper irrigation, and clean seed and transplants are critical in managing this disease.
- Fields that have a history of Phytophthora rots should be avoided or if they are planted will need to be regularly scouted for the development of the disease.

Cultural Control

The disease can be effectively prevented by a program integrating crop rotations of 2 years that exclude susceptible plants, irrigation management, and clean seed and transplants.

In heavy soils that are poorly drained, root and crown rot may be reduced by irrigating every second furrow at one irrigation and the alternate furrows at the next, or by carefully managed drip irrigation.

Practices that reduce or alleviate soil compaction may improve control; for example, growing plants on raised beds.

Commercial hybrid cultivars with acceptable levels of resistance to the disease are available.

Treatment Decisions

- Fungicides are sometimes used in fields with histories of root rot or problems with drainage.
- Common Fungicides used:
  - MEFENOXAM (Ridomil Gold)
  - PHOSPHOROUS ACID (Various products)
  - DIMETHOMORPH (Acrobat)

Integrated Weed Management of Peppers

- Effective weed management is one of many critical components of successful pepper production.
- Weeds compete with pepper for light, nutrients, water, and space as well as interfere with harvesting practices.
- Peppers are very poor competitors with weeds early in the season
  - Weeds germinating during the first 6 to 8 weeks after crop emergence can severely reduce yields
  - After 8 to 10 weeks, the yield of peppers is less affected by late-emerging weeds; however, weeds can interfere with harvest and produce weed seeds that can be troublesome in rotational crops.
- Additionally, weeds can harbor insects and diseases.
- Severe weed infestations will significantly reduce fruit yields

Integrated Weed Management in Peppers

- Combined with good cultural practices, available herbicides can control many of the weed species that are found in pepper fields.
- The choice of herbicide depends upon the weed species that are present and the cultural practices followed by the grower.

IPM weed Management in Peppers

MONITORING

- To plan a weed management program, it is essential to know which weed species are present and the relative abundance of each.
- Conduct weed surveys of each field at least twice a year: the first after planting but before weeding and the second just before harvest.
- Records from previous crops will indicate which weeds escaped control and will likely infest the pepper crop.

Integrated Weed Management in Peppers

Crop rotation

- Crop rotations help to reduce weed problems
  - Corn is a good rotational crop for peppers because herbicides
  - Alfalfa is a good choice for a rotational crop because the frequent cutting cycle reduces many weeds and available herbicides eliminate most other weeds.
  - Other crops considered to be useful rotational crops with peppers include beans, cereals, cotton, garlic, rice, onions, carrots, lettuce, cole crops and safflower.
  - Avoid crops such as tomatoes, potatoes and eggplant; they are in the same family as peppers (Solanaceae) and similar herbicides are used in their production, resulting in similar uncontrolled weeds.

Integrated Weed Management in Peppers

Cultural practices

- Preventing weeds from setting seed helps reduce the population of weeds in the following crop; this also applies to areas adjacent to cropped fields.
- Buried drip irrigation can help reduce weed problems by keeping the tops of the beds dry.
- If peppers are direct-seeded, a second irrigation system (furrow) is generally needed to germinate the pepper seed.
  - But this favors germination of weed seeds

Integrated Weed Management in Peppers

Cultural practices

- If furrow irrigation systems are used, maintaining deep furrows keeps the bed tops from becoming overly wet while providing adequate moisture for the crop.
  - By keeping the bed tops drier, less weeds are likely to germinate in the soil surface.
- The use of black, brown, or green plastic mulch can inhibit most weed growth on pepper beds, except for yellow nutsedge.
  - However, immediately around the pepper plant, where it emerges through the plastic, weeds can also emerge and they will need to be removed by hand.

Nutsedge

- **Yellow nutsedge, *Cyperus esculentus.***

Nutsedges

- Nutsedges are perennial weeds in the sedge family somewhat resembles grass.
- However, leaves of sedges
  - thicker and stiffer than most grasses
  - V-shaped in cross-section
  - arranged in sets of three at the base
- Stems are triangular in cross-section whereas grass stems are hollow and round.
- Yellow nutsedge can be distinguished from purple nutsedge by its underground tubers or "nutlets."
  - Tubers of yellow nutsedge are produced singly on creeping underground stems, mostly in the upper foot of soil, while purple nutsedge tubers are produced in chains, several on a single creeping underground stem.

Yellow nutsedge

Scientific name: *Cyperus esculentus*
(Sedge Family: Cyperaceae)

Purple nutsedge

Scientific name: *Cyperus rotundus*
(Sedge Family: Cyperaceae)

Integrated Pest Management of Sweetcorn

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Sweetcorn

- New crop for Afghanistan that has lots of potential
  - Warm-season, grass crop
  - 3 genes in sweetcorn genetics that separate it from field corn
    - su (sugary locus)
    - se (sugary enhanced locus)
    - sh-2 (shrunken-2 locus) - 'supersweets'
  - These genes can occur individually or together (synergistic hybrids)
  - sh-2 types must be isolated from other types or kernels will be starchy
  - Isolation can be achieve by planting differing maturity dates at once or by succession plantings
  - Differing kernel types for color: white, yellow, or mixed (bicolor)

Sweetcorn Production

- Pest management
  - Key to successful crop production
  - Many pests are devastating to horticultural crops
    - Disease pests
    - Insect pests
    - Weed pests
  - Without effective control measures many crops cannot be grown in a profitable manner
- The IPM approach can be easily applied to horticultural crop production
- IPM takes advantage of all appropriate pest management options including, but not limited to, the judicious use of pesticides.
- IPM is a more sustainable approach to managing pests

Sweetcorn Production

- Pests
  - Diseases are not generally a problem in sweetcorn production
    - Rust
    - Smut
    - Blight
    - Stewart's Wilt
  - Weeds can be effectively controlled by minimal herbicide applications and hand cultivation
    - Sweetcorn is a good competitor with weeds once the crop gets established
  - However, insects are often devastating to sweetcorn as they can severely reduce crop yields as well as marketability of the ear

Disease and Weed IPM

- Plant sweet corn only in fields where sweet or field corn have not been grown in the previous year to avoid anthracnose, smut, northern corn leaf blight.
- Use tolerant or resistant varieties whenever possible for controlling maize dwarf mosaic, common rust, smut, barley yellow dwarf, and Stewart's wilt.
- Try to use of banded herbicide applications and cultivation in order to reduce herbicide use.

Focus on Insect Control

- There are three major insect pests of sweet corn: European corn borer, corn earworm and fall armyworm.
- All spend their adult life as moths, but the damaging stage of the insects are the larvae or caterpillars, commonly referred to as "worms," which feed on the leaves, stalks and ears of the corn plants.
- Integrated pest management (IPM) strategies developed for these insects are designed to maximize effectiveness and efficiency of control programs while reducing amounts of pesticides used and increasing profitability.

- **An IPM program in sweetcorn for insect control consists of:**
  - 1) monitoring the populations of the major pest species in each field;
  - 2) using action thresholds based on pest populations to determine when a spray should be used to control a pest;
  - 3) when possible, using an effective and safer alternative to reduce pest populations.
- In the past, pest control has largely been accomplished by applying pesticides according to the stage of growth of the plants (e.g. tassel or silk) with little or no regard to actual pest populations in a field.
- By monitoring fields for pests and injury, and using action thresholds to decide when to spray, the amount of pesticides used is often significantly reduced, and the amount of corn lost to insects is also reduced, leading to a higher profit margin for the crop.

CORN EARWORM (CEW), *Heliothis zea*
(Also know as bollworm and tomato fruitworm)

Adult moth:

Wings are a light grayish-brown, marked with dark-gray to olive-green irregular lines

Has a 4 cm wing expanse

Larvae stage:

Larvae vary from light green or pink to brown or nearly black with alternating longitudinal dark and light stripes that mark its body

Larvae vary from light green or pink to brown or nearly black

Coloration is so variable that it is not dependable for identification

Short microspines (visible through a hand lens) on the skin are useful for identification

Corn earworm larvae feeding in ear

Feeding damage:

Young larvae begin feeding on the plant where eggs were laid on corn silk

Larvae burrow into and eat the developing kernels (mostly at tip)

May also feed in whorls of young corn plants, usually is not economic threat

Larvae are cannibalistic and usually only one larva grows in each ear

Silk (female flower)

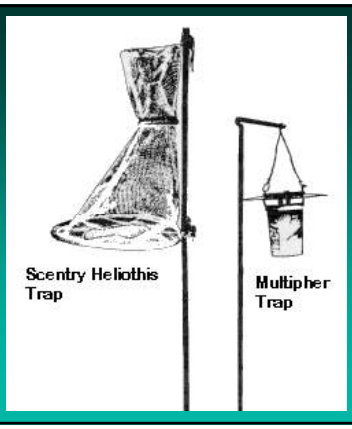
- The night-flying female moths search for fresh (green) corn silk on which to lay their eggs.
- The eggs are laid singly on the silk, although several may be laid on one silk mass.
- Each female can lay several hundred eggs.
- If fresh silk is not available, they may lay eggs on other hosts such as tomatoes or peppers.
- The eggs hatch in two to 10 days.
  - The newly hatched larvae feed on the corn silk, working their way down the silk channel to the tip of the ear.
  - Once there, the larvae feed on the silk and developing kernels.
  - The feeding area becomes filled with moist waste.
  - This damage causes severe economic loss, and may go unnoticed until harvest.

- A method used to estimate the CEW number in a field is to monitor moth populations as they move into a field to lay eggs
- Sampling the rate at which moths are moving into a field can help you to estimate the potential injury their offspring will cause and decide what control measures to use.
- You can sample moth populations by using pheromone traps.
- These traps are typically plastic nets or containers placed in or near the corn field and baited with a chemical attractant called a pheromone.

- Insect pheromones are very specific, and usually only attract a single species.
- This greatly simplifies the problem of proper insect identification associated with other trap types.
- The pheromones are usually placed in a small piece of plastic or rubber, which is placed in the trap to attract the moths.
- The pheromones used are chemicals female moths excrete to attract male moths. Therefore, only male moths are caught in the traps.
- The traps by themselves do not offer a means of controlling these pests, but are very useful as a monitoring tool.

Scouting and Control Thresholds

- Because corn earworm moths lay their eggs on the silks and the larvae crawl directly into the ears, field scouting is not an effective way to monitor for this insect.
- Therefore, control recommendations are made based on the number of corn earworm moths caught in pheromone traps on a nightly or weekly average.
  - Scentry Heliothis® traps or Harstack 50:33 or 50:25 traps are currently recommended.
  - The traps should be baited with Hercon® Helicoverpa zea or an equally effective pheromone.
  - Place traps in corn fields just as the fresh green silks begin to appear.
  - Place traps so that the base is at the same height as the silks.
  - Traps should be checked at least once a week until the first CEW moth is caught, and checked two to three times a week thereafter.
  - Insecticide treatment is recommended on any fresh silking corn when the first corn earworm is caught.
  - Spray intervals after the initial application should be based on the number of moths caught on a nightly basis.



Scouting and Control Thresholds

- Corn Earworm Spray Thresholds for Pheromone Traps
- Moths per Week (Moths per Night) Spray Interval
  - 0.0 - 1.4 (0.0 - 0.2) No spray
  - 1.5 - 3.5 (0.3 - 0.5) Spray every 6 days
  - 3.6 - 7.0 (0.6 - 1.0) Spray every 5 days
  - 7.1 - 91.0 (1.1 - 13.0) Spray every 4 days
  - More than 91 (More than 13) Spray every 3 days
  - Note: If maximum daily temperature is less than 80°F, lengthen the spray interval by one day.
- The provides the spray thresholds you can use to determine if control measures are necessary based on the number of CEW moths caught in pheromone traps.
- Corn that is not yet in silk need not be sprayed.
- Once the silks have dried, the corn no longer needs to be sprayed, and the pheromone traps should be moved to corn with fresh silks.

Briefly…..Other important insects of Sweetcorn

- Fall Armyworm
- European corn borer

Fall Armyworm (FAW)
Spodoptera frugiperda

Fall Armyworm

- Larvae are smooth skinned, and vary in color form tan to green to nearly black.
- Three thin, yellowish white lines run the length of the back. On each side, next to the yellowish lines, is a wider dark stripe and below it, an equally wide, wavy, yellowish stripe with red markings
- The larva also has four dark spots at its posterior end.
- The FAW closely resembles the true armyworm, but usually has a prominent white inverted Y on the front of its dark brown head.

- However, the Y marking is not always prominent enough to serve as a reliable characteristic.
- FAW larvae may also be confused with corn earworm larvae because of its similar appearance and habits.
- The moths lay green to gray eggs in clusters of 50 or more and cover the egg masses with body hairs.
- The moths prefer to lay eggs on young corn.
- The eggs hatch within 10 days, and the newly hatched larvae begin feeding voraciously on the whorl, tassels or ears, leaving large, ragged holes and masses of sawdust-like excrement
- The FAW does its most serious economic damage by feeding on the ears, although feeding on the leaves is most commonly noticed.

- After the larvae have reached maturity (in about two to three weeks), they crawl down to the ground and pupate in soil near the plant's base.
- Within two weeks, the moths emerge.

Typical FAW damage

Scouting and Control Thresholds

- **Whorl to silk stage:** To scout for FAW, check 20 plants in each of the four corners and one location in the center of the field for a total of 100 plants.
- This will give a good representation of the field as a whole. Look for the large, ragged holes in the leaves and sawdust-like waste, then see if you can find live larvae to be sure the damage is fresh.
- After you have scouted, simply take the number of damaged corn plants out of 100 and you have the percentage of damaged corn.
- A treatment is recommended if 30 percent or greater of the plants scouted show fresh damage.
- If European corn borer damage is also found, include it as part of the percent injury.

Scouting and Control Thresholds

- **Silk stage:** Once the corn has reached the silk stage, the threshold for treatment should be lowered to 15% of plants in the field showing feeding injury.
- Pheromone traps are available for FAW moths, and may provide some indication of fall armyworm activity in unsprayed fields.
- Place a Multipher® trap baited with Scentry® FAW pheromone in corn field at silk height.
- If silking corn is not being sprayed for other pests, such as corn earworm, a spray is recommended if more than three moths are caught in a trap within a week.

European Corn Borer (ECB)
Ostrinia nubilalis

- The European corn borer (ECB) moth varies in color from yellowish brown to dark tan with two dark, irregular, wavy bands across the front wings.
- European corn borer moths emerge and lay eggs, in masses of up to 50, resemble overlapping fish scales and are usually found on the underside of the corn leaves
- The eggs hatch in four to nine days.
- Just before hatching, the eggs turn black because of the darkening of the larval head capsule.

- The larvae feed on the corn leaves, frequently in the whorl, causing a characteristic "shot-hole" injury that becomes most apparent when the whorl leaves unroll
- The larvae will also tunnel into the tassels and stalk, weakening them and sometimes causing them to break
- The tunneling habit makes control at this stage very difficult.
- On more developed corn, the ECB larvae may enter the ear at the base, side or the tip through the silk channel.

- At the end of the season, the full-grown larvae can remain in the corn stalks and stubble throughout the winter.
- In the spring, the larvae pupate and emerge as moths in about two weeks.
- Plowing corn stalks and stubble under at the end of the season is an effective and important means of controlling the ECB.

Scouting and Control Thresholds

- Whorl Stage (eight leaves):
- Scout 100 plants per field or block (20 plant samples in five locations).
- Look for shot-hole injury in the leaves. An insecticide treatment is recommended if 30 percent or more of plants scouted show fresh feeding injury.
- Pretassel stage:
- Scout plants as above, look for feeding damage on the leaves and in the developing tassels.
- An insecticide treatment is recommended if 15 percent or more of the plants scouted show injury.

- Tassel-silk stage:
- Scout plants and, as above, look for fresh feeding injury on leaves, in tassels or on the sides of ears, especially where the ears meet the stalk.
- Give the stalk a gentle twist near the ear to detect larvae in the stalk. An insecticide treatment is recommended if 15 percent or more of the plants scouted show fresh injury.
- Pheromone traps:
- Two Scentry Heliothis® traps or traps of similar design should be placed in grassy weeds bordering the field, spaced at 30 m
- Bait with Scentry® ECB pheromone (or equivalent).
- In young corn (whorl-tassel), these traps should be used to judge the emergence of ECB, i.e. no spray threshold.
- In silking corn that has not yet been sprayed for CEW, a treatment is recommended to protect the silks from egg-laying ECB moths if 5 or more moths are caught in traps in a week.

Pest Monitoring and Forecasting

- Key to Effective IPM program
- Scout as recommended for European corn borer, fall armyworm, corn earworm, flea beetles, and common rust.

- Try to maintain records of pest densities, biological control techniques used, cultural procedures, and pesticide applications.
- For insecticide use: permethrin or similar compounds once pest threshold is exceeded

Integrated Pest Management

- Pest management
  - One of the keys to successful crop production
  - Many pests can be devastating to horticultural and agronomic crops
    - Disease pests
    - Insect pests
    - Weed pests
  - Without effective control measures many crops cannot be grown in a profitable manner

In practicing IPM, growers who are aware of the potential for pest infestation follow a four-tiered approach. The four steps include:

1) **Set Action Thresholds**
2) **Monitor and Identify Pests**
3) **Prevention**
4) **Control**

E**conomic threshold** is a key IPM decision-making tool

- Definition = The pest (insect, disease, or weed) population level at which some control should be used to prevent a pest population from increasing further and causing economic loss or point at which pest damage exceeds cost of control
- For example, leaf miners in melons: chemical treatment is recommended if an average of 15 to 20 larvae per leaf are found.

Integrated Pest Management for Tomato

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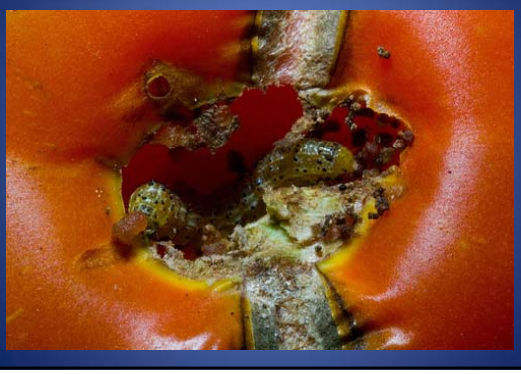
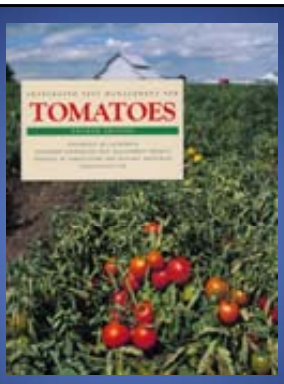
Blossom-end Rot

Tomato Fruitworm





Integrated Pest Management for Tomatoes

Provide information about pest identification, and IPM methods and tactics for Tomato

Tomato

Insects –

- Beet leafhopper
- Cutworms
- Tomato fruitworm
- Whiteflies

Tomato Fruitworm
Scientific name: *Circulifer tenellus*

Larva of tomato fruitworm (also called cotton bollworm or corn earworm).

Mating corn earworm moths (also called tomato fruitworm and cotton bollworm).

Recently laid eggs of corn earworm (also called cotton bollworm or tomato fruitworm).

- The tiny, spherical eggs are slightly flattened on top with coarse striations or ribs running from base to tip
- Fruitworm eggs are laid singly on both upper and lower surfaces of the leaves usually in the upper part of the plant
- When first laid they are creamy white, but develop a reddish brown ring after 24 hours and darken just before larvae hatch

Early Instar of Tomato Fruitworm Larvae

- With available fruit, the tomato fruitworm will complete its larval development inside fruit.
- Early stage larvae enter fruit at the stem end when it is between 2 to 5 cm in diameter.
- Their feeding results in a messy, watery, internal cavity filled with cast skins and feces.
- Damaged fruit will ripen prematurely.

MANAGEMENT

- Management of tomato fruitworm requires careful field monitoring for eggs and small larvae.
- Conduct a search of 30 randomly selected leaves for eggs; If more than 5 eggs are found, a treatment is warranted.
- When control is needed, it is essential to treat before large numbers of larvae enter fruit, where they are protected from sprays.
- Late-season fields may be more seriously affected.

- **Organically Acceptable Methods**
  Biological control and sprays of ***Bacillus thuringiensis*** and the **Entrust formulation of spinosad** are acceptable for use
- **Insecticides**
  - ESFENVALERATE (Asana XL)
  - FENPROPATHRIN (Danitol)
  - METHOMYL (Lannate)
  - SPINOSAD (Entrust)
  - BACILLUS THURINGIENSIS ssp. KURSTAKI (various products)
  - CARBARYL (Sevin) 80S
  - PYRETHRIN (PyGanic)

Tomato

Diseases –

- Blossom-end-rot
- Curly top
- Alternaria stem canker
- Anthracnose
- Damping-off
- Early blight
- Fusarium/Verticillium wilt
- Tomato Spotted Wilt

Blossom-end rot

Various appearances of blossom end rot of tomato.

- Blossom-end rot is an abiotic disease
- Symptoms may occur at any stage in the development of the fruit, but, most commonly, are first seen when the fruit is one-third to one-half full size.
- Symptoms appear only at the blossom-end of the fruit.
- Initially a small, water-soaked spot appears, which enlarges and darkens rapidly as the fruits develop.
- Large lesions soon dry out and become flattened, black, and leathery in appearance and texture.

- The occurrence of the disease is dependent upon a number of environmental conditions, especially those that affect the supply of water and calcium in the developing fruits.
- Factors that influence the uptake of water and calcium by the plant have an effect on the incidence and severity of blossom end rot.
- The disease is especially prevalent when rapidly growing, succulent plants are exposed suddenly to a period of drought.
- When the roots fail to obtain sufficient amounts of water and calcium transported up to the rapidly developing fruits, the fruit become rotted on their basal ends.

- Control of blossom end rot is dependent upon maintaining adequate supplies of moisture and calcium to the developing fruits.
- Irrigation must be sufficient to maintain a steady even growth rate of the plants.
- Mulching of the soil is often helpful
- Foliage can be sprayed with calcium chloride.
- Foliar treatment is not a substitute for proper treatment of the soil to maintain adequate supplies of water and calcium.
- Although differences exist among varieties with respect to susceptibility to blossom end rot, no varieties as yet have commercially useful resistance.

Tomato Damping-Off
Pathogens: *Phytophthora, Pythium,* and *Rhizoctonia* spp

The tap root and lower stem are shriveled and darkened in seedlings affected by damping-off (right).

- "Damping-off" is a general term for the death of seedlings, either before or after emergence
- Seedlings affected by damping-off fail to emerge or fall over and die soon after emergence.
- Stems usually have a dark, shriveled portion at the soil line.
- Damping-off is generally limited to areas where drainage is poor or where soil is compacted, but whole fields can be affected, especially in early plantings exposed to rain.

- Infection is most common under cool conditions, although both *Phytophthora* and *Rhizoctonia* can also infect seedlings in warmer soils.
- Once tomato seedlings reach the 2- or 3-leaf stage, they are no longer susceptible to infection by *Pythium* or *Rhizoctonia;* however, *Phytophthora* can infect tomato plants at any stage.

MANAGEMENT

- Proper field and seedbed preparation and good water management significantly reduce losses from damping-off.
- If possible, avoid planting when the soil is cool; seeds germinate faster and seedlings are more vigorous when the soil is warm, so they are less likely to be damaged.
- Often shows up in transplant flats due to overcrowding and excess moisture
- The use of fungicide seed treatments can help prevent damping-off
  - Fungicides: captan, metalaxyl, mefenoxam

Integrated Weed Management in Tomato

- Weeds reduce yields by competing for space, light, water, and nutrients, weakening crop stand, and by reducing harvest efficiency.
- Some weeds can also increase pest problems by serving as alternate hosts for insects, diseases, or nematodes.
- Weeds are most competitive if they emerge up until about 6 to 8 weeks after crop emergence.
- After 6 to 8 weeks, tomatoes become more competitive and they are usually less affected by late germinating weeds.
- However, even late germinating weeds can produce seed and, in some instances, interfere with harvest.

Integrated Weed Management in Tomato

- Effective weed management in tomatoes involves crop rotation practices, cultivation, proper field preparation, sanitation, and proper selection of herbicides.
- When combined with good cultural practices, available herbicides can control many of the weed species that are found in tomato fields.
  - The choice of herbicide depends upon the weed species that are present, the cultural practices followed by the grower, and the crops planted following tomato.

Integrated Weed Management in Tomato

- Herbicides can be classified according to their use as:
  - **Preemergence** (controls weeds after the seeds germinate but before they emerge from the soil and usually provides residual control)
  - **Postemergence** (controls emerged weeds but gives little or no residual control)

  Preemergent herbicides are absorbed by roots, emerging shoots (hypocotyl), or both.

  Postemergent herbicides are absorbed by leaves and stems of weeds.

Integrated Weed Management in Tomato

- Herbicides work best if soil moisture is adequate for plant growth.
- Preemergent herbicides will kill germinating seeds but not dry seeds.
- However, do not to apply these materials to wet soils because application equipment can cause soil compaction, particularly where power driven rotary tillers are used for soil incorporation.
- Postemergent herbicides work best on plants that are not stressed for moisture.
  - Nonstressed plants translocate the herbicide from where it is absorbed (mostly leaves) to the site of action.

Integrated Weed Management in Tomato

- Knowledge of target weeds is essential for weed management in tomatoes because most currently labeled herbicides only control germinating weeds.
  - Conduct weed surveys on each field at least twice a year: the first after crop planting but before weeding, and the second just before harvest
- **Crop rotation**
  - Can effectively reduce difficult weed problems by altering the environmental conditions that favor a particular weed species or by permitting the use of alternative methods to control these weeds.
    - Crops considered as useful rotational crops with tomatoes include alfalfa, corn, wheat, cotton, rice, dry beans, onions, carrots, and safflower.

Integrated Weed Management in Tomato

- Rapid, even stand establishment allows the crop to better compete with weeds.
  - Full tomato stands with good shading of the soil surface reduce the ability of late germinating weeds to compete.
  - Transplanting into fields with high potential weed populations provides the crop an initial growth advantage over the weeds and subsequent cultivations can further reduce weed populations along the sides of the planted row.

Integrated Weed Management in Tomato

- **WEED MANAGEMENT AFTER PLANTING**
  - Preventing weeds from going to seed helps reduce weed populations in subsequent crops
  - With furrow irrigation systems, maintaining deep furrows keeps the bed tops from becoming overly wet while maintaining adequate soil moisture for the crop. By keeping the bed tops drier, less weeds are likely to germinate in the soil surface.

Integrated Weed Management in Tomato

- **WEED MANAGEMENT AFTER PLANTING**
  - Cultivation is effective at controlling many weeds in tomatoes
    - One exception is the parasitic weed dodder.
    - Once dodder attaches to the tomato plant, it does not require connection with the soil and cannot be selectively controlled with cultivation.
    - To reduce dodder problems, control broadleaf weeds that act as alternate hosts for dodder, allowing it to spread onto tomatoes.
    - Eliminate tomato plants that have dodder attached at thinning and again 2 weeks later to help reduce the spread of this weed.

Some Herbicides for Tomato

- PARAQUAT (Gramoxone) and GLYPHOSATE (Roundup)
  - Control emerged weeds before transplanting or as directed spray
- METOLACHLOR (Dual Magnum)
  - Usually preemergence, but may be applied to postdirected transplants, try to minimize contact with tomato plants.
  - May be applied to direct-seeded tomatoes that are at least 10 cm tall.
  - Will provide control of yellow nutsedge during crop establishment. Use allowed under a supplemental label. Rate depends on soil texture.
- PENDIMETHALIN (Prowl)
  - Preemergence or postdirected
- Poast (sethoxydim) and Select (clethodim)
  - Emerged grasses