

Organic Integrated Pest Management

How to Avoid Problems

Good Pest Management is Based on Healthy Soils

- Healthy soils contain many different organisms that compete with pest organisms, keeping them in check
- Having a variety of flowering plants on the farm provides food — pollen & nectar — and refuge for numerous beneficial insects.



Healthy soils contain many organisms that feed & protect plants.

Maintain the Diversity and Fertility of the Soil

- By using compost
- By planting cover crops and green manures
- By rotating crops in the field

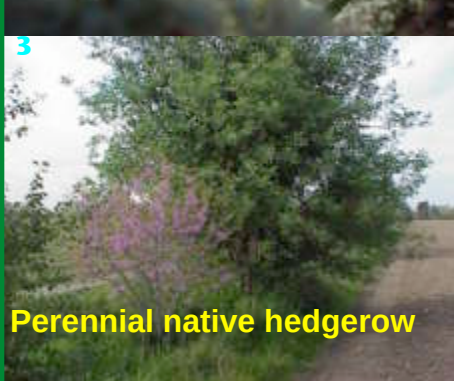
Healthy soil protects and feeds plant roots. The plant on the left grew in better soil.



Tachinid parasitic fly on California buckwheat

It's Important to Care for the Beneficial Organisms Both Above *and* Below the Soil Surface.

Keep a diversity of plants in the field to feed and shelter the beneficial organisms that help fight pests.



Perennial native hedgerow



Flowering annuals in crop rows



Ladybugs overwintering in deergrass



First year perennial hedgerow

For more information, call us toll-free at ATTRA: 1-800-346-9140

2 Providing Habitat for Beneficial Organisms

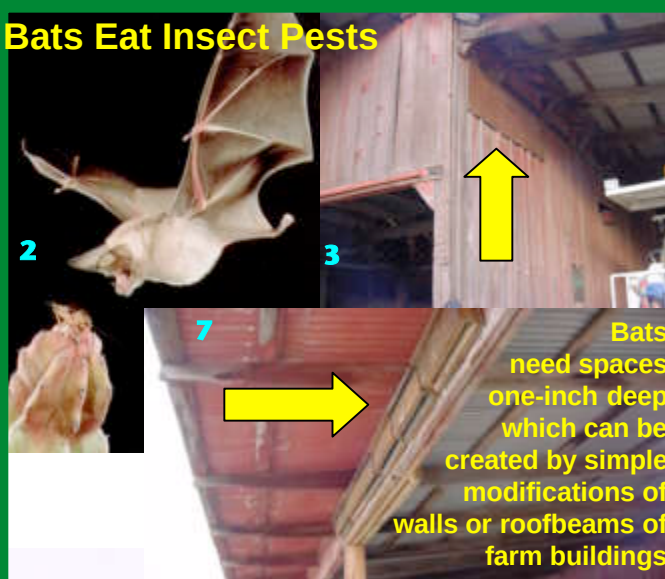
Keeping a diversity of plants on the farm helps with pest control

Hedgerows and Plant Habitat Provide:

- Habitat for beneficial organisms and wildlife
- Windbreaks to slow erosion
- Dust barriers
- Pesticide barriers between conventional and organic fields
- Protection from soil loss by water erosion

- Food, fruit, nuts, & aromatic herbs
- Beautiful landscape

Bats Eat Insect Pests



6 Trees and bushes offer protection from the wind, and perches for birds that eat insect pests



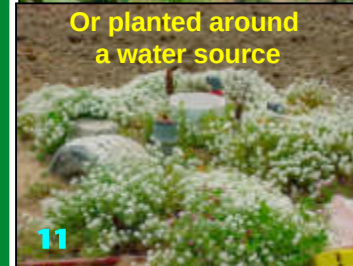
8 Perennial hedgerow

Flowering annual plants attract beneficial insects



Planted with the crops

Or planted around a water source



- Bats are nocturnal, like the moths (armyworm and cutworm adults) that plague many crops.
- One colony of bats can consume as many as 100,000 insects — such as cucumber beetles and moths— in a single season.

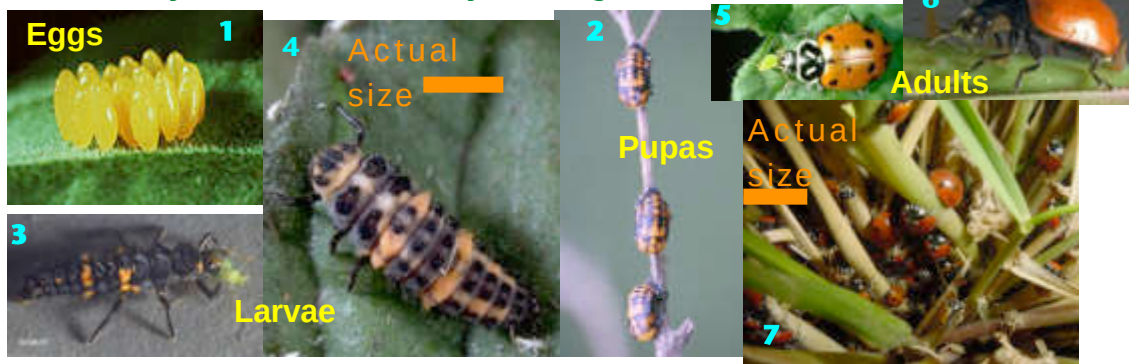


Nest boxes can be made for owls. These night hunters eat many insects and rodents.

For more information, call us toll-free at ATTRA: 1-800-346-9140

Protect these Beneficial Insects that Eat Insect Pests!

Life Cycle of Lady Bugs



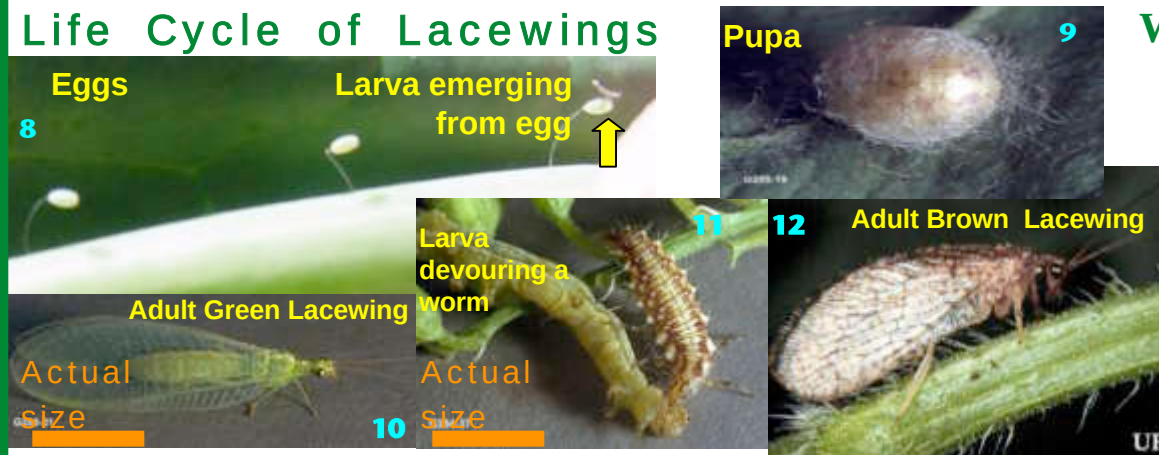
What do they eat?

Larvae & adults eat:
Aphids
Mealy bugs
Mites
Soft scale
Eggs of insect pests.

Where do they live?

In plants of the carrot family — fennel, dill, Queen Anne's lace. Also yarrow and sunflowers. Deergrass and other clumping grasses are excellent habitats for overwintering ladybugs.

Life Cycle of Lacewings



What do they eat?

The larvae eat soft-bodied insects including aphids, thrips, mealy bugs, soft scale, worms, and mites. The adults eat pollen & nectar.

Where do they live?

In plants of the carrot family — fennel, dill, Queen Anne's lace. Also yarrow, sunflowers, buckwheat, California buckwheat, corn, amaranth, holly leaf cherry, alyssum, coyote brush.

Life Cycle of Syrphid Flies



What do they eat?

The larvae eat aphids. The adults eat pollen & nectar.

Where do they live?

In plants of the carrot family — fennel, dill, Queen Anne's lace. Also yarrow, sunflower, buckwheat, alyssum, coyote brush, and other flowering plants.

Protect these Beneficial Insects that Eat Insect Pests!

Life Cycle of Damself Bugs



What do they eat?

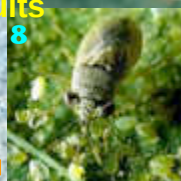
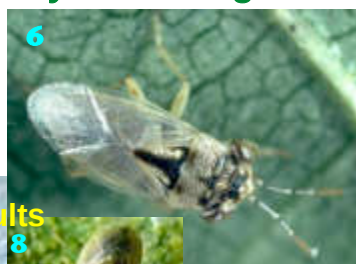
Nymphs & adults eat:
Aphids
Mites
Thrips
Worms
Lygus bugs
Leafhoppers

Where do they live?

Yarrow
Alfalfa
Goldenrod

Plants of the
sunflower family.

Life Cycle of Big-Eyed Bugs



What do they eat?

Nymphs & adults eat
many insects including:
Aphids
Mites
Thrips
Worms
Flea beetles
Insect eggs

Where do they live?

Cool season
cover crops
(berseem clover &
subterranean clover)
and common
knotweed

Tachinid Flies



Trichopode pennipes
(Big Foot Fly),
a parasite of
squash bugs.

What do they eat?

The larvae parasitize many
worms, Japanese beetles,
and some bugs.

Adults eat pollen & nectar.

Where do they live?

In plants of
the carrot family —
fennel, dill,
Queen Anne's lace.
Also yarrow, sunflowers,
buckwheat, alyssum,
coyote brush.

Protect these Beneficial Insects that Eat Insect Pests!

Life Cycle of Pirate Bugs



What do they eat?

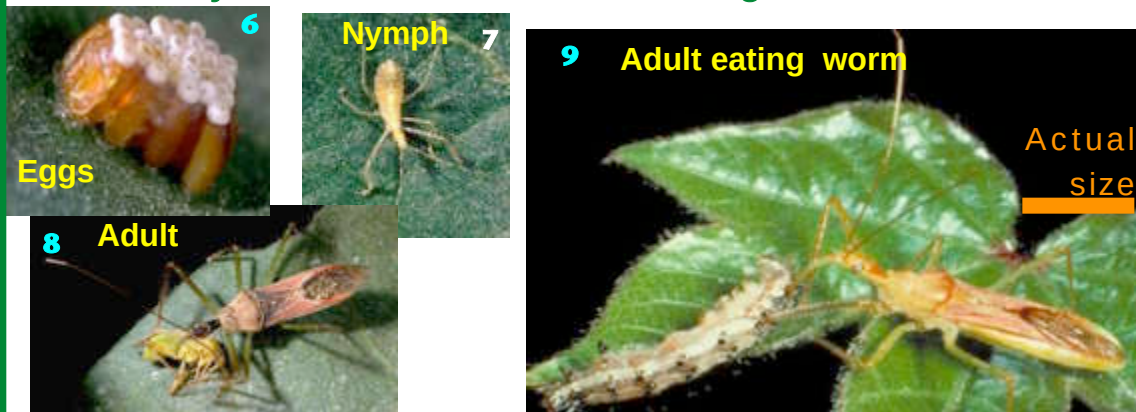
Nymphs & adults eat:

- Thrips
- Mites
- Leafhoppers
- Small worms
- Insect eggs

Where do they live?

In plants of the carrot family — fennel, dill, Queen Anne's lace. Also yarrow, sunflowers, buckwheat, alyssum, coyote brush, alfalfa, corn, clover, & vetch.

Life Cycle of Assassin Bugs



What do they eat?

Nymphs & adults eat:

- Many insects including large insects and worms

Where do they live?

In permanent plantings such as hedgerows, which provide shelter and food.

Spiders

Jumping Spider



What do they eat?

Spiders eat a great variety of pests, including aphids, flea beetles, cucumber beetles, leafhoppers, & many others.

Where do they live?

One of the best ways to increase the number of spiders is to use straw mulch and maintain undisturbed habitat strips, such as hedgerows.

For more information, call us toll-free at ATTRA: 1-800-346-9140

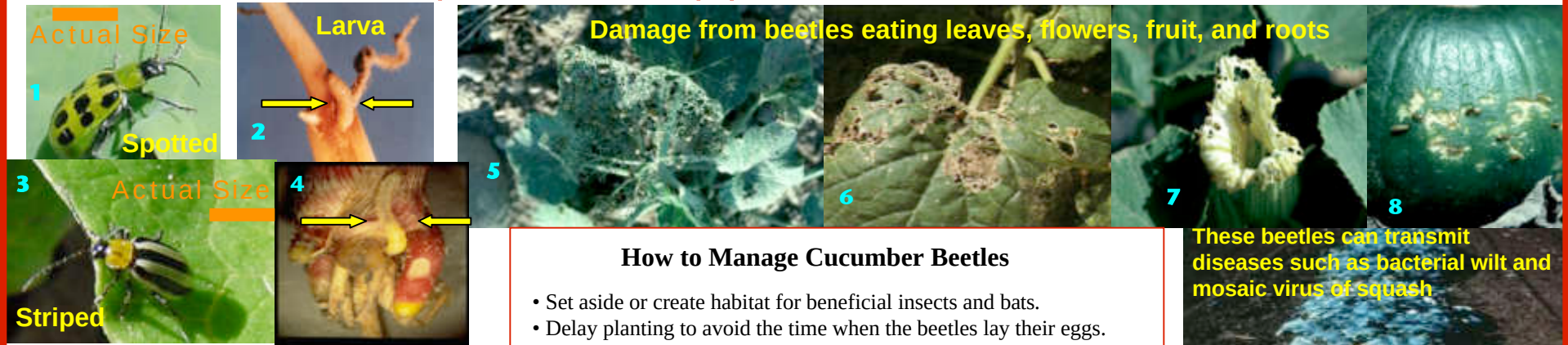
Important Insect Pests

Why Is It Important to Understand the Life Cycles of Pests?

1. To understand what these insects are like in all phases of their life cycles. Many juveniles do not look at all like the adults and can live in completely different kinds of places.
2. To understand the various stages and forms that these insects take, and to manage the places they live — whether on the undersides of leaves, in the soil, or other locations—to decrease their populations.
3. To manage the insects by varying planting dates, and using trap crops, and sticky traps.

Cucumber Beetles (*Diabrotica* sp.)

Damage Caused by Cucumber Beetles



Preferred Hosts of Cucumber Beetles

Most Susceptible to Damage

Number one is highly susceptible and number seven is least susceptible.

1. Cucumber
2. Cantaloupe
3. Honeydew Melon
4. Casaba Melon
5. Winter Squash
6. Summer Squash
7. Watermelon

Also:

- Corn • Potatoes
- Tomato • Fruit • Beans
- Cabbage • Lettuce



How to Manage Cucumber Beetles

- Set aside or create habitat for beneficial insects and bats.
- Delay planting to avoid the time when the beetles lay their eggs. (Beware: this could cause you to miss an early marketing window.)
- Use row covers or paper cones to protect the young plants. (Beware: this may interfere with weeding.)
- Thick mulch prevents pest insects from laying their eggs in the soil at the base of the stems.
- Trellis the plants to get them up off the ground.
- Cultivate and eliminate crop residues.
- Monitor the pest populations twice a week when the plants have less than five leaves: Check five plants in five different parts of the field. If you find more than five beetles per plant, some treatment is called for.
- Use trap crops, bait, and sticky traps.
- Consider using protective substances and organically approved insecticides.
- Be aware that the following varieties are extremely susceptible to damage:
 - Zucchini*: all varieties.
 - Other squash*: Cocozelle, Caserta.
 - Butternut Squash*: Early Butternut, Waltham.
 - Buttercup*: Honey Delight, Buttercup Burgess, Ambercup.
 - Pumpkins*: Happy Jack, Big Max, Baby Boo.

These beetles can transmit diseases such as bacterial wilt and mosaic virus of squash



Grow Crops

These Beetles Don't Eat

Try to grow the varieties that are LEAST attractive to cucumber beetles:

Summer Squash

Yellow Squash: Sunbar, Slender Gold
Straightneck: Seneca Prolific, Goldbar.
Crookneck: Yellow Crookneck
Scallop: Peter Pan

Winter Squash

Acorn: Table Ace, Carnival, Table King
Pumpkins: Baby Pam, Munchkin

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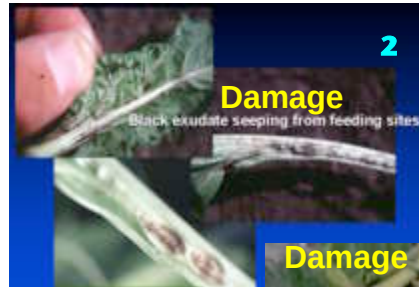
Important Insect Pests

7

Lygus Bugs



Adult



Damage

Black exudate seeping from feeding sites

Crops Affected by Lygus

- Strawberries
- Green Beans
- Cotton
- Lettuce
- Dry Beans
- Alfalfa
- Fruit



Damage in strawberries



Damsel Bug devouring Lygus

Methods of Controlling Lygus

- Create habitat for beneficial insects
- Eliminate weeds
- Monitor plantings for beneficial insects
- Plant trap crops (alfalfa & radish)
- Botanical pesticides as a last resort

Beneficial Organisms that Attack Lygus

- Fungus: *Beauveria bassiana* (Mycotrol™)
- The parasitic wasps *Anaphes ioles* & *Peristenus* sp.
- Damsel Bugs, Big-Eyed Bugs, Assassin Bugs, Lacewings, Spiders



Nymphs



Caterpillars of Moths & Butterflies



Cabbage looper



Egg



Cutworm



Corn ear worm



Pupa



Cabbage

butterfly



Peach Twig Borer



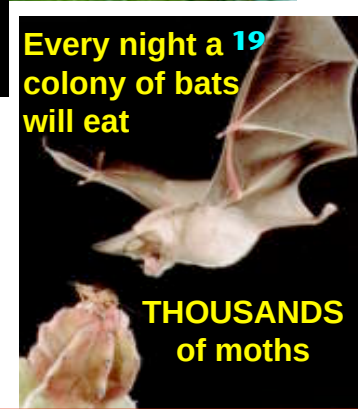
Cabbage worm



Pheromone trap



Pirate bug eating worm



Every night a colony of bats will eat

THOUSANDS of moths



Parasitized caterpillar



Wasp parasitizing an egg

Methods of Controlling Caterpillars

- Create habitat for beneficial predators and parasites
- *Bacillus thuringiensis* (Bt)
- Botanical pesticides
- Repellents: dilute garlic, onion or chilis with water
- Pheromones

Important Insect Pests

Aphids



Methods of Control

- Create habitat for beneficial insects
- Control ants
- Repellents: Dilute garlic, onion or chilies with water
- Insecticidal soaps
- Diatomaceous earth
- Vegetable oils
- Botanical Insecticides (Neem)
- Physical (water sprays)



Ants tend aphids, harvesting the juice they exude.

Natural Enemies

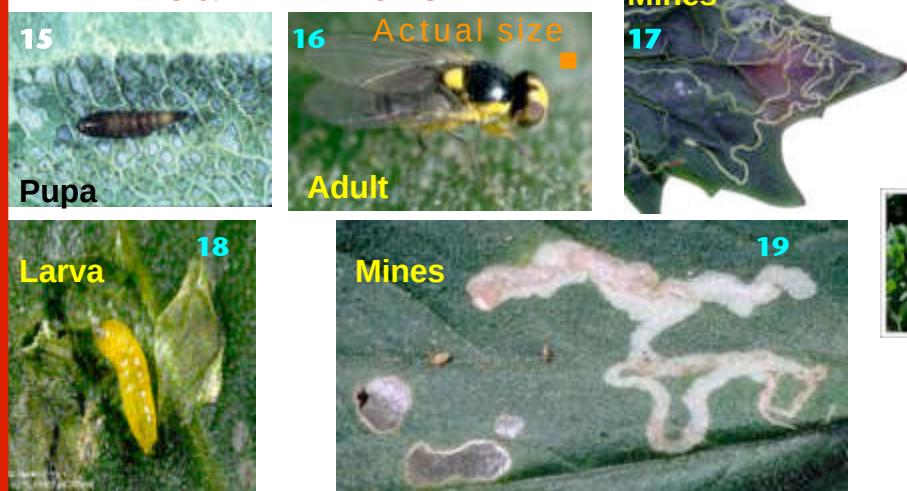
- Predators such as Lacewings, Syrphid Flies & Ladybugs
- Parasites
- Diseases



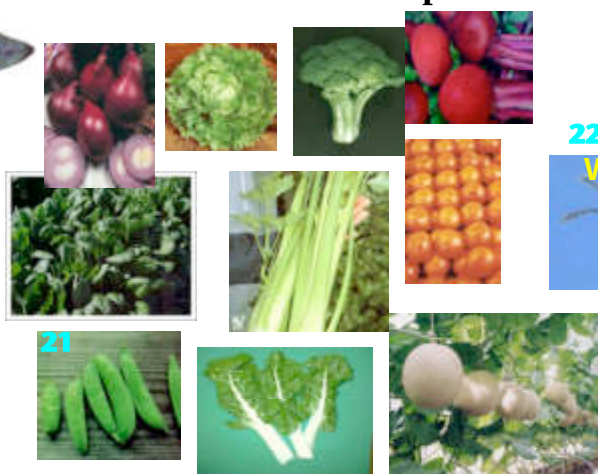
Aphid mummies, showing exit holes of parasitic wasps



Leaf Miners

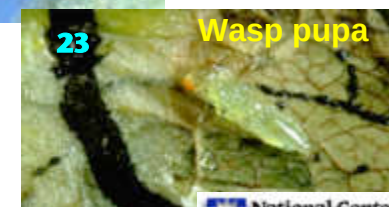


Some Affected Crops



Methods of Control

- Parasitic wasp (*Diglyphus isaea*)
- Row covers
- Don't plant next to infected crops
- Use botanical pesticides (on adults)
- Use "Neem" (for larvae)
- Sanitation
- Mulches



Important Insect Pests

9

Mites



Affected Plants

- More than 300 host plants
- 100s are cultivated crop plants
- Strawberries, cotton, peppers, chiles, tomatoes, tree fruit, & various ornamental plants

Biological Control of Mites



- Beneficial Mites
- Predators:
 - Pirate Bugs & Big-Eyed Bugs
 - Lacewings
 - Thrips
 - Ladybugs



Other Controls for Mites

- Sulfur
- Soaps
- Vegetable Oil
- Citric Acid or Lemon Juice
- Some Botanical Insecticides



Cultural Controls for Mites

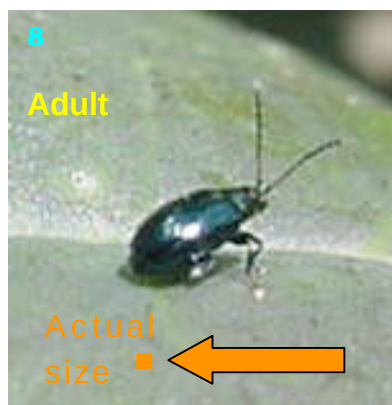
The most important practice: Eliminate dust by...

- Creating hedges and windbreaks between roads and fields
- Using cover crops or mulches and leaving crop residues after harvest
- Wetting down roads
- Giving crops sufficient moisture
- Using sprinkler irrigation
- Planting cover crops

Remember to apply only materials accepted by your certifier!



Flea Beetles



*They jump like fleas and chew numerous holes in plant leaves.
They can transmit diseases.*

Controls

- Row covers
- Beneficial nematodes
- Sticky traps located every 15 to 30 feet along the rows
- Repellents: Dilutions of garlic, onion, or chilies with water
- Botanical Insecticides

For more information, call us toll-free at ATTRA: 1-800-346-9140

Plant Diseases



Fungal Damage:
Botrytis



Fungal Damage:
Powdery Mildew



Viral Damage: Cucumber Mosaic

What causes diseases in plants?

Many times they are caused by microscopic organisms such as:

Fungi



Fungal Damage

Fungi cause soil-borne diseases such as:

- Damping off
- Root rots

They cause diseases above ground on the plant such as:

- Powdery Mildew—squash and cucumbers
- Downy Mildew—lettuce and spinach
- Botrytis—strawberries and grapes

Bacteria

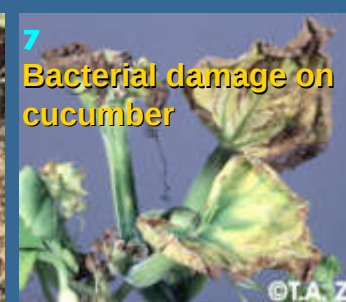


Black rot on cabbage

Bacterial wilt transmitted by



the cucumber beetle



Bacterial damage on cucumber

- Resistant varieties
- Crop rotation
- Nutrient management

Prevention of bacterial diseases

- Sanitation; removal of prunings
- Some copper fungicides
- Irrigation management
- Spacing, air circulation.

Virus



Viral symptoms on lettuce

Virus examples

- Tobacco mosaic virus
- Cucumber mosaic virus
- Lettuce Big Vein virus



Viral damage on beans

Nematodes



Root nodules caused by nematodes

Worm-like microscopic animals that live in soil and water. Some are parasites to animals and plants but most are beneficial.

Nematodes are only visible by microscope.



An ounce of prevention is better than a pound of cure.

How to prevent plant diseases.

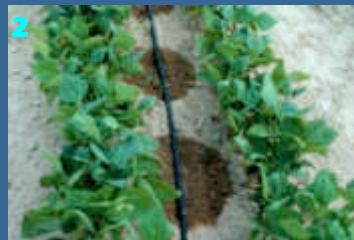
CULTURAL PRACTICES THAT STRENGTHEN YOUR CROPS

1

Good drainage:
Don't let water stand in
your field



2



Drip irrigation
provides desired
amounts of water and
nutrients,
keeping the foliage
dry and preventing
diseases.

Good air flow between plants

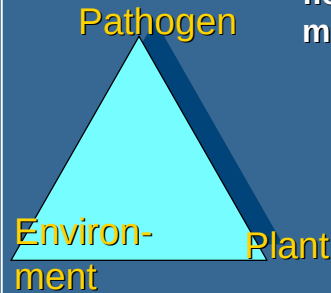


3



4

- Sanitary practices that exclude or remove pests (or residues that may contain pests) from the field or orchard.
- Selection of well-adapted varieties that are resistant to pests.



When pathogens are present in the field, damage can be reduced by manipulating one of these three points:

1. Strengthen the plant: use resistant cultivars, manage for healthy soil
2. Make environment friendlier to plant or less friendly to pathogen
3. Reduce pathogen load (crop rotation & sanitation)

SOIL MANAGEMENT: CROP ROTATION AND GOOD NUTRIENT MANAGEMENT

Crop Diversity

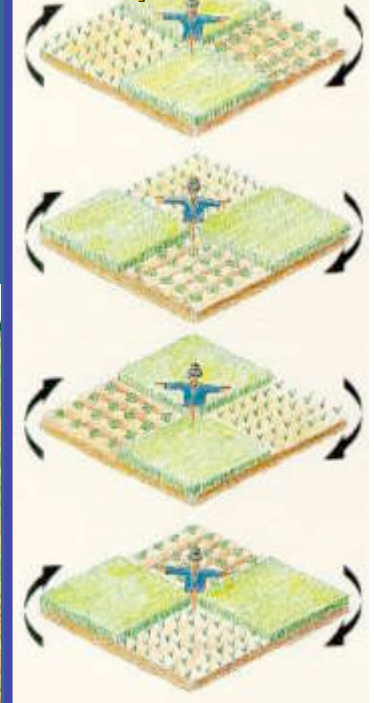


5

The wheat crop on the left followed cotton. The wheat on the right followed wheat.

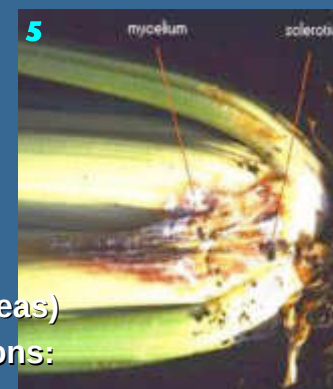


7 Crop Rotation



12 Sclerotinia or White Mold

This disease is caused by a soil fungus and its symptoms are a moist rot covered by white cottony mycelium.



Controls for Sclerotinia

- Resistant varieties
- Drip irrigation
- Rotate with grains and other grasses
- Control weeds and increase air circulation
- Solarization with clear plastic (warm inland areas)
- Biological control options:
Serenade®
Intercept®

Powdery Mildew

- Caused by one or two fungi: *Erysiphe* sp. and/or *Sphaerotheca* sp.
- These fungi primarily infect leaves & stems of cucumber, squash, melon & watermelon plants.
- Damage consists of weakening & killing the plants.



Control Options for Powdery Mildew

- Resistant varieties
- Plant in full sun with good drainage
- Don't crowd plants (this reduces air circulation)
- Don't over fertilize
- Cull infected plants or prune infected plant parts
- Irrigate in the morning
- Sulfur (garlic)
- Vegetable oil
- Bicarbonate of soda recipe:
 - 4 Tbls/ gallon of water
 - 8 drops of liquid soap per gallon
 - 4 Tbls hydrogen peroxide per gallon

Diseases: Mosaic Virus



Prevention

- Control insects that vector the virus (aphids)
 - Harvest by hand (without a knife that transmits the virus from plant to plant)
 - Wash hands
- Do not smoke

There are no controls

- Compost teas
- Yeast & sugar solutions
- Milk (10% milk/water mix or more by volume)
- Biological Controls:
Ampelomyces quisqualis
Serenade®

For more information call the
ATTRA project toll free at
1-800-346-9140

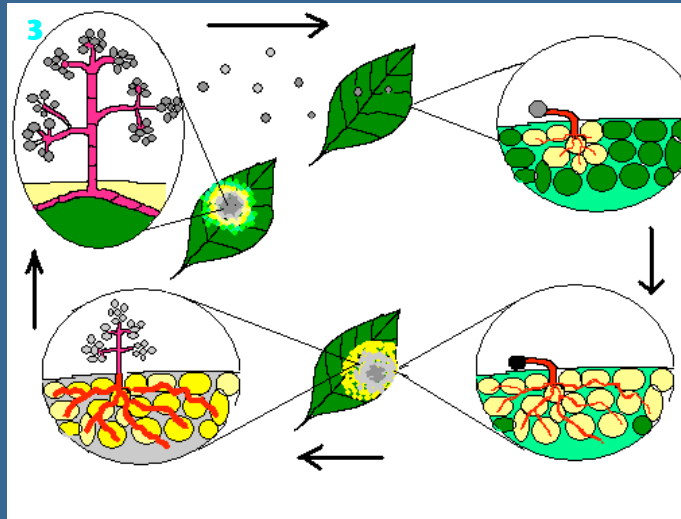
Botrytis or Gray Mold

Botrytis Life Cycle

13



Botrytis is a fungus that rots stems, buds, leaves, flowers and fruit.



Botrytis attacks numerous crops: flowers, strawberries, raspberries, grapes, apples, cherries, kiwis, pears, lettuce, asparagus, onions and many others.

Botrytis infects through wounds, preferring new tender succulent growth of stems and leaves.

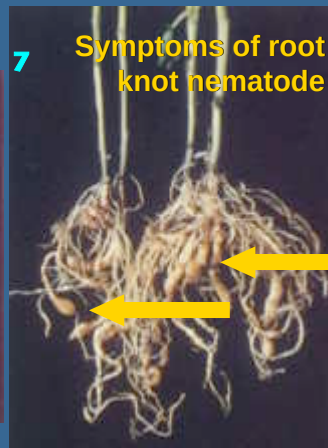
Botrytis Management Options:

- Avoid wounding plants
- Good water, drainage & fertilization management
- Good ventilation (plant spacing & leaf thinning in vineyards)
- Crop rotation
- Cull infected plants & prune plant parts
- Bicarbonate of soda
- Compost tea
- Nettle tea
- Vegetable oil
- Biological controls

Root Nematodes



Cysts of root knot nematode



Root nematodes are miniscule eel-like animals less than 1 mm long in the adult stage, only visible with a microscope. They possess a stylet that penetrates cell walls in order to absorb their content. The plant's roots form tiny nodules or cysts that are visible to the naked eye.

Nematode Controls

- Resistant Varieties
- Cover Crops:
 - Castor bean
 - Chrysanthemum
 - Sesame and marigolds
- Red plastic mulch
- Solarization

- Botanical Controls:
 - Caraway oil & seed fennel
 - mint or oregano

- Biological Controls:
 - Ditera®
 - Prospernema®
 - Deny®
 - Beneficial Nematode: *Steinernema* sp.

For more information call the ATTRA project toll free at 1-800-346-9140

14 Organic Integrated Weed Management

One Year Seeding is Seven Years Weeding



How to Prevent Weed Damage

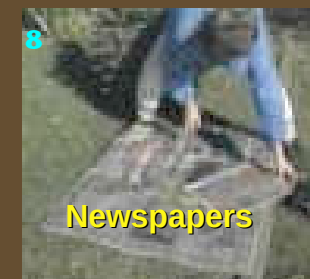
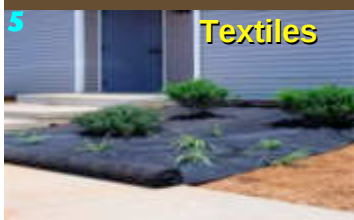
- Plant clean or certified seed
- Avoid importing manure or compost that has not been well composted or decomposed
- Crop rotation decreases the seeds of weeds that grow well with certain crops



- Remove the weed before it produces seed. It is easier to weed one plant today than 1,000 weeds next year.
- The soil is a reservoir of seeds, a seed bank.

Early weed competition reduces quality and yields

Ground Covers



For more information call the ATTRA project toll free at 1-800-346-9140.

1

Pre irrigation

Before planting, a pre-irrigation followed by a cultivation can reduce weeds.

3

Tractor mowers

4

Transplants give your crop a head start.

5

Hand hoeing weeds

2

Hand mowers

Flamers

6



7



9



8

Solarization

This works better in warm regions. Cover moist soil with 1 or 2 layers of clear plastic for 6 to 8 weeks during the summer. It will sterilize 4 to 6 inches deep, destroying weeds seeds and other pests.

Flamers on Tractors

10

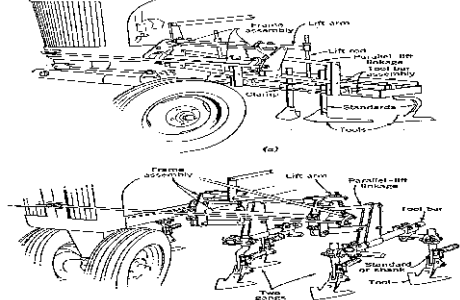


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For more information call the ATTRA project toll free at 1-800-346-9140.

1 Mechanical Cultivation



2

Implements

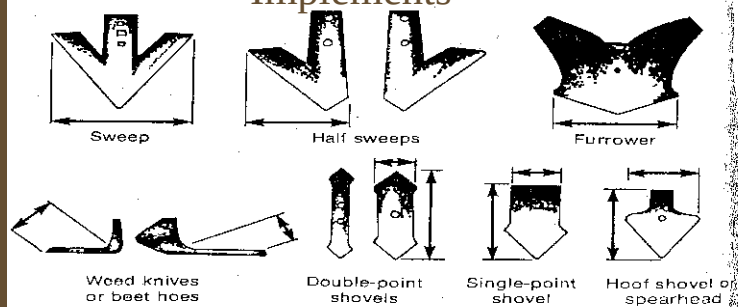


Photo: PAV Lelystad, The Netherlands

3

Lilliston



Squirrel Cages



Rotary Cultivator

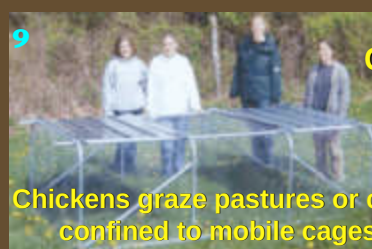


Flexible Tooth Cultivator

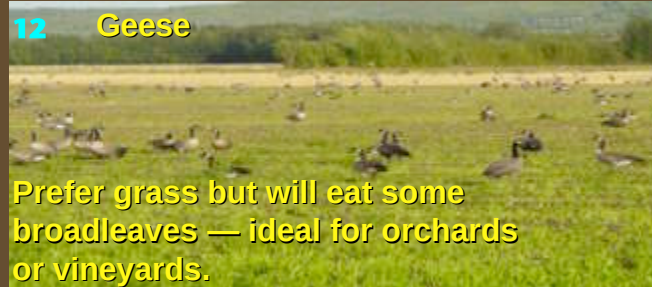


Manual Cultivators

Weed with Animals

Chickens
Chickens graze pastures or clean up after harvest if they are confined to mobile cages known as chicken tractors.

Chickens



12 Geese

Prefer grass but will eat some broadleaves — ideal for orchards or vineyards.

11 Sheep
Can be used to clean up fields after harvest13 Goats
Good for brush & noxious weed management

Gophers

Gopher Controls

- Exclusion
- Keep areas weed-free
- Traps
- Flooding (if practical)

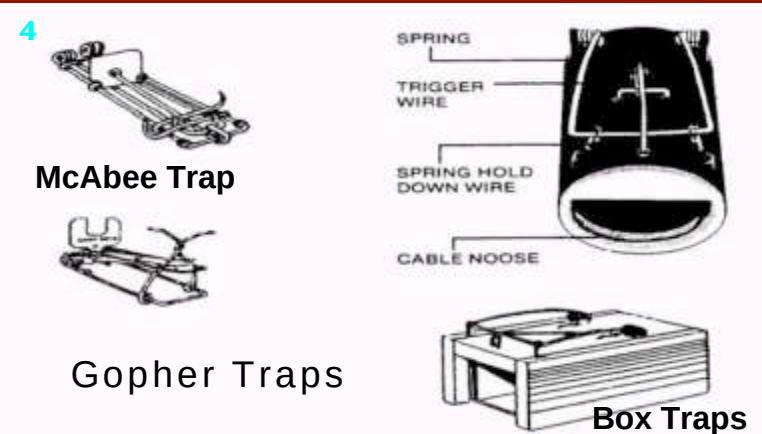
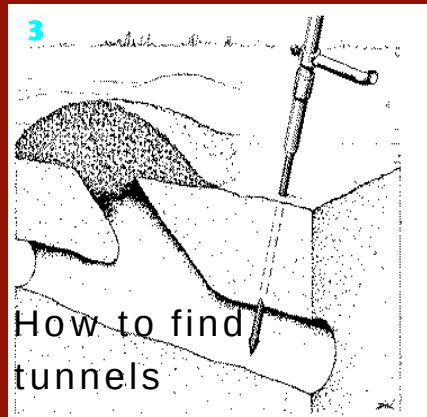
- Repellents (non-synthetic)
 - Blood meal
 - Hair
 - Rotten eggs in tunnels
 - Predator scents (urine)
- Vitamin D3 (Cholecalciferol)

PREDATION

- Birds of prey
 - Owls
 - Eagles
 - Hawks
- Coyotes & Foxes
- Snakes
- Dogs & Cats



Gopher mound

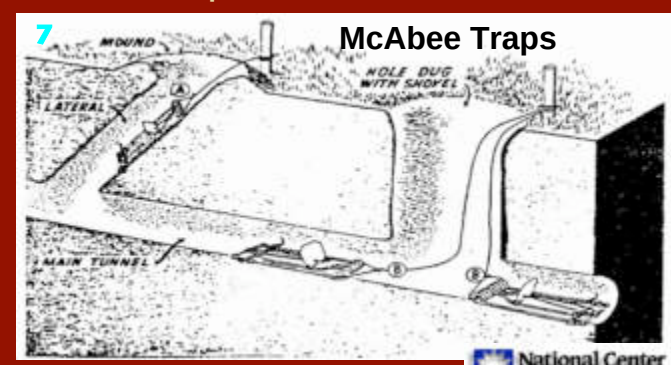
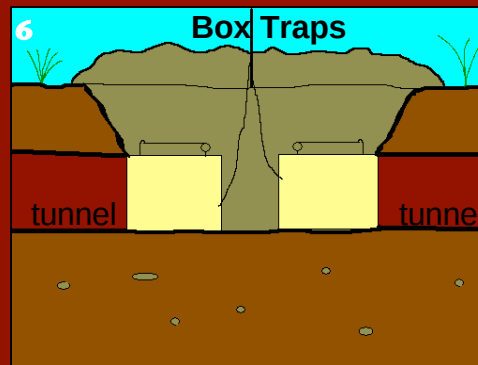


How to Place Traps



Moles dig tunnels in search of insects, they do not feed on roots.

The tunnels cause plants to dry out.



For more information call the ATTRA project toll free at 1-800-346-9140.

Owls hunt many vertebrate pests



PROTECT these nocturnal hunters

An owl can consume 155 gophers per year, and it also eats rats and mice.

A pair of owls can have a clutch of 5 to 6 chicks.

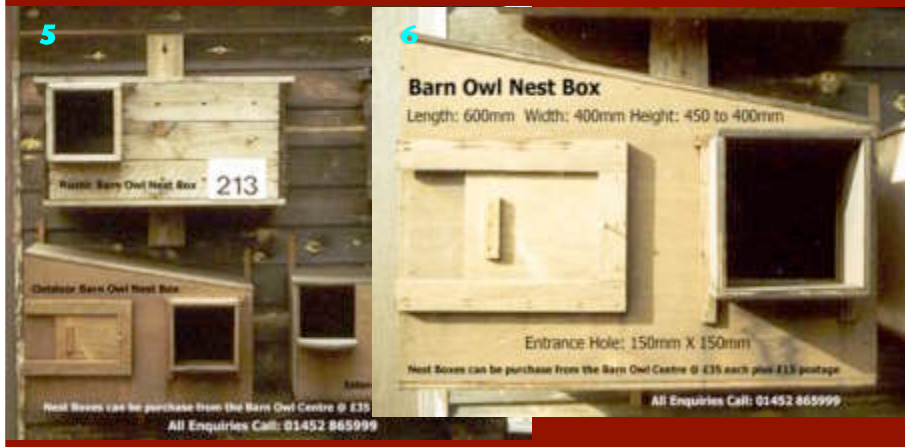
One nest for every 10 acres is needed if the problem is severe, one nest every 20 acres if the pest pressure is average.



PVC nest for owls



Box nests for owls



Owls hunt rodents:

Gophers

Rats

Rabbits & Jackrabbits

Mice

Ground Squirrels and
Tree Squirrels

For more information call the ATTRA project toll free at
1-800-346-9140.

Squirrels



Squirrel Controls

- Traps
- Repellents
- Remove obstacles like trash, rocks and tree trunks
- Pellet or squirrel gun (use with caution)
- Predators: hawks, owls, eagles, snakes, coyotes, foxes & dogs
- Vitamin D-3 Cholecalciferol

Squirrel Traps



Deer



Deer Controls

- Fencing — electric
- Row covers
- Scare devices
 - Sound
 - Lights
- High powered rifle (use with caution)
- Dogs
- Repellents
 - Rotting meat
 - Soap
 - Hair
- Repellent plants

Feral Pigs



Feral Pig Controls

- Fencing
- Hunting
- Traps
- Dogs



For more information call the ATTRA project toll free at 1-800-346-9140.

Rabbits and Hares



Rabbit & Hare Controls

- Fencing 4 feet high and buried 6 inches
- Traps
- Repellents-egg whites
- Hunting at dawn and dusk (use caution)
- Dogs & cats
- Eagles, hawks and owls
- Coyotes & foxes
- Wild cats & pumas
- Vitamin D3 (Cholecalciferol)

Birds



Nets protect against birds in this vineyard.

Bird Controls

- Scare Devices
 - Sound
 - Lights
 - Mylar tape
- Bird netting
- Row covers
- Repellents
- Shotgun (use with caution)
- Other animals



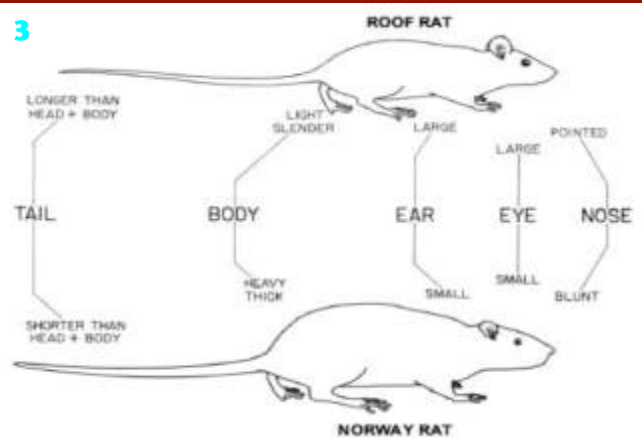
Rats



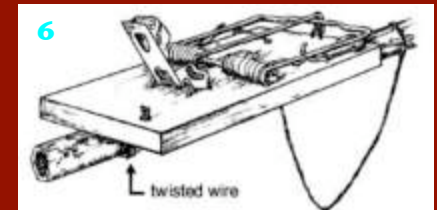
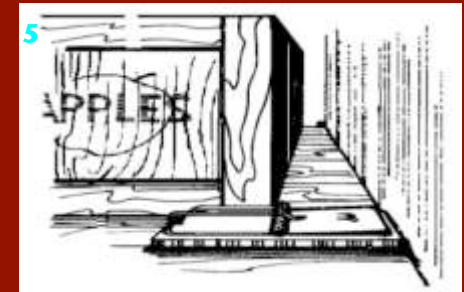
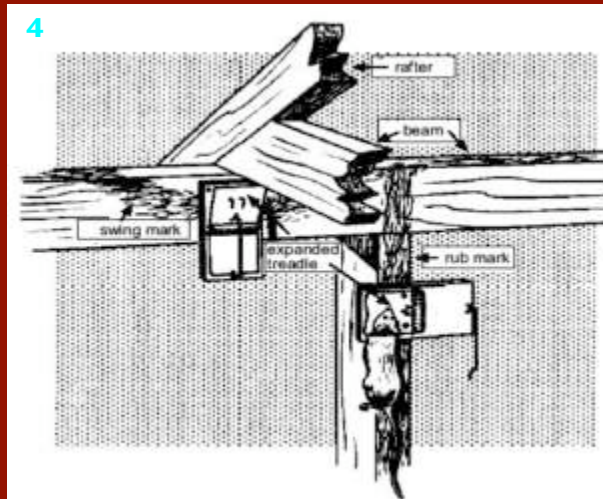
Rat Controls

- Cleanliness & sanitation
- Limit access to homes & warehouses
- Owls
- Cats
- Snakes
- Traps – place baits on trigger, using meat, nuts or dried fruits.
- Vitamin D3 (Cholecalciferol)

Differences between Norwegian rats and roof rats



How to place rat traps



Mice



Mice Controls

- Cleanliness & sanitation
- Eliminate weeds
- Fencing 1 foot high and buried 6 to 10 inches
- Traps
- Repellents
- Coyotes & foxes
- Cats
- Vitamin D3 (Cholecalciferol)
- Hawks
- Owls
- Gulls

For more information call the ATTRA project toll free at 1-800-346-9140.

Organic Integrated Pest Management for Some Agricultural Pests

Adapted from a series of workshops sponsored by
**OFRF (Organic Farming Research Foundation) and
NCAT (National Center for Appropriate Technology)**

by Ann Baier, Rex Dufour, Martín Guerena, Karen Van Epen

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