Pest Control of Spinach, Seedlings, Alfalfa & Citrus Disease
By Tim and Robert Braun

Spinach Pre-Emergence Pest Control By Tim Braun

Spinach is a major crop in the vegetable growing areas of the United States. The demand for vegetables like spinach with high levels of beneficial carotenoids, especially the antioxidant luttein, has created a large consumer market. Clearance for the use of pest control products for spinach is catching up with the increase in crop production. Spinach is listed in the Chenopodiaceae (Goosefoot) family. The other agriculturally grown vegetables in this family include beets. The weeds in the Goosefoot family of plants include pigweed, lambs'-quarters, and Russian thistle or "tumbleweed". Spinach plants grow well in many areas of the country.Spinach is grown year round in the coastal areas of California. In the southwest deserts and central valley of California and Arizona spinach is grown in the fall and winter. In the eastern area of the United States which includes New Jersey, spinach is grown in the fall, winter and spring.

It is a cool weather plant with many shallow feeder roots near the soil surface and this makes it susceptible to shallow applied herbicides. Spinach is a dicotyledon with two seed leaves. Spinach has a tap root and it is a broadleaf and this also makes it susceptible to broadleaf herbicides. There are two basic leaf types: smooth or flat and crinkled. The newer hybrids are less crinkled and smoother. The leaves are triangular, oval, round or arrow shaped. The stems are edible and are one to six inches long. With new varieties and hybrids being planted in new areas, more spinach pest control problems have increased. These pest problems include diseases, weeds, insects, and nematodes.

Before planting spinach on a piece of ground several things should be considered. The weed history of the field is very important. The surrounding crops that may carry virus infestations should be noted. Nematode infestations of previous crops should be investigated. This is especially true of sugar beets and previous crops of spinach. With the advance of new housing into rural areas any new zoning for roads or buildings should be investigated. Building equipment can create a great deal of dust that could destroy a field of spinach just before harvest. Spinach is very susceptible to herbicide residues. The plant back restrictions on any herbicides that were recently used on the field that will grow spinach should be taken into account.

The type of spinach cultivar should be chosen to overcome the various diseases that exist under the weather conditions that the crop will grow in. The time needed for land preparation should be considered. Some diseases build up as crop residues rot in a soil. Depending on weather some previous crop residues should be turned under a month or more before planting to prevent diseases like damp-off.

Nematode in Spinach

Spinach is a host for the sugar beet cyst nematode. If a field about to be planted with spinach had sugar beets that had a history of cyst nematode infestations the chances of damage from sugar beet cyst nematode should be considered. Sugar beet cyst nematode is a microscopic round worm that exists in the soil and roots of spinach. The nematode worm is pinhead size, white and oblong in the early stages of growth. They turn brown as they mature. Soil sampling for nematode infestations is the best way of being sure of the pest problem. These soil samples should be taken during the months of June through October.

Sugar beet cyst nematode activity occurs in soil temperatures above 77 degrees F. This temperature should be taken at a 4 inch depth. At soil temperatures below the 77 degree F

temperatures, spinach crops grow without damage occurring from sugar beet cyst nematode infestations. The nematode cysts and eggs can be present in the crop below this temperature, but the nematode is not active enough to damage the spinach. As soils warm up in the spring of the year, spots in the fields may have damaging infestations. This can happen in the late summer and fall of the year if soil temperatures stay above the 77 degree F level.

When I went into a partnership on a Loral air type dry fertilizer spreader with one of its founders, Al Anderson, I had a lot of growers looking at my spreading jobs done with the original demo rig from Minnesota to see how this new application technique would work in our desert agriculture. I had one field that ran down to the Colorado River on the Arizona side. I applied phosphate for this grower's field for lettuce during October. When the seedlings emerged the field showed some streaks running in the same direction that we applied the dry preplant fertilizer. Streaks of phosphate applications on seed planted crops appear where water soluble phosphate isn't applied. New seedling roots need water soluble phosphate because the new roots do not produce enough acid to dissolve the citrate soluble phosphate in the soil and the seedlings suffer causing streaks if a miss application occurs.

I had just come from a grower meeting in El Centro where one of the speakers showed slides of sugarbeet cyst nematode damage on lettuce seedlings. The streaks looked the same as the fertilizer application streaks so I and the grower checked the lettuce plant seedling roots where the fertilizer streaks had appeared. We found cyst nematode. The streaks were caused by the spreading of the nematodes when the field was disked before bedding. The weather was cooling the off and the field of lettuce wasn't harmed. The sugarbeet cyst nematode need warm soils to exist. We watched the field that following spring and fall. The nematode never came back. Now, these air applicators are all over the place and they have almost replaced the spinner and gravity Barber dry spreaders.

Infestations of sugar beet cyst nematode can take over the entire field or be located in specific areas of the field. Infested spinach plants are smaller and do not mature as rapidly as the plants that aren't infested. The spinach seedlings can be killed or emerge slowly. The yield and quality will be damaged. Sugar beet cyst nematodes are plant parasites that infest a wide variety of plants both cultivated crops and weed pests. The infested weeds are nematode hosts and are a source of infestations. Pre-plant applications of the soil fumigant Telone II is used to treat nematode infestations. Use only as directed on the label. The cultural control of this pest includes crop rotation. Crops that are hosts of sugar beet cyst nematodes include: beets, spinach, cole crops and of course sugar beets. Weeds that host these nematodes include mustards, sheperd's purse and wild mustard. Intermediate hosts are include the weeds: common lambsquarters and redroot pigweed.

Wireworms in Spinach

Wireworm larvae are hard-bodied, slender, yellow to brown, shiny and cylindrical. Depending on the species, wireworms are about 0.5 to 1.25 inches in length. The adults are tan to black beetles that are from 0.25 to 1.0 inch in length. They are called "click" beetles because when they are turned upside down they can snap and flip their bodies into the air. Wireworms eat seeds and damage roots . By feeding on rootlets, tap roots and the lower part of the stems of spinach seedlings they damage the vascular system of the plant. This stops the flow of water and nutrients to the upper portion of the plant resulting in death or stunting. The wireworm damage to the epidermal tissue of the plant will result in the entry of diseases into the plant .

Wireworms are found in every kind of soil and exist throughout the year. Wireworms can last for several years in the soil in their beetle larval stage. Wireworms are most prevalent in

fields with high levels of organic matter. Crops of turf, alfalfa, vineyards, citrus and grains leave high residues of organic matter. Reducing the crop residue and allowing enough time before planting to decompose organic matter will produce an environment where wireworm will not multiply. If possible avoid planting in cold, wet soils. Baited traps may be used to monitor wireworms. Treating the seed with Lindane and the soil with Metam fumigant or Diazinon are chemical pest control methods.

The Seed Corn Maggot

Seed corn maggots are a white, legless larvae of an adult insect is a small, light gray fly. The larvae will over winter in the soil but if the adult lays its eggs in late winter the eggs may overwinter in the soil. Three to four generations occur per year, but the first generation is economically destructive to young seedlings and seeds. Seed corn larvae bore into the spinach seed and feed on germinating seedlings. The plants yellow and die within a few days. Cool wet weather combined with high organic matter where the adult maggot can lay eggs are ideal situations for populations of maggots to establish themselves.

Avoid planting in fields with high crop residues. Allow a period of time for residues to decompose. Apply manure months before planting. All of these cultural practices will reduce the organic matter that seed corn maggots thrive in. Chemical control of seed corn maggots includes the use of the seed treatments. These chemicals include: Lindane and Lorsban. Soil incorporation of Diazinon before planting is a chemical control method for seed corn maggot. Read and follow label directions.

Pre-Plant Weed Control

Weeds are one of the major pests of spinach. Weed competition can do the following to a spinach crop: Buyers will reject the crop because they cannot sell spinach with weeds in it. Weeds in nearby fields, and on the edges of the field are a source of insect pests, diseases and vertebrate pests (rodents) .Spinach is a poor competitor against weeds resulting in loss of nutrients, water, space and sunlight to the growing crop. Harvest of a weed infested spinach crop is too costly for the grower. The crop is often destroyed.

Because of the thickness of the fast growing spinach crop, cultivation is not possible and expensive hand weeding is often required. There are weeds that are considered to be spinach production problem weeds. These include: burning nettle; little mallow; chickweed, London rocket and shepherd,s purse. There are several others, but these thrive under the same growing conditions that spinach grow in. Spinach is a broadleaf plant and so are most of these weed pests. Economical cultural and chemical types of weed control have to be managed in a year round planned program to produce the desired weed free spinach crop. If the crop is organically grown, the chemical type of weed control is replaced by costly hand weeding.

The weed management program should begin when the grower chooses the field where the crop of spinach will be grown and continues even after the spinach crop is harvested. Mapping and recording of the weeds in a field includes the conditions that caused them to grow in that field. These conditions include the weather, moisture (irrigation or rainfall), soil and air temperature, calendar dates when the weeds grow, cultural practices, soil type and so on. This also includes the name of the weeds. There are several web sites that contain pictures of weeds for identification. This type of information gives you an idea of what the field's weed seed bank contains.

This seed bank of the field can contain weed seeds that have been there for several years. Weed seeds will not germinate until they encounter specific environmental cues. This means the conditions (temperature, moisture, salt, acid, nutrition and other stimulants) will make these

specific weeds germinate.. You may have seen flushes of different weeds growing in a field where you haven't seen them before. These weed flushes often appear in fields that have recently received an application of manure.

Research has shown that the nutrient stimulation from the manure causes seeds in the field's seed bank to finally grow. In many situations the weed seeds are already in the field and the manure application doesn't put them there. Manure nutrition can stimulate the fields old weed seeds to germinate.

A good pre-irrigation can give your field a wide variation of stimulation that weeds seeds might like. If there are several weeds after pre irrigation the field may need an application of a contact herbicide like Paraquat or a systemic like Roundup before you disk them. With the slower acting Roundup there can be a build up of diseases like
Rhizoctonia that can infect the spinach seedlings. A waiting period after applying Roundup will allow the disease to run its course before planting.

Spinach is sensitive to Balan, Glean, Gallery, Prowl, Treflan, Kerb, and Prefar. The labels on all of these products will give you the length of time needed for these herbicides to dissipate before planting your spinach crop. There are plant back label instructions that can reduce the plant back period by plowing. Always read the labels.
There are a limited number of herbicides used in spinach weed control. California allows growers to use Ro-Neet which is incorporated before bedding or applied on the beds after they are formed. Ro-Neet can be applied after planting and before emergence and incorporated with sprinklers.

The fumigant Metam Sodium can be applied pre-plant by injection or sprinkler irrigation. Glyphosate (Round Up) can be applied to weeds that have emerged after pre irrigation. Pelargonic Acid a contact herbicide can be applied to weeds that have emerged after pre-irrigation.

Pre-plant Disease Control

One type of pests often overlooked is soil-born diseases. These are treated before a crop is planted. As with most diseases, the pest control for spinach is done on a preventive basis. Usually the seed has been treated for soil-borne disease. Soil-borne diseases that infect spinach include: pythium, rhizoctonia, Phytophthora and fusarium. They are present in fields for years and only infect the plants when conditions are favorable for their growth. These soil borne diseases are parasites that exist in the soil in different forms: spores and hardened tubes or mycelium masses. When a source of food is available these parasites come out of their dormant stage and begin feeding. Healthy fast growing crops with strong root systems grow away from these diseases. Slow growing emerging spinach seedlings have weak tender roots that the parasitic fungus disease can penetrate. Spinach seeds that are slow to germinate soften and can be penetrated by the parasitic diseases. Crops like spinach that are planted and grown in cool moist soils are susceptible to these diseases. These diseases grow best under these conditions. We manage these diseases in our normal growing practices which include: planting in soils with good drainage, leveling and irrigating so that flooding doesn't occur, crop rotation and choosing cultivars that are resistant to these diseases.

Cultural pre-plant weed control includes:

1.) Field selection. Weed free fields or fields that have been planted to cool season crops and have been observed without weeds.
2.) Sanitation. Try to keep weeds from going to seed.
3.) Rotation. Follow crops that have had a low amount of weed problems.

4.) Land preparation. Uniform beds that allow cultivation and well tilled fields (no clods) where herbicides do their best job.
5.) Solarization. In warm areas this technique will control several weed species.
6.) Pre-irrigation. Encourage as many weeds as possible to emerge and destroy them before planting.

Pre-Plant Fungicides For Damping Off Diseases

Buy spinach seed that is treated.
Ridomil Gold is sold in two formulations:

The emulsifiable concentrate, Ridimil Gold E, is registered for spinach. It can be applied to the soil only and can be incorporated or injected with liquid fertilizer. It can also be banded over the row.

A granular formulation of Ridomil is registered for use in spinach as a soil application only. It can be pre-plant incorporated or pre-emergence.

Do not use in greenhouses. Always read the label.

Acknowledgements:
Authored by University of California faculty, specialists, and farm advisors, produced and edited by IPM
Education and Publications, University of California Statewide IPM Program. Guidelines Coordinator: Barbara
Ohlendorf; Technical Editor: Mary Louise Flint.

"/PMG/selectnewpest.spinach.html"
Trujillo, Linda Speaking of Spinach , Master Gardener
Monterey County Managing Diseases for the Rapidly Increasing Spinach Industry
http://www.ipmcenters.org/cropprofiles/docs/NJspinach.html
Crop Profile for Spinach in New Jersey

SPINACH POST EMERGENCE PEST CONTROL

Spinach sold for the fresh vegetable market has to be free of any contaminants. The contaminates include weeds, discolored leaves, dirt from dust and insect pests. Even beneficial insects are considered to be a contaminate when found in harvested fresh spinach. Beneficial insects that form webbing and pupate on the leaves contaminate spinach. The aphid dead bodies found after beneficial wasps have laid their eggs in them are considered a contaminate of fresh spinach.

Green Peach And Potato Aphids

There are two major aphid insect pests that affect the spinach crop. The potato aphid and the green peach aphid. The potato aphid is a larger aphid than the green peach aphid and it is not as active on spinach as the green peach aphid. The body of the potato aphid is longer than the green peach aphid and can be pink or green. The potato aphid can be found in colonies with the green peach aphid or by themselves. Potato aphid adult occur alone or with clusters of young aphids with them.

There are several differences between these two aphids. Aside from the fact that potato aphids are larger than green peach aphids the other body part that is different is the tubercles of the two aphids. Tubercles are found inside the base of the aphid antenna. The tubercle of the potato aphid slope to the outside and the green peach aphid tubercles converge toward one another. The green peach aphid colonies tend to start at the bottom of the plant whereas the potato aphids are found all through the plant. The green peach aphid is green unlike the potato

aphid which can be green and pink. Of the two aphids the green peach is more of a problem on spinach. Both aphids when in high numbers stunt the spinach and will contaminate the crop. Green peach aphids carry some viruses that can affect spinach.

The green peach aphid reproduces asexually and sexually. Most of the green peach aphids reproduce asexually. Asexual reproduction occurs when females give birth without mating. Sexual reproduction in aphids occurs when male and female mate. The result of asexual reproduction is a great many active aphids in a very short time period. The young aphids grow to adulthood in 4 to 5 days.

With their piercing sucking mouthparts the aphids stick their mouthparts into the plant tissue and sucks out the plant fluids. This is usually into the phloem that carries the spinach life supporting sugars to vital growth areas of the plant. This can cause stunting and plant deformity. During this feeding process the green peach aphid can be inserting virus diseases. While feeding on the plant in this manner the aphid produces large amounts of excrement. This excrement produced by the aphid, called honey dew, is dropped onto the leaves causing fungus and molds to grow. The result is a contamination of the spinach that cannot be shipped to market.

When monitoring for aphids the edges of the field should be checked for aphids. The aphids first appear on the edges of the field. They will sometimes be found in the edges of bare spots within the field.

There are beneficial insects that feed on the aphid. Certain wasps insert their eggs into aphids that produce larvae that kill the aphid. A fungus, *Entomophthora aphidis*, can kill some of the aphid population. The beneficial enemies are not numerous enough to protect the kind of spinach production needed by today's growers.

The organic control methods include insecticidal soap sprays. Cultural control methods include tents or covers and controlling nitrogen excesses. Aphid populations multiply on spinach plants that contain excess nitrogen. Monitoring the soil for excess nitrogen with soil nitrate quick tests will determine nitrate excesses immediately. Soil nitrate levels for spinach become excessive when they test over 100 to 120 parts per million.

The use of the following insecticides have been approved for spinach: Diazinon in different formulations, Dimethoate, and Thiodan. Admire can be applied pre-plant. Read and follow label directions.

Leafminers Adults hatch from pupa in the soil. They mate and lay their eggs in the leaf tissue of spinach. The larvae hatch and continue growing and feeding between the upper and lower parts of the spinach leaf. The tunnels inside the leaf made by the leafminer are referred to as leaf mines. The larvae grows inside the mines. In the process the mines are enlarged. At maturity the larvae cut a hole in the leaf and either pupate on the leaf forming a pupal case or in most cases the larvae drop to the soil and pupate in cracks in the soil.

This leaf burrowing damage results in a reduction of the spinach plants photosynthesis. The leafminer larvae leaves fecal matter in the leaf mine. This contamination reduces the market value of the spinach. Leafminers are usually not a problem, but like any other pest they can multiply under the right conditions. When the small spinach seedlings have four to five leaves with high populations of leafminer, control measures may be necessary.

There are natural predators for the leafminer. Because the leafminer live inside the leaf, predators are limited in their control of them. Parasite wasps can insert eggs into the leafminer larvae then the hatched wasp larvae kills the leafminer larvae.

Disking recently harvested adjacent fields that had high populations of leafminer will reduce the pest.

The chemical control includes: Agri-Mek 0.1.5 EC (Check with your farm advisors because of limitations on this product). AgriMek will kill the leafminer larvae in the leaf.; TriGard is a growth regulator that is effective against leaf minors. The product called Neemix only kills the leaf minor pupae. It does reduce future populations. Neemix in a restricted use product for organic farming

There are certain insecticides that kill the predators of the leafminer. The loss of these predators of leafminer can cause economic damage to the spinach crop. Insecticides that can kill the predators of leafminer include: Lannate, Pounce and Ambush. The use of these pesticides should be limited to high or damaging infestations.

Cabbage Looper (caterpillar)

This is one of the major pests of spinach. Cabbage looper can show up in harvested fresh vegetables and they also inhabit fresh harvested spinach unless controlled. The holes that cabbage looper make in spinach leaves and the fecal matter produced by them reduce the marketability. Cabbage looper are green in color with a narrow white stripe along each side. They have several white lines on their backs.

. When looper caterpillars move across a surface they form a loop with their body by arching their back. The adult is a brown winged moth with mottled front wings. Cabbage looper has a small silver figure like an 8 on its wings.

The eggs that cabbage looper adults lay are on the bottom of the older spinach leaves. These eggs are dome shaped. The looper eggs start out white but get darker as they approach hatching. The looper eggs have a surface with light ridges. The corn earworm has the same dome shape, but it has deeper ridges on the egg surface.

Corn Earworm

The color of corn earworm is variable with stripes. Corn earworms have one or two prominent hairs on their back. On the backs of corn earworms are rows of nodules or swellings that are referred to as tubercles. When corn earworm eggs are first laid they are white. Then a dark red to brown colored ring forms around the top of the corn earworm egg. The egg will turn dark just before the egg hatches.

Cutworm

There are three types of cutworm that feed on spinach. Black greasy cutworm larvae have black bumps or tubercles on each segment of their body. The black greasy cutworm has a greasy gray to brown color. Tunnels in the soil are made by the black greasy cutworm. The tunnels in the soil are where the black greasy cutworm takes the plants that it cuts off above the soil.

The granulate cutworm does not make tunnels in the soil like the black greasy cutworm and it has a variety of skin colors that are lighter than the black greasy cutworm.

The larva of the variegated cutworm is yellow to brown with four to six diamond shaped spots on its back. These spots are in a line and they are dull yellow and pink colored.

The front wings of the adult are dark gray or brown with irregular spots or bands. The hind wings are of a lighter color.

Beet Armyworms

The adult beet armyworm lay their eggs in groups of 50 to 75 eggs. They cover these eggs with white scales from their bodies. The egg mass then looks like a cotton mass. The larvae that hatch are green in color with light colored bands on their back and a broad stripe down each side. While the young larvae is feeding they will spin a web over themselves on the underside of the leaf.

The young armyworm begin feeding together but as they mature they feed alone. They

can travel to many plants causing damage and contamination. Their entire life cycle can last 36 days in 80 F. degree weather.

Western Yellow Striped Armyworm

Even though the western yellow striped armyworm is an occasional pest in spinach it will make itself known by the large amount of damage that it can produce. The western yellow striped armyworm has an entire lifespan of around 54 days. Adult
17 days; egg 4 days: larva 18 days; and pupa 15 days.

The adult western yellow striped armyworm lays 200 to 500 eggs in masses covering them with body scales. The larvae can grow to be one and a half inches long or more. The color of the larvae is black with two lines of yellow stripes down each side. The larvae will skeletonize the plants, but they may consume the entire above ground parts of young plants. Western yellow striped armyworm can do this in a very short period of time.

Caterpillar Pest Control

The above army worms, cut worms, corn earworms and loopers are classified as caterpillars. Biological control of caterpillars includes the wasp parasites. Caterpillars are susceptible to virus diseases.

The cultural controls for caterpillars include destroying host weeds near the spinach fields. By disking the harvested fields caterpillar worms, pupae and eggs are destroyed.

When monitoring fields for caterpillars the period right after the spinach seedlings first emerge from the soil is a critical period. Check for egg masses. Try to have most of the eggs hatched before making applications of any pesticide. Fields with emerging seedling should be monitored twice per week.

Chemical control includes the following: Bts, Bacillus Thuringiensis (Dipel, Thuricide and many other formulations). Bts are bio pesticides that when eaten by the caterpillars produce a toxin that kills. Bts can produce spores in the caterpillar body that multiply and cause septicemia that kills the larva. This material is easy on predators. Bts are very specific and Bts can be used by organic growers. The younger the larva the better the control with Bts.

Lannate is a carbamate insecticide and nematicide. Lannate is both a contact and a systemic insecticide. It is a stomach poison.

The permethrins Pounce and Ambush are contact and stomach poisons. The same precautions on leaf minors applies to these two chemical pesticides.

Success (spinosad) gives a quick knockdown of caterpillars. Effective on armyworms when they are small. Success has to be eaten by the larvae to be effective. Success has low toxicity to predacious insects.

Confirm is a insect growth regulator. This insect growth regulator is safe to use where predacious insects are needed. Confirm is long lasting, but new growth should be treated. To prevent insect immunity the label says: “Not to be used on more than 3 generations of a pest.”

Caterpillars must feed on the pesticide Larvin. It is a weak contact killer. It is an oxime carbamate inceticide/ovicide. When spinach has dense foliage and there is a heavy infestation of caterpillars the higher label dosage is required for control.

Diazinon is an organophosphate insecticide. Diazinon is both an insecticide and miticide. Being a stomach poison as well as a contact pesticide Diazinon can control caterpillars when eaten or when applied to their bodies.

Spinach Crown Mites

Spinach crown mites damage new leaves at the heart of the plant. The spinach crown mites are very small and transparent. The damage of crown mites is outgrown by the spinach

plant unless the plant is growing slowly. Crown mites can injure the plant to the point where diseases can infect the spinach. Dust will dry out the spinach plant and allow spinach crown mite to multiply.

When high populations of crown mites occur and predators are not able to control them, miticides are available. The pesticides that are available include: Agri-Mek; Thiodan and Neemix.

Damping Off Disease

Damping off disease is usually overcome with the use of disease resistant spinach plants, seed treatments and preplant soil treatments. Damp off can occur throughout the growth of the spinach crop. The disease is caused by several soil fungi including: Fusarium, Pythium and Rhizontonia.

Post emergence control of damp off disease is controlled by good water management. Never let water stand in the field. Excess water can cause the same damage with or without a fungi pathogen. The damage includes grownd water soaked roots with some top plant curling of the leaves. Damp off damage to mature plants can cause stunting and death.

Downy mildew

One of the most important diseases in spinach is the downy mildew or blue mold. Spinach does well in cool, damp conditions. These are the same conditions that downy mildew does best in. The spinach is grown during the fall, winter and spring months when conditions are usually cool. The damp weather is provided with sprinkler irrigation systems when rain isn't available. The spinach itself provides plenty of humidity with its lush growth of leaves.

The first signs of an infection by downy mildew are yellow spots on the leaves. These spots become darker and dry out. Spores form on the bottom of the leaf that have a blue cast to them.

Within the spinach downy mildew species there are many variations that infect newly produced spinach plants that are resistant to the older disease species.

When treating for downy mildew in spinach, applications should be made before the mildew appears. Once the field is infested efforts to contain it and control are almost impossible. Ridomil Gold/Copper) WP as a foliage application has been effective against downy mildew in spinach. Aliette 80 WDG can be used as an alternate to reduce mildew immunity to other treatments.

Anthracnose

Applying prevention copper sprays to spinach fields likely to be infested with anthracnose is the only recommended chemical spray. The post emergence prevention efforts of controlling anthracnose include reducing the use of excess sprinkler irrigation.

Other diseases that infest spinach include: Cladoporium leaf spot and Stemphuylium leaf spot. Both of these diseases have been treated with the preventative copper fungicides, but when the infection is severe copper fungicides are ineffective.

Colors of the infection spots can be used to distinguish these spinach diseases.

Downy mildew has purple spots. Anthracnose has black fruiting bodies inside circular spots. Cladoporium has dark green spots. Stemphuylium has circular tan papery spots.

Post Emergence Spinach Weed Control

There are two herbicides that can be used post emergence on spinach. The herbicide, Spin-Aid, can only be used on spinach grown for processing or seed. Spin-Aid is a contact herbicide that controls some of the broad leaved weeds and grasses in spinach. Apply when the seedlings are small. Some damage can occur to the spinach.

Poast a systemic herbicide that is specific for grasses can be used until 2 weeks before harvest. Poast may also result in some damage to the spinach. Poast will not control annual bluegrass.

Acknowledgements:
http://www.ipmcenters.org/cropprofiles/docs/NJspinach.html
www.ipm.ucdavis.edu/PMG/selectnewpest.spinach.
Nick Laminski *Grower Solutions Magazine"http://www.lefroy-valley.com.au/"*
Biology-Pages.Info Kimball's Biology Pages

Spinach Pesticide Application
By Tim Braun

Pre-plant Pesticide Application

Fumigants should be used for pest control when other methods have been found to be ineffective. There are three fumigants approved for spinach pest control. Clean Crop Metam Sodium (sodium methyldithlocarbamate anhydrous), Telone II (1,3-dichloropropene) and Inline (1,3-dichloropropene w/ chloropicrin)

The fumigant, Clean Crop (Metam Sodium), is used to control soil borne diseases, nematodes, symphylids (garden centipedes) and many weed species. (Refer to label). Metam Sodium is a water soluble liquid. After it is applied to the soil, the liquid becomes a fumigant (gas) that can control target pests. The fumigant dissipates in a period of time and a spinach crop can be planted in the treated soil.

Metam Sodium can be applied in irrigation water. The label has specific instructions on the application of Metam Sodium by sprinkler, drip and flood irrigation. The following information is taken from the Clean Crop (Metam Sodium) label. The entire label must be read and understood by the applicator before use of this product..
Metam Sodium can be applied mixed in liquid fertilizers. It can be injected, disk applied, with rotary tillers or power mulchers. The label rate for metam sodium is from 40 to 100 gallons per acre. The rate is based on the texture of the soil. The heavier the soil the more Metam Sodium needed. Organic soils require the higher rate per acre. The concentration of the pest population will determine the need for high or low gallons per acre. The rate per acre should take into account the volume of soil treated.

The application method used to mix the material in the soil will decide how much volume is being treated. The condition of the soil should be tilled to break up any clods. The soil moisture content should be adequate to form a ball in the hand that breaks up easily. The soil should be from 40 degrees F. to 90 degrees F.. Temperatures above 90 degrees F. will result in product loss due to gas escape. Vegetative residue in the soil should be reduced by allowing enough time for organic matter decomposition. Heavy organic soils will require higher rates. Application through a sprinkler over an existing cover crop is approved on the Metam Sodium label.

The sealing of Metam Sodium in the soil after application can be done with a light sprinkling of water. If the material is sprayed on top of the soil and worked into the soil rollers should be used to seal the soil. Tarping over the treated soil will help prevent gas escape of the applied Metam Sodium fumigant.

Shut off sprinkler applications when high winds occur. The water in the spray mist will contain enough Metam Sodium to injure surrounding emerged crops. If strong odors occur

during or after application the application should be stopped until the source of the odor is found and corrected.

The personal protective equipment for handlers and applicators is explained in detail on the Clean Crop Metam Sodium label and other approved labels.

Telone II is another approved liquid soil fumigant that can be applied preplant to spinach crops. It controls nematodes, centipedes and some plant pathogens. Telone II is not recommended for weed control. California requires the use of Telone II Ca. The label restrictions on application have differences to the standard Telone II label. Read and follow all label directions.

Telone II and Telone II Ca cannot be used through irrigation systems. Telone II and Telone II Ca must be injected to a depth of 12 inches or more below the soil surface. The chisel marks from injection must be sealed by destroying them with ring rollers, mulchers or by re forming the beds over them. This is done to prevent loss of Telone II to the atmosphere. Tarps to further seal the soil can be used, but the injection marks must be destroyed before covering the soil with tarps.

The rates of Telone II should be 12 gallons per acre in mineral soil. When applying Telone II to muck or peat soils the rate can be increased to 25 gallons of material per acre. Telone II should only be applied when the soil temperatures are between 40 degrees F. to 80 degrees F.

The soil fumigant, Inline, is a liquid preplant fumigant used in spinach production. Inline is used to control parasitic nematodes, centipedes, wireworms and some soil borne pathogens. Inline fumigant can only be applied to the soil through surface or buried drip tape. Tarping is required and should be kept in place for period of 14 days.

Inline cannot be mixed with other chemicals such as fertilizers or weed killers. The rates for Inline on spinach are 13 to 20.5 gallons per acre in mineral soils. Inline is not recommended for peat or muck soils. Read and follow label directions when applying Inline to Spinach.

RO-NEET 6-E is a liquid formulation herbicide used to kill weeds in spinach. It can be applied pre plant to spinach crops in California. RO-NEET is not approved for use on spinach in the state of Arizona. RO-NEET is taken up by the seed and shoots of germinating weeds. It stops germination of the seed and shoot development. It will not control established or germinated weeds. RO-NEET 6-E is a product of HELM AGRO US, INC. Use only according to the recommendations of the RO-NEET 6-E label. RO-NEET 6-E has a CAUTION word label.

In California RO-NEET 6-E should be applied broadcast on the soil at the rate of 2/3 of a gallon material per acre in 10 to 50 gallons of water with a boom sprayer set at 20 to 50 pounds pressure per square inch .

RO-NEET 6-E should be incorporated to a mixing depth of 3 inches in the soil in California. *Soil incorporation implements have different operating depths with their own individual mixing depths. Be sure to rely on the mixing depth not the operating depth of the implement for the soil incorporation of herbicides*.

RO-NEET 6-E can be combined with water, liquid fertilizer or impregnated on label specified dry fertilizer. When applied in water RO-NEET 6-E must be incorporated into the soil immediately.

When applied in liquid fertilizer, RO-NEET 6-E must be incorporated into the soil within 4 hours of application. When applied impregnated on dry fertilizer RO-NEET 6-E must be incorporated into the soil within the same day of application. If the soil is damp or wind conditions are over 15 MPH, incorporation of RO-NEET 6-E applied in liquid fertilizer or

impregnated on dry fertilizer must be incorporated immediately.

RO-NEET 6-E can also be incorporated into the soil for spinach with irrigation sprinklers in California, Idaho, Nevada, Oregon, Utah and Washington only. According to the RO-NEET 6-E label, the soil surface should be dry and free from dew or incidental moisture to a depth of at least 1/2 inch before application. The RO-NEET 6-E can be applied before or immediately after planting. Start sprinkler irrigation immediately after application. Incorporation should be completed within 36 hours after application using enough water to penetrate to a depth in the soil of 3 to 4 inches.

Band application of RO-NEET 6-E can be used for spinach by reducing the rate from the amount needed for the band width compared to solid coverage. This can be done by reducing the number of injection shanks. An example would be: use 4 injector shanks per row for a band of 10 to 12 inches and 6 injector shanks for a band of 15 to 18 inches. Shanks should be set 2 1/2 to 3 inches apart and set to inject RO-NEET 6-E at a 1 1/2 to 2 inch depth. Shanks should be staggered to avoid trash build up. To protect the seed, place shanks 1 1/4 to 1 1/2 inches on either side of the drill row.

The RO-NEET 6-E label has directions on how to, how much and what kinds of fertilizer to mix or impregnate when applied to spinach.

Ridomil Gold EC or Ridomil Gold Gr when applied as a soil application will control the diseases: damping off, white rust and downy mildew. Pre plant applications of Ridomil Gold EC Liquid or Ridomil Gold Granules can be made to spinach crops. The Ridomil EC can be mixed with water or liquid fertilizer then applied to the surface of the soil at the rate of 1 to 2 pints per acre. The granule formulation should be spread onto the surface of the soil at a rate of 20 to 40 pounds per acre. Both materials should be incorporated and mixed into the top two inches of soil.

Ridomil granules should not be allowed to contact the planted spinach seed. If the Ridomil granules or EC formulation is not mechanically incorporated when applied at planting, the Ridomil can be moved into the seed zone after planting with a sprinkler irrigation of 1 to 1 1/2 inches.

Both the granule and liquid formulations of Ridomil can be applied in bands to the soil surface. The width of the bands of Ridomil applications should not be less than 7 inches. The labels for both Ridomil G and Ridomil EC have formulas for the rates recommended at different band widths in the **General Information** section of the label. Admire 2 Flowable Insecticide and Admire Pro can be applied to spinach, but not for use on spinach grown for seed unless allowed by state-specified supplemental labeling. The directions on the labels allow the application with ground or chemigation methods. Do not apply Admire 2 Flowable Insecticide or Admire Pro with aerial application equipment. To be effective applications of Admire should be placed in the areas of the spinach seed or root system. Admire should be placed where it will stay in an aqueous solution within the root zone of the plant.

Add water to the mix tank. Then add Admire while agitation is occurring. Keep mixture agitated to prevent settling of the Admire. When mixing with other materials, add water; add wettable powders, then Admire and other flowable materials and then emulsifiable materials last. Always confirm the label use of any added pesticide or nutrient before mixing with Admire. Test a small amount for compatibility.

Admire mixtures can be applied with pressure sprayers in a narrow band directly below the seed row in the bedding operation. With the planting operation Admire mixtures can be sprayed directly below or on the seed. A narrow band (2”or less) of Admire mixture can be sprayed over the seed line during planting then incorporated within 24 hrs. with sufficient

irrigation to a depth of 1 to 1 1/2 inches of water. Admire mixtures may also be applied pre plant through the method of chemigation into the root zone through low-pressure drip, trickle, micro-sprinkler or equivalent equipment.

Post Emergence Pesticide Applications On Spinach

Up to two sidedress applications of Ridomil Gold G or Ridomil Gold EC at a rate of 5 pounds per acre for the control of White Rust and Downey Mildew is allowed.. Ridomil EC can be used at a rate of 1/4 pint per acre. The Ridomil EC can be applied with water or liquid fertilizer. The first application for White Rust and Downey Mildew should occur 21 days after planting or after the first cutting. The additional sidedress application can be made after the next cutting of the spinach.

SPIN-AID is a selective herbicide for use in spinach that is grown for processing or seed. Applications of SPIN-AID should be made when temperatures are below 75 degrees F. in order to prevent possible injury. Do not apply SPIN-AID through any type of irrigation system. Read and follow label directions to avoid injury to the spinach crop, the plant back crop and any neighboring crops. Do not add additional wetting agents or other spray adjuvants to SPIN-AID. Add sufficient water to fill the lines. Then add the desired amount of SPIN-AID and the remaining quantity of water. By pass agitation is sufficient. Prepare only enough spray solution to last less than four hours. By Ground: Apply 3 to 6 pints per acre in 11 to 22 gallons of water through a broadcast basis. By Air: Apply 3 to 6 pints per acre in 5 to 20 gallons of spray per acre.

Aliette WDG should be applied by air or ground equipment to the foliage of spinach at the rate of 2.0 to 5.0 lbs. per acre in not less that 10 gallons of water per acre. Adding surfactants or foliar fertilizers to Aliette WDG is not recommended. An alkaline buffer like Diammonium phosphate added at 5 #s to 5#s of Aliette WDG or potassium carbonate added at 3#s to 5 #s of Aliette WDG can be used to raise the spray solution to pH of 6.0. Do not exceed seven applications per season or apply within 3 days of harvest

POAST may be used for the control of grass weeds in spinach. Poast should be applied at a rate of 1.5 to 3.0 pints per acre, 15 days before harvest applied by air or ground. The label has thorough directions on how, when and where Poast is to be applied to spinach. The label recommends the use of some specific additives to be used with POAST.

These application mixing instructions apply to most of the approved pesticides for spinach pest control:

Air And Ground Application

!. Fill the mix tank to a recommended level with water before adding the pesticide.

2. Mix no more pesticides than needed for the immediate operation.

3. Thoroughly clean spray equipment before starting the spray operation.

4. Agitate the mixture before and during the spray operation. In some cases the label will require mechanical agitation.

5. Flush the spray tank daily after use.

6. Apply rinsate to the site that has already been treated.

Always have an approved label with local use amendments available when applying pesticides. Read and follow label directions for all pesticides.

Acknowledgements:

http://www.cdms.net/pfa/LUpdateMsg.asp Various Labels

http://www.ipm.ucdavis.edu/PMG/selectnewpest.spinach.html

UC IPM Online University of California . Agriculture and Natural Resources

How to Manage Pests Spinach

Authored by University of California faculty, specialists, and farm advisors, produced and edited by IPM Education and Publications, University of California Statewide IPM Program. Guidelines Coordinator: Barbara Ohlendorf; Technical Editor: Mary Louise Flint. http://www.ipmcenters.org/cropprofiles/docs/NJspinach.html

SEEDLING PEST CONTROL By Tim Braun

History, scouting, cultural, biological, chemical, species and crops.

Sweetpotato Whitefly, Bemisia tabaci Bstrain (Silverleaf Whitfly, Bemisia argentifolii

History

On a worldwide basis for the study of whiteflies there a over twelve hundred species of whiteflies. According to the history of the silverleaf whitefly it was found in the united States in eighteen ninety seven on some sweet potatoes and is referred to as the potato white fly. It became a serious pest in the United States and Mexico in the nineteen eighties. The speculation of where the insect came from centers around the importing of ornamental plants. India gets credit for the area where it started. Poinsettias grown in green houses in Florida were invaded by the pests in the years of nineteen eighty six and by nineteen ninety one the silverleaf whitefly had spread to the agricultural areas of Georgia, Louisiana, Texas, New Mexico, Arizona and California. The United States Agriculture and ornamental industry has incurred plant damage of over a billion dollars due to the silverleaf whitefly.

In 1990 the whitefly was found to cause a silvering of the leaves of infested cucurbits and was named the squash silverleaf disease and a yellow blotching or streaking on tomatoes that caused the infested tomatoes to ripen unevenly. Since then the whitefly population has also increased in the population levels of infestation. Scientists have decided that there is another strain of the whitefly insect. The name for this new strain is “silverleaf“.

The adult has its yellowish body and wings covered with a white powdery wax. It is one to one and a half millimeters (about six hundreths of an inch long). The wings are held in a tilted position over their backs like a roof without meeting and the wings have a space between them. A similar whitefly, the greenhouse whitefly has wings that are flatter over their backs and do not have a space between their two wings. I mention this difference because when scouting whiteflies they are similar but have slight differences. Greenhouse whitefies are not as damaging to seedlings. Another whitefly that is similar and easier on seedling crops is the banded winged whitefly that has brownish bands across their wings.

The female silverleaf whitefly lays fifty to four hundred eggs on the underside of the leaf into the plant stomata or on a cut made by female’s ovipositor. Eggs are oval shaped and about two tenths of a millimeter long (about the size of a pinhead). They are yellow and attached to the leaf surface. Eggs darken in color as they get ready to hatch. Time required before hatching is five to seven days. Both adults and eggs of Silverleaf Whitefly are found on the underside of young leaves and the scale like nymphs are found on the underside of older leaves. The male silverleaf whitefly emerge from eggs that are unfertilized and haploid. The female emerge from fertilized eggs and are diploid. Bees, ants and wasp males are also born from haploid eggs that are not fertilized. Diploid cells have two copies of chromosomes whereas haploid cells have one copy of chromosomes.

The first yellowish instar nymphs of Silverleaf Whitefly are mobile wingless crawlers with antennae and legs and move about until they find a minor vein to feed on. These first instar nymphs lose their legs and antennae during their first molt. Then they become immobile for the next four instars and remain fixed to the leaf surface. The 3rd and fourth instars of the

Sweerpotato Whitefly nymph have red eyespots. They are referred to as “redeye” nymphs. They pupate after the fourth instar. Even though whitefly have an incomplete life cycle and do not pupate they do form a pupae case and their young are called nymphs instead of larvae. The pupae case is dome shaped and seven tenths to eight tenths of a milimeter in length. The edges of their pupae case tapers down to the leaf surface and the surface of the pupae case has very few long waxy filaments unlike the greenhouse and banded-winged white fly pupae that have numerous long waxy filaments around the edge that is almost vertical where the edge comes in contact with the plant leaf. The Silverleaf Whitefly life cycle takes as little as 16 days in warm weather and two months in cool weather.

Their damage includes sucking out the carbohydrates and amino acids of the plant. This heavy feeding by the whitefly stunts the seedling growth and it causes a bleaching in the stems and leaf petioles. They destroy the chlorophyll and reduce photosynthetic activity. They can and do cause desiccation of leaves and plant death. They exude honey dew producing sooty mold that reduces the photosynthesis activity of the young seedlings. .

Noting the general size of the population and the use of sticky cards are used for scouting silverleaf whitefly infestations. Sample for Silverleaf Whitefly early in the morning when the adults are sedentary. Scouting the field edges will find the population size because the edges of fields are where infestations of silverleaf whiteflies begin. The underside of the leaf is where the whiteflies congregate. This is especially true for the nymph populations. Scouting may indicate that treating the edges of the field can be all that is necessary.

Because the silverleaf whitefly was brought to this area (the predators do not exist in this area); therefore the predators that are active against this pest are not adequate to prevent damage to the crop. The predators that do attack the silverleaf whitefly include the wasps, Encarsia and Eretmocerus, and bigeyed bugs, lady beetles and lacewing.

Control by cultural methods include: planting in cooler weather; if populations are known to exist in the area try to plant susceptible crops a half mile upwind of the known field; remove or destroy infested crops, weeds and crop residues.

If a decision to treat is made the use of combinations of pesticides may have to be applied because of the immunity that sillverleaf whiteflies have acquired for several known pesticides. Combinations include: Capture (pyrethroid) plus Thiodan (cyclodiene) or Orthene (organophosphate), or Lannate (methymyl). For light populations Capture and Thiodan can do the job, but for moderate to heavy populations of silverleaf whitefly the combinations should be used. Instead of the above combinations the use of the neonicotinoids (Admire) or Assail can be used as preplant applications. Other materials that are used include: insecticidal soap, Narrow range oils, Combinations of Brigade and Movento. or Actara, or Oberon. Always follow label directions.

The systemic pesticide developed by Bayer and named Admire has been one of the most effective pesticides used for control of silverleaf whiteflies. A patent for imidacloprid was filed in January of nineteen eighty six in the United states. The patent was granted in May of nineteen eighty eight. The pesticide has many trade names but the name “Admire” is the most common name used for it. It interferes with the nerve impulses of insects by binding with nerve receptors. It translocates moving in the xylem of the plant from the roots where it is taken up to the leaves, pollen, fruit and nectar. It can also be applied to the leaf surfaces where it enters the leaf for insects that feed on plant leaves. Aphids and silverleaf whitefly are two of its target insects. The pesticide binds to the nicotinic receptor and stimulates a nervous reaction that commonly occurs in the insect, but it doesn’t stop and continues until the stimulation of the nerve cells cause the

death of the insect. Because admire binds to insect neuron receptors more strongly than to mammal neuron receptors it is selectively more toxic to insects than to mammals.

When silverleaf whitefly became a definite problem insect during the early nineteen nineties in the Arizona and California desert fields the University of Arizona's extension service came to the rescue with in-field test plots using Admire. Two of the researchers were D. L. Kerns and J. C. Palumbo. Their publication of this work came out in nineteen ninety five. There work on application methods found out that the soil applied pesticide had to be placed in the soil where it had to stay in a aqueous solution that the plant root system could have access to for it to be effective. The crops they worked with included the lettuce and cole crops which are very numerous to the Yuma area. The root systems of both plants are concentrate in the frame area of the plant. Applying the material before planting with injection blades that release the material (Admire) in the seed bed between the two rows of seed and at a depth that is one and a half to three inches below the seed puts the material in the aqueous solution area of the planted bed of the crops. This is done, of course, before planting the seed or on the equipment that plants the seed. This method is used on crops have two rows of vegetables per bed row. For crops like cauliflower where the seedling is transplanted the Admire is injected below where the transplant plug is placed. When Admire is applied over the seed line and irrigated in with overhead sprinklers pre-emergence of the crop. The application of Admire should be applied before irrigation in bands of two to three inches over the seed lines. Irrigations with the sprinklers should be made within twenty four hours after application. The University found that using row irrigations instead of sprinklers didn't work. Applying Admire by sidedressing didn't do the job because of the root pruning done with the shanks when sidedressing the Admire.

Admire can also be applied through drip irrigation. The emitters should be placed so that the base of the seedling plants receives the material. The material injected in the system should be allowed to clear the last emitter in the drip irrigation system. When the last emitter has ejected the Admire stop the injection. The intensity of silverleaf whitefly populations is so great that the University of Arizona does not recommend that Admire be used below elevations of seven hundred feet between May first and October first without applying foliar adult insect pesticides to help control the immense populations on the fully grown crops.

The researchers state that white fly control can be expected to last anywhere from thirty to fifty days with these methods of application. Green Peach aphid control was maintained for a period of one hundred days. Winged forms of peach aphids will be found after these treatments, but they do not colonize. The presence of adult whiteflies and eggs on crop cotyledons that have been treated with Admire is a sign of the delay in uptake of the Admire. Wait for the three leaf stage before treating the field and adults may enter to field after the field has been treated. Examine the plant to see if the adults are dead or alive and check with a hand lens for eggs and nymphs. Research has shown that treated fields will have ten or fewer eggs and five of fewer nymphs or immature insects. While untreated plants will have twenty to eighty eggs and thirty to forty immatures. Maintaining an untreated spot in the field will tell you if the treatment is working or not.

Just because yields of crops have increased with the applications of Admire doesn't indicate that Admire is a plant growth regulator. If the whitefly and aphid are not present in the crop and Admire is applied yields will not increase. Admire only controls insects. It is not a plant growth regulator. Admire like any other control substance will eventually produce pest populations that become immune to it. The use of alternate pesticides should be used when white fly populations are low. This practice will extend the use of Admire as a pesticide.

Field Crickets, Gryllus spp., are annual pests with eggs laid in damp soil. Nymphs and adults are present throughout the growing season in mild weather. The adults are black or brown and they are 0.5 to 1.0 inch in length. When crickets are in large numbers they can reduce stands of vegetables. They feed on the emerging seedlings. Even though crickets will lay their eggs on the field where they become a problem they usually migrate from nearby cotton or Sudan grass fields. The edges of the fields are first to suffer from their feeding.

Field Crickets feed at night and during the day. They can be found in cracks in the soil or under leaves and sprinkler pipes. Populations are difficult to monitor. When they are a problem the damage is the only way to tell when they are present; therefore constant checking of emerging crops is necessary. When experience indicates high-risk fields have been planted, treatment of field crickets should take place when the crop seedlings first emerge. This is a precaution against loss of stand.

Darkling Beetles, Blaspstinus spp. are similar to crickets in that they feed on and destroy emerging vegetable seedlings. They are about a 1/4 of an inch in length. They are shiny dark black or brown with the tips of their antennae slightly enlarged or clubbed.

The Ground beetle, Carabids, is often mistaken for the Darkling beetle because they are the same size and colored black, brown or reddish. Their antennae are not enlarged at the tip. Ground beetles are predators. They will however uncover seeds and damage emerging seedling while digging in the soil for insects and this makes them seedling pests.

Rove Beetles, Staphylidids, are another predaceous beetle that creates the same damage to emerging vegetable seedlings while exploring for insects. Rove beetles are less than a 1/4 inch in length. They are shiny dark black or brown with short elytra covering their wings, but their abdomen is not covered. When Rove beetles are excited they elevate their abdomens taking on the appearance of scorpions. Again these beetles are very hard to monitor without discovering some type of feeding damage. Close field checking is required and where a history of presence has occurred preventive treatment is necessary.

Wireworms, Limonius spp., eat seeds and damage roots. They will also bore into underground growing crops like carrots, radishes and potatoes. By feeding on rootlets, tap roots and the lower part of the stems of vegetable seedlings they damage the vascular system of the plant, which stops the flow of water and nutrients to the upper portion of the plant resulting in death or stunting. The wireworm damage to the epidermal tissue of the plant will result in the entry of diseases into the plant . Wireworms are found in every kind of soil and exist throughout the year. Wireworms can last for several years in the soil in their beetle larval stage. Wireworms are most prevalent in fields with high levels of organic matter built up by plantings of turf, alfalfa, vineyards, citrus and grains.

Wireworm larvae are hard-bodied, slender, yellow to brown, shiny and cylindrical. Depending on the species Wireworms are about 0.5 to 1.25 inches in length. The adults are tan to black beetles that are from 0.25 to 1.0 inch in length. They are called “click” beetles because when they are turned upside down they can snap and flip their bodies into the air. Because the damage symptoms can occur suddenly, monitoring for this insect is difficult. Plant stands are reduced and seedlings appear yellow, diseased and dead. Where wireworms have been a pest in the past or where the previous crop residues are a problem pre plant treatments of the soil may be needed.

The trapping technique consists of digging a hole 2 to 3 inches deep and 6 to 9 inches wide at the soil surface. Place into the hole a half cup of an equal mixture of untreated corn and wheat seed which has been presoaked for 24 hours prior to use in order to facilitate germination

of the seed. Fill and slightly mound each station with soil. Cover each mound with an 18-inch square of black polyethylene plastic (appropriately sized trash bag) topped with a 1-yard square sheet of clear polyethylene or similar clear plastic bag. Cover the edges of the plastic layers with soil to hold them in place. The black plastic layer absorbs heat and the clear plastic helps retain heat in the soil, thus allowing for more rapid germination of the bait seed.

Carbon dioxide is produced during the germination process and attracts wireworm adults to the bait. Just prior to planting, remove the plastic layers and soil from the bait and count the number of wireworm larvae in and around the bait. If the average number of wireworm larvae collected in all bait stations located in the field average one or more per bait station, the economic threshold has been exceeded and treatment is justified. An average of one wireworm per station is equivalent to 40,000 wireworm larvae per acre.

Cutworms, Agrotis ipsilon, Peridroma saucia, and Feltis subterranea

Cutworm adults are mid sized, brown or gray with spots and light hind wings. Depending on the species they lay eggs by the hundreds singly or in clusters. These eggs are laid on leaves and stems close to the ground. Cutworm adults will also lay their eggs on any form of organic matter . This occurs when the only growing plants in the field are emerging seedlings. After hatching the larvae feed on the organic debris or the plant that they were deposited on. During the day the larvae hide under the debris of the organic matter or soil clods and come out at night to feed on the growing plants. They cut off the seedlings of young plants at or just under the soil level. The larvae are 1/2 to 1 inch in length. They are gray or mottled brown. When disturbed cutworms react by immediately curling up.

Constant monitoring of the young emerging seedlings for wilted or partially wilted plants that are cut off at ground level is the best method of finding cut worm populations. Sometimes they will only occur at the edges of fields but when there is abundant organic matter in the field they may be present throughout the field. Cutworms feed out from where they hatched. This method of feeding forms circular patterns of damage.

Beet Armyworm, Sodoptera exigua (Hubner)

Beet armyworm adult moths have a wingspan of 1 1/4 inch. The beet army worm moth has grayish brown forewings and a pale spot in the mid front margin. The hind wings are white with a dark anterior margin. The adult will lay an average of 500 to 600 eggs over a four to ten day period. These eggs are laid in masses of 50 to 75 eggs. The Beet Armyworm moth covers the eggs with white scales from her body. This gives the egg mass a cottony appearance. The eggs are light green when first laid and then darken before they hatch in about 2 to 5 days. The larvae are olive green in color. Beet armyworms have light colored stripes down the back with a broader stripe down each side. They have a dark spot above the second true leg on each side of the body. The larvae have five instars and grow to a length of 1 1/4 inches in length.

The young beet armyworm larvae will spin a web over them on the underside of the leaf when they first start feeding. When in the first instars they feed together then they disperse feeding as individuals. The larger beet armyworms are very mobile and will feed on several plants before they pupate. Their larval stage lasts for 2 to 3 weeks in warm weather. The entire life span of a beet armyworm is about 36 days in 80 degree F. weather. Young seedlings can be entirely consumed by beet armyworms. More often they stunt or kill the seedlings. Monitoring the young seedlings often will let you know when to treat. As eggs darken you know that the hatch is near. When a high percentage of eggs have hatched spraying of the young 1st and 2nd instars are most effective as a control measure

The Seedcorn Maggot, delia platura, is a white, legless larva of an adult that is, a small, light

gray fly. The larvae will over winter in the soil or the adult may lay eggs in late winter. Three to four generations or seedcorn maggots occur per year. The first generation is economically destructive to young seedlings and seeds. Seedcorn maggat larvae bore into and feed on the seed and germinating seedlings. The plants yellow and die within a few days. Cool wet weather combined with high organic matter where the adult maggot can lay eggs is ideal situations for populations of maggots to establish themselves.

Salt Marsh Caterpillars, Estigmene acrea,

The adults have white to yellowish colored wings with many black spots. They have a wingspan of around 2 inches. They lay their eggs in clusters of twenty or more on the leaves of the host plant. The Salt Marsh Caterpillar larvae are 2 inches long with yellowish brown bodies covered with red and black hair. They are often called wooly bear caterpillars. As they migrate across the field Salt Marsh Caterpillars devour the entire young emerging seedlings . On full-grown plants they skeletonize the leaves as they feed through them.

Vegetable Leafminer Liriomyza sativae, are prevalent in seedling vegetables in the late summer and fall and the leafminer, liriomyza trifolii, attack young seedling vegetables in the spring. The two have subtle differences in color between the adults. Knowing that the trifolii is prevalent in the spring and that sativae are dominant in the late summer and fall is a form of identification used. L. trifolii is more resistant to pesticides than the L. stivae. Another form of identification is the use of phermone sticky traps that attract the leaf minor by species.

The adult leafminer is the size of an eye gnat. The adult leafminers are flies that are shiny, black and yellow. They have a yellow triangular spot on the upper thorax between the wings. Both male and female leafminers feed at puncture sites. Several puncture sites are made. The female will deposit her eggs in some of these puncture sites. Eggs hatch within a few days after being laid. The larvae feed on the plant mesophyll tissue just below the upper surface of the leaf. As the leafminer larvae mine through the leaf they leave a trail of their fecal matter that forms easily identifiable lines throughout the leaf. After completing three instars the larvae emerge from the leaf and drop to the ground where they
pupate. Adults emerge from the soil in a period of 7 to 25 days. The entire life cycle is complete in 3 weeks if temperatures are in the 85-90 degree F. range. This means that many generations can be produced in a year's time.

Damage of leaf miners consists of reduced photosynthesis when chlorophyll is removed by the mining of the leafminer larvae. The leafminer mines between upper and lower leaf surfaces creating winding tunnels that are initially small and narrow, but increase in size as the larvae grow. Mines and feeding punctures provide entrances for disease systems to infect the plant. In seedlings most of the mines occur on the cotyledons and the first true leaves. When seedlings only have three to four leaves and most of them are mined treatment is usually recommended. If plant-growing conditions are good, the vigorously growing seedling can tolerate high populations of leafminers and treatment can be avoided

Cabbage Looper, Trichoplusia ni, is found year round and is a special problem in the fall planted vegetable seedlings in the desert. The spring and summer build up of populations of cabbage loopers are at a peak period in the fall and can be very destructive, but the cabbage looper can be a problem in any mild temperature zone.

The moths of cabbage looper are mottled brown in color. Cabbage loopers have a small silvery spot near the middle of its front wing resembling a figure eight. This is unique to the cabbage looper. The cabbage looper moth lays single dome shaped eggs on the underside of leaves. One cabbage looper moth can lay as many as 275 to 350 eggs. Eggs darken as they hatch

which takes about 2 to 5 days.
The larvae of the cabbage looper are light green in color with a white stripe down either side. This color makes them often hard to find in a green salad. Unless they move. The larvae of the cabbage looper have two sets of legs in the front of the body and three sets of heavier, unjointed prolegs at the rear of their bodies. This allows them to move in a looping movement, arching the leg less middle of their body as they move forward. They go through five instars in two to four weeks.
Cabbage looper pupae are brown in color, wrapped in a white cocoon of fine threads. The cocoon is found attached to the underside of a leaf. The cabbage looper pupation stage lasts 10 to 16 days. They have 3 to 5 generations a year.

Thrips, Western Flower Thrips, Frankliniella occidentalis. Onion Thrips, Thrips tabaci.

Thrips are present all year, but they build up during warm spells.
The stages of metamorphosis for thrips are egg, two larval stages, prepupae, pupa, and adult. This is classified as being between a simple and complete metamorphosis.

The eggs are small, white and bean shaped. Thrips eggs are laid in plant tissue and hatch in 2 to 7 days. Nymphs are paler in color, smaller in size and without wings when compared to the adult thrips. Otherwise they resemble the adult. Nymphs have four instars that take 15 to 30 days. The two later instars are spent as pupae in the soil or litter beneath the plant where they do not feed.

The difference between the flower thrips and the onion thrips should be known because the onion thrips are very easy to control when compared to the western flower thrips. The western flower thrips has many color forms and is difficult to define. The female has color ranges from light yellow, yellow with brown blotches on the body, to dark brown while the male western flower thrips is light yellow.
The onion thrips female body is yellow with brown blotches on the thorax and abdominal terga with legs that are yellowish brown. During warm temperatures the light colored onion thrips adults predominate over the brown forms which occur during cool temperatures. The immatures of both western flower thrips and onion thrips are generally light yellow in color. The western flower thrips have eight-segmented antenna while the onion thrips have seven segmented antenna. The onion thrips antennal segment I and the base of segments III to V are brownish white. The rest of the onion thrips antenna are brown. The onion thrips have gray colored ocellar pigmentation and the western flower thrips have reddish orange ocellar pigmentation. In the United States there are no onion thrips males and the onion thrips reproduce asexually through parthenogenisis.

The length of the adult western flower thrips is about 1/20 in. while the onion thrips are smaller at 1/25 inches in length. Another method of identification is the use of sticky traps. These can be placed on the field margins when the light intensity is moderate-high and temperatures exceed 63-65 degree F. Small plant seedlings can be checked for thrips by examining the folds in the leaves of the plants. Researchers say that if 3-5 thrips are found on a plant there are probably 3 times as many hidden in the folds in the leaves.

Thrips feed by making a hole in the epidermis with a single mandible. Then they puncture the cells with their maxillary stylets and suck the sap that oozes out. When slow growing seedlings are fed on in this way they become wrinkled. If the weather is warm enough for the seedlings to outgrow this damage, treatment is unnecessary. If cool weather persists and thrips continue to feed control methods may have to be applied.

The feeding causes brown scarring that has a scorched or speckled appearance. Leaves

dry out and drop from the plant. This damage can be mistakenly diagnosed as wind burn or blown sand damage, but it can be distinguished by the black specks caused by thrips fecal matter scattered over the burn area. Usually this damage is evident after the thrips population has reached its peak and does not require treatment.

The use of trade names in this course is solely for the purpose of providing specific information. It is not a guarantee or warranty of the products named, and does not signify that they are approved to the exclusion of others of suitable composition. Use pesticides safely. Read and follow directions on the manufacturer's label.

Acknowledgements:

http://www.sel.barc.usda.gov/whitefly/wfframe.htm
http://en.wikipedia.org/wiki/Silverleaf_whitefly
http://ucce.ucdavis.edu/files/repositoryfiles/ca4506p10-69573.pdf
http://ag.arizona.edu/crop/vegetables/insects/wf/admire.html
http://www.ipm.ucdavis.edu/PMG/r114300311.html
http://www.ipm.ucdavis.edu/PMG/crops-agriculture.html
W. E. Chaney, UC Cooperative Extension, Monterey Co. M. LeStrange, UC Cooperative Extension, Tulare Co. *Spinach Insects and Mites* UC IPM Pest Management Guidelines: UC ANR Publication 3467
Johnson, F. A. and Stansly, P. A. *Insects That Affect Vegetable Crops* Florida Cooperative Extension Service/ Institure of Food and Agricultural Sciences / University of Florida June, 1995, Date Revised September *, 2001*
Palumbo, J. C. Rev. 8/oo. *Management of Aphids and Thrips on Leafy Vegetables*. Cooperative Extension, College of Agriculture and Life Sciences, University of Arizona, Tucson, Arizona
Palumbo, John C. & David L. Kerns *Melon IPM : Southwestern USA* Department of Entomology Yuma Valley Agricultural Center University of Arizona Yuma, AZ 85364

Alfalfa Pest Control By Tim Braun

Where do all the beneficial insects come from? A great deal come from alfalfa fields. Researchers say that alfalfa is an insectery for beneficials in the Central Valley of California. This source of predacious pest control is not only good for the alfalfa crops, but the surrounding crops gain from this treasury of beneficial animals including birds that consume cutworms. Sweep an alfalfa field in almost any area and see how many different predators are out there.

In the cool weather of late winter, the weevil and aphid infestations multiply. The cool weather of late winter keeps population levels of predators down. However predators like the wasps do not tolerate extreme heat and dry conditions. This is thought to be why the larva of the alfalfa butterfly increases in numbers and lowers alfalfa yields during dry hot conditions.

Alfalfa Caterpillars Also Referred To As Alfalfa Butterflies

In 1996 which was a very hot year in New Mexico and Texas it was reported that a large outbreak of alfalfa caterpillars resulted in an estimated yield reduction of 1/2 ton per acre in alfalfa fields. In the California and Arizona deserts alfalfa caterpillars appear in the summer months after the weevils and aphid populations have been reduced by hot weather. Alfalfa butterfly larva damage alfalfa by eating the entire leaf including the veins. They do not skeletonize leaves like the beet army worm or cause flagging where the terminals dry and turn whitish gray. They can and do defoliate fields. If the alfalfa caterpillar infestation occurs after the plants are half grown early cutting will avoid some of the yield reduction.

The alfalfa caterpillar has a complete life cycle consisting of egg, larvae, pupa and adult

stages. The white American football shaped eggs are 1/16 of an inch long. They are laid singly standing on their end on the top surface of the alfalfa leaves. Brown alfalfa caterpillar larva with black threads and legs hatch in 3 to 10 days. The larva skin surface is hairy and velvety green in color with a white stripe on their sides as they grow to a length of 1 ½ inches. Alfalfa larva grows through 4 instars in about two weeks depending on weather conditions. The pupa are formed and hang by silken threads from stems or can be found on top of leaves. These alfalfa butterfly pupa are gray green and turn yellow just before the adult butterfly emerges. The adult alfalfa butterfly is 1 inch in length and has a wingspan of 2 inches that is white or yellow in color. The adults feed on flowers, mate and begin laying eggs usually on alfalfa shoots that are less than 6 inches tall. The life history from egg to adult alfalfa butterfly is synchronized with the number of days between cuttings. There are 4 to 7 generations depending on the weather. The alfalfa butterfly will over winter in the pupa stage in the alfalfa or surrounding weeds emerging as adults in late spring or early summer.

There are several natural predators of the alfalfa caterpillar as well as natural pathogens. Damsel bugs, big-eyed bugs and spiders will consume the eggs and larva. Parasitic wasps, Trichgramma, inject their eggs into the larva of alfalfa butterfly. Natural pathogens, bacillus thuringenisis, infect the larva bodies that become limp, dark colored and hanging from leaves. Alfalfa butterfly cultural control includes cutting the field early.

Sweeping th field with conventional sweep nets is used to monitor the fields for treatment. When 5 to 10 healthy unparasitized alfalfa butterfly larva are found in a hundred and eighty degree sweep, treatment is recommended. BTs (Bacillus thuringenisis) and Malathion can be used at a 0 day post harvest spray. Other pesticides include: Sevin, Lorsban, Baythroid, Warrior, Lannate, Pyrethroids and Pencap-M. Follow label directions for any use of Pesticides.

Beet Armyworm

A common pest of California and Arizona alfalfa is the beet armyworm. Alfalfa is a prime source of predators and pathogens that control armyworm; therefore the army worm only becomes a problem every few years when the natural enemies are limited by weather or other conditions. From spring through the fall months beet army worms produce at least five generations. Beet armyworms go through a complete life cycle including eggs, larva, pupa and adult. The eggs are greenish or pinkish, striated with white cottony material deposited in egg masses on the top of to alfalfa leaves. After a few days larva emerge from the hatched eggs. Beet armyworm larva are smooth skinned, have a yellow stripe down both sides of the olive green to dark colored body. Beet armyworm grow to a length of 1.25 inches in 2 to 3 weeks.

The larva feed on the tips of plant stalks causing the terminal leaves to turn white. This whiteness of the plant tips is called flagging. Beet armyworm skeletonize the leaves. Beet armyworm eat the leaf material between the leaf veins. This beet armyworm feeding in clusters causes the green field to have white tattered spots known as “whitecaps“. The “whitecaps” are visible across the field. The larva continue to feed and the “whitecaps” come together to give the entire field a tattered look. If the larva begin feeding when the height of the alfalfa is short the loss of yield is very severe.

When using a sweep net check the field twice a week early in the season. Take 180-degree sweeps in several places in the field. If the count of nonparasitized armyworm larva is 15 or more and the field won’t be cut for 10 to 15 day’s treatment is recommended. Materials for treatment of beet armyworm in alfalfa include Steward, Lannate, Xntari and Agree. Early cutting without treatment is used if the field is ready.

Western Yellow Striped Armyworm.

Like beet armyworms the western yellow striped armyworms are a pest problem that occurs only every few years. It is reported by Bisabri-Ewshadi and Ehler (1981) that 96% mortality occurs by predators on the egg and early larval stage.

They have a complete life history. Western yellow striped armyworm go through a complete metamorphosis with eggs, larva, pupa and adult stages. Western yellow striped eggs are laid in masses on top of leaves and covered with the grey scales from the adults' bodies. Yellow striped armyworm egg masses can contain 200 eggs or more. Eggs hatch in three to five days. The larvae or worms are black with two large bright stripes plus many narrow ones down both sides of the worm. The larva have as many as six instars in a period of 14 to 20 days. Yellow striped armyworm reach a length of 1.5 to 2 inches. The last larva instar drops to the soil surface and burrows just below the soil surface to pupate. The pupal stage can last 9 to 22 days during the summer months. As winter and cool temperatures approach the western yellow stripe armyworm will over winter in the pupa stage. The adult is a brown moth that mates and lays eggs.

Skeletonizing the alfalfa similar to the beet armyworm is the form of damage caused by the western yellow striped armyworm. The feeding is in patches that can reduce the yield when the predator population is low. Most of the time the predators and pathogens that are abundant in alfalfa control the western yellow striped armyworm . Using the sweep net in the same manner, as when sweeping for beet armyworm and using the same count, 15 or more nonparasitized larva, is a monitoring method for treatment. If the net count is 10 or more of a combination of nonparasitized alfalfa caterpillar, beet armyworm and western yellow striped armyworm treatment is recommended.

Cutworms in Alfalfa

In alfalfa cutworms are often declared an occasional pest, but they can be damaging when conditions are right for their survival. Alfalfa grown on beds are more likely to get cutworm damage. Alfalfa fields that are flood irrigated will drown cutworms. This is why birds like Egrets, blackbirds, ibis, gulls and others are attracted to alfalfa fields that are being irrigated during daylight hours. The flooding waters drive the worms from their soil hiding areas to the borders and high spots in the field. Rolling sprinkler irrigated fields are subject to cutworm damage because less water is applied.

In California and Arizona the two kinds of cutworms that are pests in alfalfa are the variegated and the granulate. Cutworms have a complete life cycle including eggs, larva, pupa and adults. The eggs are greenish and white laid singly or in clusters. Variegated cutworm eggs are laid in elongated clusters. The eggs hatch in three to five days. The granulate larva are dust brown with rough, granulated skin. The length of the granulate cutworm is up to 1 1/2 inches. The variegated cutworm larvae grow to be 2 inches in length before pupating. Variegated cutworm larvae are colored pale, dirty brown with a pale yellow dot on the mid-dorsal line of the first four abdominal segments. The larvae or worms will roll into a C shape on their side when held in the palm of a hand. Cutworms can have five to eight larval instars in a total of 3 to 4 weeks time. The pupa are about 3/4 of an inch long and dark brown to mahogany in color. The pupa stage will last two weeks The cutworm may over winter in the last larval stage or as pupa. The adult granulate cutworm moths have yellowish-brownish forewings with a wingspan that is 1 1/2 to 1 3/4
inches. The variegated cutworm moths are yellowish or brownish with a wingspan that is 1 1/2 to 2 inches. They mate and lay eggs on alfalfa leaves or stems near the base of the alfalfa plant.

When the cutworm cut off the new shoots emerging from the meristem cells in the alfalfa

crown, the starch in the crown that is the alfalfa plants stored sugar becomes depleted by the resulting excessive re-growth. When the stored starch runs out no more shoot growth occurs. Often the first sign of cutworm damage is the lack of re-growth after hay cutting and removal of the bales. Because cutworm are active at night checking under the soil clods and hay duff is a method of finding the worms. Assessing the damage to stem growth is the best way of monitoring damage by cutworms. Treatment if needed includes application of pyrethroid and a product called Steward. If baits are available apply in the evening for best results.

The other pests found in Arizona and California alfalfa fields include insect pests that are found in the fields but are seldom a problem causing financial losses. In most cases chemical control for lesser alfalfa pests is not recommended because of a lack of label registrations available for control. The list includes white fly, grasshoppers, leaf hoppers, thrips, clover root curculio, ground mealybug, morman crickets, sharpshooters and webworms.

Spider Mites

Spider mites can be a problem in alfalfa in the low desert areas. Spider mites are a serious pest to alfalfa that is suffering from water stress. They are usually found feeding in colonies on the lower side of the leaves. They are very small and oblong shaped. The leaves they are feeding on turn yellow and are covered with webbing. The infected leaves eventually turn brown and drop from the plant. A field can appear green from a distance, but upon investigation only the top leaf canopy may be left. Unlike the aphid populations that devour large quantities of liquid low in protein the spider mite populations thrive on high protein with less water. When dry alfalfa fields infested with spider mites are irrigated the mite problem is noticeably reduced.

Infestations of spider mite in alfalfa can occur from March to October in the desert areas. Mites that occur include: carmine mite, desert spider mite, strawberry mite and two spotted mite. The use of sulfur can be used to suppress the mite infestation until harvest.

Alfalfa Weevils

Alfalfa weevils are the most damaging insect problem in the United States. Alfalfa weevils of the western strain were first reported in Salt Lake City, Utah in 1904. In 1939 alfalfa weevils in Yuma, Arizona were identified as the Egyptian strain. The eastern strain of alfalfa weevil was found in Maryland in 1953. The difference in the strains of weevil in alfalfa can't be determined by physical identification because they are almost identical. Biological and territorial identification is used instead. The Egyptian strain is located in the desert areas of California and Arizona. The western strain of alfalfa weevil is found in the western areas of the country. The eastern strain is found in the mid west and eastern territories of the United States.

There is considerable overlapping of strains of alfalfa weevil. In New Mexico the use of DNA testing for strains now discovered a fourth strain of alfalfa weevil. When the alfalfa weevil larvae populations peak is a another method used for identification. Western strain larvae peak 1 to 3 weeks after the eastern strains. The Egyptian weevil strain peaks 1 to 3 weeks after the western strain. The Egyptian weevil strain is considered to be the more serious strain and it has replaced the western weevil in most of California and Arizona.

The alfalfa weevil has a complete metamorphosis. Alfalfa weevils have a life history that includes eggs, larvae, pupae and adults. The eggs are smooth, shiny and yellow. The alfalfa weevil larva grows to be a quarter of an inch long, without legs. It is pale green with a white line the center of the back and a brown head. The pupa is a round, white cocoon on the ground below the alfalfa plant. The adult weevil is light brown with gray markings on their back. They are about two tenths of an inch long.

The adult alfalfa weevil spends the summer in a dormant or resting stage in weeds near

the alfalfa or under the loose bark of trees and in some cases between the shingles of buildings. In the fall as the weather cools off the adults come out of dormancy and fly to alfalfa fields where they mate. The female inserts her eggs into holes that she chews in the living or dead stems of alfalfa plants. The eggs hatch in five to ten days. The weevil larva grow through four instars. The entire larval stage lasts for about three weeks and ends about the time of the first cutting of the alfalfa crop. The pupa stage takes another ten days.

Originally the second-generation weevil adult left the alfalfa field, but through the years the adult weevil now stays in the alfalfa field. After mating the adult weevil lays her eggs in the same field to produce a second generation and in some cases a third generation. Field checking for alfalfa weevil should continue after the fields have been harvested as well as before harvest.

The first two instars of weevil larvae feed on the young alfalfa leaves. The 3rd and 4th instars feed on the alfalfa tissue located between the veins of all leaves. This causes the most damage to the crop by skeletonizing and bronzing the alfalfa leaves. This feeding often results in defoliation. Adults will also feed on the alfalfa but their damage isn't as severe as the larva. Results from yield studies in Ohio concluded that a count of one weevil larvae feeding on a stem in 12 inch alfalfa produced a loss of 0.4 tons per acre dry alfalfa. A count of one larva on a stem in 16-inch alfalfa produced a loss of only 0.1 tons of dry alfalfa yield per acre.

Instead of a pesticide treatment cutting early is an alternative. Monitoring by stem counts is one method. Sweep counts are more often used in California and Arizona. The current recommendation in California is twenty weevil larva per sweep. In Arizona treatment is recomended if 5 to 8 Egyptian weevil larva are caught in a 90 degree sweep. A treatment with Malathion sprayed from a boom on the swather can be used if control is needed. After the bales have been removed a treatment with Ambush or Pounce and Furadan can be used to control aphid and weevil. Other chemical treatments used include Steward, Imidan, Warrior, Baythroid, Lorsban, Sevin, Lannate and Methyl Parathion.

A report "Insect Pest Management In The Western US: Weevils, Aphids and Caterpillars" by Michael D. Rethwisch stated that [application of pyrethoid insecticides may result in increased production of certain plant volatiles, which could be similar to alfalfa weevil pheromones.] Test plots in alfalfa have found an increase in adult alfalfa weevils when pyrethroids were applied. Weevil sex pheromones attract adult male weevils.

Acknowledgements:

Natwick, Eric T.; Summers, C. G.; and Godfre, L. D.; IPM in Low Desert Alfalfa University of California

Cooperative Extension Imperial Count. University of California Kearney Agricultural Center, and University of California Davis Campus.

Knowles, Tim C. Area Extension Agent La Paz and Mohave Counties, Alfalfa Caterpillar/ Butterfly 8/98 A1015 The University of Arizona College of Agriculture Tuscon, Arizona

Field Crops Report; San Joaquin County, February 2003, University of California Cooperative Extension

MANAGEMENT OF EGYPTIAN ALFALFA WEEVIL AND PROTECTION OF YIELDS WITH

SELECTED INSECTICIDES

Rethwisch, Michael D. INSECT PEST MANAGEMENT IN THE WESTERN US: WEEVILS APHIDS AND CATERPILLARS ABSTRACT

Natwick,Eric T. CUTWORM MANAGEMENT IN ALFALFA AG BRIEFS 7/2004

http://www.ipm.ucdavis.edu/PMG/selectnewpest.alfalfa-hay.html

Aphids In Alfalfa

The aphid had been sucking on this particular alfalfa leaf for some time resulting in the a reduction in the sugary juices that flow through the leaf's phloem. The fact is this particular leaf was wilting; but along comes an ant, the aphids best friend, who easily picks her up and carries her to a new healthy growing leaf full of plant juice. The ant loads up on the sugary juice by milking the feeding aphid and takes her back to the ant colony to share with the other ants. If a predator attacks an aphid the ants sting or bite them until the predator leaves, dies or falls off the alfalfa plant. At night the ant will carry the aphid to a safe place. Remember, the ant is a female too. The next morning the ant will bring her back to feed. The presence of ants in an alfalfa field is a good indication of an aphid infestation.

Aphids produce a great deal of honeydew while feeding on plants, because the aphids with their piercing sucking mouth parts take their food from the alfalfa plant's interior phloem vessels that carry sugars from the area of the plant where photosynthesis occurs to the rest of the plant where the sugars are used or stored. Photosynthesis occurs when the plant receives energy from the sun and combines it with carbon dioxide from the surrounding air with water to produce sugar. This liquid in the phloem of the growing plant has a high amount of sugar and a low amount of protein. The aphid is required to consume high amounts of the sugar rich liquid to get the protein it needs. This excess sugary liquid passes through the aphid as honeydew. Ants require a diet of high sugar so they'll do anything to keep it flowing through the aphids that it cares for.

The excessive amount of honeydew produced by the aphid covers the alfalfa foliage giving the plant a shiny sticky covering attracting other insects like butterflies and wasps. The honeydew attracts fungus that clings to it causing the plant to take on a black sooty mold appearance. The alfalfa becomes sticky causing harvest problems. The black sooty mold covers the leaves preventing sunlight from entering the plant for photosynthesis. This can affect the taste of alfalfa for domestic animals like dairy cattle. The over all effect of the aphid produced honeydew in alfalfa is a reduction in the price of hay.

When the aphid is feeding it injects its piercing mouth parts called stylets into the phloem of the alfalfa plant either in the stems, leaves or roots. The stylets which are withdrawn in the snout of the aphid for protection when it isn't feeding are similar to very fine hollow needles that can easily be damaged. To make sure the tender stylets penetrate in the right direction without bending the aphid secretes a liquid that coats its stylets. Coating the aphid stylets forms a solid cover over the surface of the stylets making them strong as metal needles used in syringes. Some aphids are able to enter the stomata that are openings in the bottoms of leaves. Aphids are also able to push their stylets through the airspaces between plant cells to reduce the force required for penetration. Penetrating the alfalfa plants cells for feeding can take aphids 25 minutes to 24 hours.

The growing alfalfa plant produces a material made up of special proteins deposited on the walls of the plant cell to plug any punctures to its cells thus avoiding loss of phloem fluids. Aphids inject a chemical that prevents the growing plant from sealing the punctures. This anti sealing chemical is from the saliva of the aphid and is toxic to alfalfa. When several aphids inject and feed on an alfalfa plant the anti sealing agent can kill the plant.

Life History Of Aphids

Several kinds of aphids feed on alfalfa and depending on the type of aphid the life history can be varied and somewhat complicated. Aphids have an incomplete metamorphosis. Aphids go through egg, nymph and adult stages. They have no pupa.

The Aphid Egg Stage

The eggs of the aphid are thick shelled and can survive cold temperatures. After the male and female aphid have mated the aphid eggs are laid on host plants either living trees, shrubs or alfalfa The eggs will last through the winter months. The eggs if they escape being consumed by egg eating predators will hatch as the temperatures
warm up.

The Aphid Nymph Stage

The host plant will put out buds that the hatching aphid nymphs will begin feeding upon. The aphid nymph go through four or more instars molting their exoskeletons that cover and contain their bodies. The nymphs are small, look like the adult with antennae, compound eyes and six legs. These nymphs hatched from the fertilized eggs are all females.

Adult Stage

When the female nymphs from fertilized eggs mature they are sexually produced adult females. Sexually produced female aphids come from the fusing of a sperm cell of a male aphid with his own mix of genes and the egg cell of a female aphid with her own mix of genes. The aphids produced from this mating or fusing of cells hatch with a new mix of genes that they will pass on to the aphids born to them. The gene in an aphid's body instructs the cell to produce proteins like enzymes that produce specific actions that allow the aphid to survive.

Aphids that encounter diseases, climate, starvation etc.. can survive if they have the right set of genes. The greater the mix of genes the greater the chances of survival for aphids with the right gene mix. Just the fact that the sexual mating of male and female aphids can produce an egg that will survive the tough winter increases the chances of aphids' species survival. The sexual union produces an egg and a mix of genes both vital to the survival of the aphid species.

As the weather warms up and the food supply increases aphids begin to multiply rapidly. Aphids born after conditions improve are born by asexual reproduction. Asexual reproduction doesn't require male aphids or a sexual union. When times are good the need for a fertilized egg that has a protective shell to withstand the winter months or other harsh conditions is not required During good conditions the female aphid produces an egg cell in her ovary and it starts dividing producing growth within her body. (No male sperm is needed.) The dividing cells produce various body parts: legs, head, antennae, abdomen ect...A female embryo is formed that becomes a nymph. This female nymph is born live and begins feeding and can give birth to more aphid nymphs both male and female without having sex. The newborn aphid nymphs can be aphid adults producing aphid nymphs in just 7 to 8 days. Each female adult aphid can produce 80 nymphs a week in this asexual manner.

Female adults that hatched from the shell protected fertilized egg can produce daughters by asexual reproduction called "parthenogenesis". The first born female nymphs that are born this way, asexually by parthenogenesis, from adult females reared from fertilized eggs, are called "parthenogens" . These first asexually born daughters of sexually produced aphid mothers are parthenogens but they are not "clones". Clones are genetically identical to the mother. The first offspring birth through asexual parthenogenesis is a process that creates new individuals from varied genetic material that was contained in the egg cell from the sexually produced mother. The aphid daughters asexually produced offspring will be parthenogens with no twins and with varied genes just like her sexually produced mother. Now, the offspring of these asexually produced parthenogens will be clones identical to their mothers.

Inside the parthenogen aphid, unfertilized egg cells are released from the ovaries and start developing into aphid embryos and the egg cells inside those embryos start developing embryos.

A female aphid may be carrying her daughter's embryos and her grand-daughter's embryos that are developing in her daughter. This telescoping asexual birth of aphids is why populations can explode in an alfalfa field. Asexual birth requires less time and energy then sexual birth.

Changes in the environment and the crowding of aphids results in loss of feeding sites. The loss of feeding sites produces a stimulant in aphids to produce young with wings when they become adults. Both male and female can grow wings because it is an inherited trait, but conditions have to stimulate the need for wings. The winged aphids move to allow the aphid population to survive. The winged aphids are not very strong flyers, but with the aid of winds they can move long distances in a relatively short period of time. Winged aphids can fly at speeds around 1.5 miles per hour when the air is still. As night darkness occurs the aphids fly up to 3000 feet where the winds can carry them for a distance of 250 miles in 9 hours. They land during the early dawn to avoid dangerous updrafts caused by the warming sun on the earths surface.

As the aphids land they aim for the leaves that reflect the green and yellow tinged light wave length given off by actively growing or aging plants. Both of these types of leaves are either taking in sugars from photosynthesis (young shoots) or producing and sending out sugars (mature leaves). Both areas provide aphid nourishment. The edges of fields seem to attract the descending aphids and this is one reason that crop border strips are used as aphid trap crops by some growers. Aphids can be found all over the field and this is because the aphid females engage in "trivial flight". Winged aphids find a suitable plant to feed on using the following clues: taste, visual and chemical. They fly short distances, testing plants that they land on by probing with their styllets. As they fly from plant to plant aphids lay more female aphids and spread diseases carried on their mouth parts throughout the field.

Aphids can and do defend themselves to a certain extent. Aphids will kick at an attacker and try to discourage any attack. The aphid will pull up their mouthparts from the plant they are feeding from and walk away and this includes jumping off of the plant. Some species of aphids can also spray out a waxy solution on their attacker.
During these defensive actions the aphid will emit a alarm pheromone alerting the surrounding aphids to the attack. Some species of plants have been found to put out the same pheromone to drive aphids off of their leaves. The aphid alarm pheromone is emitted in short bursts by the aphids whereas the plant pheromone is constant; therefore the aphids are not usually alarmed by the plant pheromone. Researchers have tried using plant pheromones to mimic aphid alarm pheromones to protect crops, but to date without success.

Inside the body of the aphids, usually in the digestive system there are bacteria that are vital to the continued existence of the aphids. These microorganisms obtain nutrients from the food that the aphids devour. The material called glutamine sucked from the phloem of the plant that the aphid is feeding on is transported to the bacteria. The glutamine is converted to glutamic acid by the bacteria. The nitrogen contained in the glutamic acid is then used by the aphids to build amino acids needed in their growth and reproduction. The aphid depend on specific bacteria in their bodies for their protein needs. As the fall months with cooler weather and shorter days approach a change in the female aphids takes place due to the increase in darkness caused by shorter daylight days. The increased darkness releases a hormone in female aphids that causes them to asexually give birth to sexually active female aphids. The exposure to darkness has to be experienced by the new mother and her grandmother (two generations). When the

sexual female aphids are ready to be fertilized they send out a pheromone that attracts sexually active male aphid adults. The sexually active male adults are born asexually by the females that give asexually birth to sexually active females because of the increase in darkness. The adult sexually active females and males aphids have wings.

Aphids start out as single cells in their mothers' ovaries. The cells divide causing growth into an embryo. In the early division of the cells female aphids develop a XX chromosome. The male aphid starts out the same way, but during its early cell division process the male cells develop an OX chromosome. They lose an X.. This is said to happen randomly. There is a debate on how it occurs, but the male and female embryo chromosomes have this difference. When the female aphids sexually give birth to eggs after mating the sexually produced offspring that hatch are females. No males.

Aphids in Alfalfa

There are four kinds of aphids in the alfalfa fields of Arizona and California. These include: the spotted alfalfa aphid, blue alfalfa aphid, the pea aphid and the cowpea aphid. All of the aphids produce honey dew that reduces the quality of the hay. The toxin that these aphid inject into the alfalfa can stunt or even kill alfalfa. Virus infections can be spread by the aphid as they feed and also as the female aphid taste tests the alfalfa looking for the best alfalfa for her offspring.

The difference between blue aphid and pea aphid is the narrow dark bands near the tip of the antennae of the pea aphid. The blue aphid has antennae that are all brown without bands. Both the blue aphid and the pea aphid are green and large with long legs. There is a biotype pea aphid that is pink in color. This pink pea aphid has been found to attack some of the pea aphid resistant alfalfa cultivars. The blue aphid and the two types of pea aphid are active in cool temperatures and do more damage in the spring months. Pea aphid are found feeding on stems, leaves and terminals. Blue aphids prefer feeding on the alfalfa terminals. Of the two aphids the blue aphids have a more toxic material that it injects when feeding.

The green peach aphids are pale yellow or grayish with four to six spined black spots on their backs. Their wings have smoky areas along their veins. Green peach aphids like warm weather and are summer alfalfa pests. In the warmer desert areas Green peach aphids can be found in the fall and winter months. A parasite called the Trioxys complanatus was introduced to control the green peach aphid and will leave brown aphid mummies when present in an alfalfa field.

It was called a new problem by Yuma County Farm Notes in January 2001. The black aphid or Cowpea Aphid was declared a pest in alfalfa. Not only in California and Arizona, but in most of the alfalfa growing areas of the United States. The cowpea aphid has been found in damaging populations in several crops including vegetable crops. The cowpea aphid is found in desert grown alfalfa during the winter and spring. The cowpea aphid is shiny black in the later nymph instars and adult stages. The early aphid instars are gray to black and are only 2 mm long.

Most of the known insect predators feed on all four of these aphids. Wasps lay eggs inside these aphids that hatch into larva that feed and kill the aphids. Dead aphid mummies are a sign that wasps are present in the field.

Dimethoate and Chlorpyrifos (Lorsban) are two of the insecticides used in the chemical method of controlling aphids.

The use of trade names in this course is solely for the purpose of providing specific information. It is not a guarantee or warranty of the products named, and does not signify that they are

approved to the exclusion of others of suitable composition. Use pesticides safely. Read and follow directions on the manufacturer's label.

Acknowledgements:
www.ipm.ucdavis, edu
earthlwwwife.net/insects/aphids.html
Bessin, R.; U. of Kentucky Entomology; Mystery Bug Answers
Palumbo, John; Tickes, Barry Cowpea Aphid in Alfalfa; The University of Arizona Cooperative Extension Yuma County News
Davis, Gregory K.: Polyphenism and The Pea Aphid Department of Ecology & Evolutionary Biology, Princeton University
Flint, M. L. APHIDS Pest Notes Publication 7404 May 2000 University of California Division of Agriculture and Natural Resources
Rethwisch, Michael D. Insect Pest Management in the Western US: Weevils, Aphids and Caterpillars

Alfalfa Weed Controll

Sunlight is the key ingredient to plant life. Healthy active growing alfalfa prevents emerging weeds from getting their needed share of sunlight. Growers do many things to prevent weeds from growing in their alfalfa fields. A good stand of alfalfa with 55 or more stems per square foot will help the grower get good weed control. Unlike some crops, alfalfa is very competitive with weeds.

Because growing conditions are so variable if the right weed control methods aren't used by the grower, weeds in alfalfa can become very expensive. Alfalfa hay buyers want alfalfa hay without weeds. When alfalfa hay is plentiful buyers are influenced by an assortment of things besides the presence of weeds: The quality of the leaves and stems is a factor. Mold can reduce the price. The reputation of the grower as an alfalfa hay producer is a factor.

Weeds when harvested with alfalfa are more than just another source of hay. Weeds can contain burs and thorns which can harm the feeding animal. Some weeds are toxic to animals. There are weeds that when mixed with alfalfa can make the hay unpalatable to the feeding livestock. Aromatic weeds can give an odor to milk. Some weeds take longer to dry than alfalfa and can cause wet spots in the hay stacks. These damp spots can attract molds and fungi that reduce the quality of the hay in the bale. Some vine like weeds make harvesting more difficult.

Weed Competition

Healthy growing alfalfa can compete successfully with weeds. Alfalfa is a simple perennial. Alfalfa can go dormant or die back and put out new shoots from its crown. Alfalfa has deep growing roots that can pull water to the surface when the soils dries out. The alfalfa has bacteria that can obtain nitrogen from the atmosphere. Most of the weeds in weeds are dependent on the soil or applied nutrients for their nitrogen needs.

Because of conditions that can weaken the alfalfa plant's health, the large number of types of weeds can often gain the upper hand. If weather conditions delay the emergence of young alfalfa seedlings, fast emerging weeds can outgrow the alfalfa seedlings. These weed seedlings can take light, water and nutrients away from the late emerging alfalfa seedlings. Pests that specifically feed on alfalfa will weaken alfalfa allowing weeds to dominate a field for sunshine, nutrients and water.

Areas in the field where water doesn't drain can scald the alfalfa in the summer.

Phytophthora disease will attack alfalfa in standing water during cool weather. The areas in the field where this occurs allows weeds to multiply. Wheel traffic from harvest equipment can destroy alfalfa and become areas where weeds take over. Cutting alfalfa in a short cycle will reduce the vigor of the plants. This increased cutting of alfalfa will allow weeds to dominate instead of being shaded out by the healthy alfalfa plants. Some herbicides can harm the alfalfa to the extent that resistant weeds can live through the application and multiply.

Alfalfa Weeds

Because of the various types of weeds, they can compete with alfalfa on a year round basis. The weeds are either broadleaves, narrow leaf grasses or sedges. Alfalfa is a broadleave plant. Weeds that are classified as broad leaves have a tap root with smaller roots growing from it. Shallow applied soil herbicides are not as effective on weeds with tap roots. A tap root can grow deep through the herbicide treated area of the soil. In this way broadleaved weeds can survive herbicides placed near the surface of the soil.

The broadleaf weeds have two seed leaves. This is where the name dicotyledon (dicots) originates. The cotyledon leaves refer to the leaves located in the seed at planting. These two leaves usually stay with the young dicot seedling after it emerges. These cotyledon leaves are not considered to be true leaves. Cotyledon leaves are located just above the soil level on opposite sides of the stem of young seedling broad leave plants.

If you've ever had a salad with alfalfa sprouts you found that there are just two leaves on the end of the sprouts These two alfalfa sprout leaves are the dicotyledon leaves of alfalfa before the stem takes on the true leaves.

The term broadleaf refers to the structure of the leaf. The leaf has a wide surface with netlike veins. The structure of the leaf either broadleaf with netlike veins or narrow- grass leaves with parallel veins has a great deal to do with the type of herbicide applied to either leaf surface. The herbicide, Buctril, is used on broad leaved weeds like London rocket. The herbicide, Poast, is used on narrow leaved grasses like yellow foxtail.

The narrow leaved grasses have one seed leaf. The name monocotyledon is given the plants with one seed leaf. This one seed of the monocotyledon (monocots) stays below or just at the surface of the soil when monocots emerge as seedlings.

Instead of a tap root like the dicots the monocots have a mass of small roots that spread out from the stem at the soil surface. Monocot roots take up water and nutrients at or near the surface of the soil. Shallow soil applied herbicides are more effective on the monocot weeds because their roots absorb chemical molecules in this shallow area where the soil herbicides are applied.

Sedges and grasses are monocots because they have only one seed leaf. Sedge stems are solid. Grass stems are hollow. Sedge stems are triangular. Grass stems are cylindrical or round. Sedges include yellow and purple nutgrass.

Weeds are also monitored for control by the length of time they grow and the seasons that they grow in. Different methods are used for weed control depending on these growth habits. Plants and weeds are annuals, biennials and perennials.

Annual weeds only grow for one year. They germinate and bare flowers, fruit, seeds and die in one year. The objective when controlling annual weeds is to prevent them from seeding. The first mowing will control many annual weeds in alfalfa.

There are two kinds of annual weeds in alfalfa. They include: summer and winter annuals that germinate when temperatures warm up in the spring of the year. Summer annuals grow through the summer then flower, seed and die when temperatures cool down in late fall. Spring

planted alfalfa competes with the summer annuals for sunlight, water and soil nutrients. Some of the summer annuals include: pigweed, a broadleaf weed and yellow foxtail, a grass or narrow leaf weed.

Winter annuals germinate in the fall as the temperatures start to cool down. Winter annuals stay in the vegetative state through the cold winter months. As the days get longer in the spring winter annual weeds flower, produce seed and die as the temperatures warm up. Fall planted alfalfa competes with winter annuals for light, water and nutrients. A winter annual is the London rocket, a broadleaf weed.

Both summer and winter annuals can be controlled with contact and systemic herbicides. Sheep grazing in the spring months will control winter annuals that haven't flowered and the summer annual emerging seedlings.

The biennial weeds grow for two years. The first year's growth for biennial weeds is in the vegetative state. This is referred to as a rosette state. In the second summer the biennial weeds flower, produce seeds and die. Very often in the mild climates of California and Arizona winter annuals are mistaken for biennials. Biennials only produce from seeds.

There are only a few biennial weeds in both Arizona and California. Biennials are not often found in alfalfa. The purple star and burdock are biennial weeds. They are controlled by contact or systemic herbicides. Biennials can be controlled like the annuals. Biennials should be prevented from producing seed.

Biennials do not reproduce from their vegetative parts like the perennial weeds. Control should be made to biennials in the first year when they are in the vegetative stage of growth.

The Pennsylvania University Extension Service states that the burdock and musk thistle biennials should be controlled before planting alfalfa otherwise they will persist throughout the life of the crop.

Perennial weeds can lose their top growth from frost, mowing, sheep grazing or contact herbicides. Once perennials seed they can die back and when conditions are right they can grow again. Perennials grow again from their meristem cells in their vegetative structures. Perennial weeds can survive for more that two years.

Unlike the annuals and the biennials that must reproduce from seeds, perennials can reproduce from seeds and their vegetative structures. The vegetative structure of the perennial weeds consist of rhizomes, stolons, crowns, roots with adventitious buds and tubers or bulbs. The perennial weeds are grouped according to their different vegetative structures from which they reproduce: simple perennials, creeping perennials and bulbous perennials.

Simple perennials have crowns at the base of the plant. The crown can form around a tap root This simple perennial crown is where new shoots emerge from meristem cells and produce new roots, stems, leaves and flowers. When crown stems are cut during hay operations the meristem cells in the crown grow into new shoots. If perennial crowns are broken up by cultivation each piece can produce a new plants. Some simple perennials have tap roots with a crown. Dandelion tap roots have a crown at the top and contain meristem cells along the root that can grow shoots when needed. Alfalfa is a simple perennial type with crowns. Simple perennial weeds include: common mallow, dandelion, and plantain.

The vegetable structures of the creeping perennials consist of roots, under ground stems and above ground stems that spread horizontally and vertically. Roots of the creeping perennial, morning glory, have been found over 20 feet deep in the soil. Creeping stems are called stolons (above ground) and rhizomes (below ground). They are segmented. Each segment joint has stem cells that can put out new shoots and roots to form new plants that can produce shoots, stems,

leaves and seeds. Bermuda grass, a narrow leaf weed with rhizomes, is a creeping perennial weed.

The bulbous perennials have bulbs and nutlets as their vegetative reproductive structures. In alfalfa the nutgrasses or sedges are one of the serious bulbous perennial weeds. When patches of grass like Burmuda are controlled with herbicides in alfalfa the nutgrasses will fill in. This is especially true in light sandy soils.

Nutgrass or nutsedge reproduces from seed and root nutlets. The nutlets on nutgrass are similar to the bulbs on other weeds. The nutgrass is much harder to control than the grasses with their vegetative reproductive systems. Once the nuts mature in the soil the nuts no longer need sugars from the source where photosynthesis occurs. Systemic herbicides will not enter and control mature nutgrass nuts. Control of seedlings and young sedges with immature nuts that need sugar can occur with some of the systemic herbicides. Nutsedge needs sunlight and healthy vigorous alfalfa can shade nutsedge out.

Buds and shoots get their growing energy from the sugars that were stored as starch in the crowns, stolons, rhizomes, tap roots and bulbs. Sugars produced in mature leaves by photosynthesis are translocated to the root system. The applied herbicide travels with the sugar to the crowns and roots of perennial weeds where it kills the perennial weeds. Systemic herbicides that are approved for alfalfa weed control should be applied to the leaves of mature weeds. Mature leaves are where sugar is made. Crowns, stolons, rhizomes, tubers, bulbs and root nutlets are where sugar is stored. The sugar is used to grow new shoots and roots. Let the herbicide ride with the sugar to the stem cells in the perennial vegetative parts of the weeds.

There are several winter annual broadleaves that are a problem in alfalfa production. These include: Common chickweed, Fiddleneck, Fillarees, Henbit, Mallow cheeseweed, Minors lettuce, Mustard, Burning nettle, London Rocket, Sheperdspurse, Sow Thisle, Petty Spurge and Red Maid a succulent.

The winter annual grasses in alfalfa include: Hare Barley, Annual Bluegrass poa annua, Canary Grass, Wild Oat, Italian Rye Grass and Volunteer Wheat.

The summer annual broadleaved weeds in alfalfa include: California Bur Clover, Cockle Bur, Groundsel, Jimson Weed, Knotweed, Lambsquarters, Milk Thistle, Night Shade, Pigweed, Pineapple weed, Yellow Starthistle and Yellow Sun Flower.

The summer annual grass weeds in alfalfa include: Barnyard Grass and Yellow Foxtail.

There is a biennial weed, Ox Tongue, that invades alfalfa in California and Arizona.

Prickley Lettuce is referred to as a winter annual broadleaf. When prickly lettuce lasts through the summer and come back the second winter to flower and seed in the following summer it is referred to as a biennial weed.

Dock and Dandelion are simple perennial broadleaved weeds that infest alfalfa. Common Mallow Is sometimes called a broadleaved summer annual, a broadleaved biennial or a broadleaved simple perennial. This all depends where you find them. California, Arizona, Ohio or New Mexico.

Creeping perennial broadleaved weeds that infest alfalfa include: Field Bindweed or Perennial Morning Glory, Silverleaf Nightshade and Whorled Milkweed.

The grass or narrow leaved creeping perennial weeds that infest alfalfa include: Johnson Grass and Bermuda Grass.

The perennial bulbous or weeds with nut-like vegetative reproductive structures include: Yellow Nutsedge and Purple Nutsedge.

Dodder is a parasitic weed. After germination from seed in the soil the dodder plant

attaches itself to the alfalfa. It is yellow to orange and grows on the alfalfa stems. Applying Treflan granules before dodder germinates in the late winter will control the emerging seedlings. Treating the dodder on the alfalfa with Paraquat will kill the dodder and alfalfa stems but not the alfalfa crown. If the spray doesn't kill the crown the alfalfa will put out new shoots. Cutting the alfalfa below the point on the stem where dodder is attached is another control practice. Also spot flaming is another cultural control method for dodder.

Some of the weeds that inhabit alfalfa that are considered to be poisonous to livestock include: Fiddleneck, Yellow Starthistle and Common Groundsel.

Herbicides

Pre-plant and pre-emergent herbicides include: Balan, Eptam 20 Granules, Eptam liquid water run, Treflan 10 granules, Liquid Treflan can be impregnated on dry phosphate fertilizer and applied preplant; Zorial Pre-emergence: Kerb pre- emergent and post-ermergent; Sencor pre-emergent and early post emergent,.

Post-emergent weed control herbicides in alfalfa include; Pursuit, Raptor, 24-DB, Gramoxone, Poast, Buctril, Select, Prism, Buctril and Prism combo.

Round Up ready alfalfa can be treated with Round Up for weed control especially grass control.

Control of grasses and nut grass in alfalfa is possible with Eptam applied in the irrigation water. Water run Eptam at 3 pounds active lasts 30 to 45 days. Later applications of Eptam at 2 pounds active are needed after the third and fourth cuttings.

. *The use of trade names in this course is solely for the purpose of providing specific information. It is not a guarantee or warranty of the products named, and does not signify that approved to the exclusion of others of suitable composition. Use pesticides safely. Read and follow directions on the manufacturer's label.*

Acknowledgements:

K.A. Kelling and M.A. Schmitt CONSIDERATIONS WHEN APPLYING MANURE TO ALFALFA www.
uwex.edu/ces/forage/wfc/proceedings2002/manure_application
Offwell Woodland & Wildlife Trust www.offwell.free-online.co.uk/grass_id/intro
Mick Canevari In alfalfa Timing is Everything
.ucdavis.edu/symposium/2001/Proceedings/CAS01timing5
Tickes, Barry & Ottman, Mike, Alfalfa Weed Control in The Low Deserts of Arizona
ag.arizona.edu/pubs/crops/az1266/
How to Manage Pests in Alfalfa
www.ipm.ucdavis.edu/PMG/crops-agriculture.html
Robbins, W. W.; Bellue, Margaret K.; Ball, Walter S.; Weeds of California; State of California Printing Division; Revised 1940
www.forages.psu.edu/topics/species_variety_trials/species/alfalfa/weeds.

Citrus Diseases

The term disease describes the condition of the plant when the citrus plant's cells and tissues are not functioning properly due to the continued irritation by a living organism such as a virus, bacteria, fungus, nematodes and other living plants. A disease can also be caused by high or low levels of: light, temperature, pollution, soil moisture, nutrients, minerals, alkalinity, pesticides and cultural practices. Many of the diseases are named after the symptoms. Other diseases use the citrus crop name and some names use the world locations in the name. Insects,

weeds and vertebrates damage the citrus plants in a direct way by feeding on them or crowding them out of living space. These pests can infest with disease microorganisms.

Tristeza virus

Virus are one of the smallest and least equipped living disease causing creatures. They have no equipment like the Ribosomes to make proteins which are vital to other living things.

In eighteen ninety two Dimitri Ivanovshy wrote an article in which he described a pathogen type of disease that wasn't bacteria that was infecting tobacco plants. In eighteen ninety eight the tobacco mozaic virus was discovered. Since then, more than five thousand viruses have been isolated and described in detail. Viruses have been found in just about every ecosystem on earth and they are said to be millions of different types of viruses that have not been described by scientists.

The virus body is composed of three parts: nuclear or genetic material made up of RNA and in some cases RNA and DNA, a protein coat called a capsid for protection, and some viruses have an envelope of lipids that surrounds the protein coat and the gene material of RNA and DNA when they are outside of living cells.

In the normal cell of the animal, plant, fungus or bacteria there are units that produce proteins. These units are referred to as ribosomes. The ribosomes are located in the liquid of the cell. Ribosomes are the protein builders located in the cells of plants, animals, bacteria and fungi. The ribosome is made up of two pieces. One piece is larger than the other piece. The mRNA molecule of the virus that invaded the plant or animal goes in between the two pieces of the ribosome. The two pieces of ribosome come together and the ribosome read the protein building directions that the mRNA brought to the ribosome from the DNA. In the meantime another RNA protein located inside the cell is called a transfer or tRNA. The tRNA is bonded or attached to amino acids that are also located in the cytoplasm of the cell.

Now, the ribosome with instructions from the virus mRNA connects with the host's tRNA that binds with particular amino acids that are needed to make the desired protein. These amino acids are folded together in a particular order by the ribosome to form the new proteins.

When a virus invades a cell of an animal or plant it uses its RNA strand of genetic material to enter a ribosome of the plant or animal in the same manner. If the virus mRNA is compatible with the ribosome of the invaded plant or animal the ribosome begins building virus bodies. These virus multiply in the bodies cells creating an infection. "Virus can only multiply and grow inside compatible animal, plant, fungus and bacteria cells." Tobacco mosaic virus cannot multiply in other plant and animal cells.

I compare virus RNA to the activity of the use of a modern day credit card when stolen. If the thief enters the wrong card with the wrong identification codes, they obtain no money or merchandise. But if the stolen credit card is accepted by the merchant's machine (similar to the ribosome) a payoff occurs. The right virus RNA can activate the animal or plant cell's ribosome to make more virus proteins using material (amino acids) and energy taken from the invaded plant or animal. It's another form of theft and it's been in use for millions of years.

The cells in which virus multiply and can vary. Some viruses can enter and multiply in several different hosts, but many virus infections are limited to specific hosts. Some hosts have an immunity to the specific virus that eliminates the invading virus. And some hosts can build up an immunity that stops the virus activity over a period of time

Virus reproduction is only carried out inside of the host's cells. The virus doesn't have any of its own body equipment to reproduce so it uses the equipment of it's host which in this case is a citrus crop as its host. Reproduction of a living object is the process of making more of

the object. Most of the living beings reproduce by asexual or sexual reproduction. In this case the virus reproduces itself by using the host's protein maker or the ribosome. Some viruses have DNA that penetrates the host cell's nucleus then it releases strips of RNA. These pieces of RNA that leave the nucleus carry the coded information as marker or mRNA to the hosts ribosomes.

Making proteins requires the use of amino acids that the host supplies with its own transfer or tRNA. The new virus is only made like the virus RNA if the code fit's the ribosome's apparatus. This new virus body is made entirely from material provided by the host. The number of virus bodies increases to the point until the host cell kills itself by bursting apart thus allowing the virus to spread to other cells where they go through the same program until the host dies. There are plants that actually kill the cells that surround virus infected cells. This stops the spread of the virus disease.

Changes to the genes of virus happpen when accidents occur. The RNA tapes of the virus can break off even though the are protected by the protein capsid. Accidents are not common, but they do happen and when they do the result is that virus change genetically. An end may break off and be replaced by another different virus piece of RNA. This can result in a new strain of virus. In some cases several different virus can occupy the same host and this results in accidental changes in the genes of the virus. This is how virus overcome immunities that some citrus trees have built up against a particular virus over a period of time.

The citrus attacking virus is called the Tristeza virus. It is one of the longest bodied virus called clostero-virus. It has the appearance of a threadlike body. Tristeza virus is found only in the phloem cells that transport the citrus trees food from storage areas to growing areas and from food making areas where photosynthesis occurs to storage and growing areas of the citrus plants. Although Tristeza virus is not transmitted through seeds it is transmitted through the insect vectors which includes the aphids. The scion or grafting twigs, branches and rootstocks are also carriers of the Tristeza virus. Stem pitting with long grooves on the stems is a symptom of this citrus disease. This results in poor bushy growth with leaf cupping, yellowing and small distorted fruit.

The word "Tristeza" is a Portuguese word meaning sadness. The Brazilians named it because of the ruin to millions of citrus trees in the Argentina, Brazil, South Africa and other citrus growing areas in the eighteen hundreds and early nineteen hundreds. The virus appeared and was identified in the nineteen forties in California. Tristeza disease was identified in Arizona in Meyer lemon in nineteen fifty six. Right after finding the disease in the Meyer lemons it was also found in mature trees of Clementine mandarin, Dancy tangerine, and Marsh white grapefruit trees on the University of Arizona Citrus Experiment Stations at Yuma and Tempe Arizona.

In Arizona and California the disease has been kept out of the area by strict quarantine regulations on imported citrus and the certification programs of bud wood and planting material. A recent test on citrus sour root stock trees, a known carrier of the disease that are in the certification program, were found free of the disease. The aphid vectors that carry the disease, a cotton aphid, that occasionally feeds on citrus, evidently does not transmit the strains of the disease. An eradication program of old line citrus varieties carrying the Trsteza virus disease and the quarantine program has been very effective.

Citrus Exocortis

Citrus Exocortis is a viroid. Viroids are much smaller than the virus. They do not have a protein coat like the viruses, but they do have the nucleic acid RNA. Theodore Diener, an agricultural pathologist at the Agriculture Research Service in Maryland in nineteen seventy one isolated a viroid. Viroids are small RNA particles that do not use the ribosomes of the citrus

plant cell that they invade. Viroids take control of an enzyme in the citrus tree's cell called polymerase II. This enzyme can synthesize or make the messenger RNA or mRNA in the invaded citrus tree's cell by using the mRNA to copy itself then have it enter a ribosome and turn out more viroids. This is how the viroid makes more viroids. This doubling of itself causes growth of the number of viroids and at the same time becomes a disease of the invaded citrus plant by using the food and energy of the invaded citrus tree to exist until the cell fills up and splits with a populations of viroids. Unlike the virus that has a protein coat to protect itself from being digested or consumed by the citrus tree's cell, the viroid avoids being consumed by the citrus tree's invaded cell's feeding enzymes by acting like other articles of the citrus tree's cell's own internal working parts.

This viroid citrus disease is spread from infected trees and other particular plants to healthy citrus trees by budding or grafting and or on contaminated cutting tools or cultivating equipment. After the viroid enters the phloem tissue of the citrus tree it spreads to all parts of the plant. The scratching and gnawing of animals can also spread this disease. Dodder and some other growing plants can spread Citrus Excortis. Heating or the use of propane torches to sterilize the cutting tools do not appear to control the disease. The only chemical sterilant that seems to work is sodium hypochlorite solution.

Infected citrus trees with Citrus Exocortis have very narrow, vertical thin strips of bark. These thin strips of outer bark give the bark a scaly appearance. The common name for this disease is called "scull butt" because as the young infected seedlings are grafted on rootstocks and begin to grow from the root stalk they get large split and scaly bark that turns up at the graft. The infected citrus trees may get a downward bending of stems and leaves plus a cracking and darkening of petioles and veins. Their growth is stunted and lower yields are common in these infected trees. In Arizona this viroid bark splitting disease has been referred to as Psorosis. Strains of the Psorosis that occur in Arizona have not been studied.

Control includes the planting of citrus trees that do not carry this disease and the use of sanitary budding, nursery and field practices and the cleaning of cutting tools with sodium hypochlorite solutions. If trees are found with this disease they are destroyed. Psorosis or viroid disease is controlled by eradication and citrus certification programs.

Citrus Stubborn Disease

The symptoms of this disease describes the frustration that citrus growers have to put up with when dealing with this disease produced by the mycoplasmalike pathogen *Spiroplasma citri*. The common name for it says it all. It's named "Citrus Stubborn Disease". The disease is very slow in developing and as it slowly but stubbornly infects the tree, symptoms of the disease vary and just a few symptoms show up on parts of the tree or in some cases all through the tree. These symptoms appear on the fruit, leaves and stems of all commercial varieties regardless of the rootstock.

Citrus Stubborn disease can show a bunchy upright growth of stems and branches with short internodes and a high amount of shoots, multiple buds and sprouts. Some of twigs die back. Bark is thickened and sometimes has pin holes. Trees show some stunting and the tops may appear flat. Sometimes the leaves are little or miss shaped or in some cases both miss shaped and small. Leaves often can be mottled or chlorotic. The infected tree may defoliate in the winter. Diseased trees bloom during all seasons: spring, summer, winter and fall and produce very little fruit. Some of the fruit is lopsided, small and deformed in different ways. The fruit has the appearance of an acorn. The top stem end half of the fruit may have a normal thick rind while the bottom half of the fruit will have abnormally thin rinds and the rind is often dense and cheesy.

The bottom of the fruit may be green with the top showing the mature color. Usually the normal citrus shows color at the bottom first. Stubborn diseases citrus trees drop their fruit prematurely and some fruit mummify on the tree. The diseased fruit may have a bad odor and flavor that is sour and bitter. Many of the seeds of the diseased fruit are not developed, are discolored and aborted.

All of these symptoms can also be caused by other conditions such as lack of key nutrients, flooding, pesticide damage etc.. During hot weather these symptoms are more apparent. Citrus Stubborn Disease does not normally kill citrus trees. Stunting of young trees is more common than in mature trees.

Stubborn disease is prevalent in Washington Navel citrus trees and may be found in Valencias, Sweets and Grapefruit in California and Arizona. Here in the United States Citrus Stubborn disease occurs only in hot, dry areas. Areas like Florida and Texas have not found this disease. It is a primary disease in Mediterranean Countries, Brazil and South Africa, Until the nineteen seventies scientists thought the disease was caused by virus infections. In nineteen seventy it was discovered that the disease was instead caused by mycoplasma-like organisms.

These organisms are more advanced than the virus and viroid organisms. Virus have only strands of nuclear RNA and DNA and are covered with a protective protean when outside the plant cells. Virus enter their nuclear RNA tape into the plants ribosome to make more viruses until the cell splits and the virus invades the plant. Viroids use the plant cell's enzymes to copy themselves then the enzyme as a RNA tape enters the plants ribosomes that produce more viroids that eventually take over and split the cell spreading the disease throughout the invaded plant.

Stubborn Citrus Disease is a one cell pathogen named *Spiroplasma citri* and are the closest living pathogen to a bacteria. They are one celled and their nuclear material (RNA and DNA) tapes are not contained in a nucleus pouch inside the cell like the plant, animal and fungi. They have RNA and DNA plus ribosomes for making proteans out in the cytoplasm of their cells. These organisms stay in the same area of the cell, but they are not confined inside a physical container like the nucleus inside the cell. Their main difference with the bacteria cell is that Stubborn disease cells do not have a cell wall like the plants and bacteria. Instead their cell membrane is made up of a triple layered membrane. The stubborn citrus disease's cell is long, tubular and zig zags. They look like they were squeezed out of a toothpaste tube that was waved back and forth to form a zig zag look. This is referred to as a helix shape that moves by undulation. Straight branches of the cell may stick out from the tube like body.

Stubborn Citrus Disease organisms reproduce by asexual methods similar to bacteria. When the organisms consume food and reaches a certain size they split or divide into two organisms that are alike. The splitting of mycoplasmalike into two cells that are alike is referred to as binary fission. The binary fission process starts as the genome or DNA splits. The two identical cells that are formed both survive and go on to divide again as long as the conditions are compatible for their growth, but the main condition is food availability. Unlike the bacteria that can form spores when the food runs out. (Spores are resting stages that allow bacteria to survive until food and conditions are good enough to allow normal bacteria cells to thrive.) Mycoplasmalike or *Spiroplasma citri* populations reduce in numbers until conditions change to the better.

Spiroplasma citri was the first mycoplasmalike pathogen to be cultured in laboratories. The disease is confined to the phloem of the infected cirtrus. Stubburn citrus disease is not sensitve to penicillin, but it is to tetracycline. Young trees treated with this antibiotic showed some curing of the disease when the roots were soaked with it, but injection and spraying didn't

affect the disease.

Budding and grafting will spread the disease, and this disease is spread naturally by leaf hoppers, *Circulifer tenellus, Scaphytopius nitridus* and *S. acutus delongi.* The leaf hoppers have an incomplete life cycle including: eggs, nymphs and adults. The adults and nymphs carry the disease, but eggs do not. Upon hatching from the egg the nymph must feed on the citrus taking in the pathogen, *Spiroplasma citri.* The flea hoppers have to feed on the infected citrus plants for several hours or even days. More flea hoppers become infected after feeding on young leaves and stems rather than on mature leaves and stems. After a required incubation period of ten to fourteen days the insect can inject the disease to other citrus plants. During cool weather it takes longer to transmit the disease than during warm or hot weather.

The insect is first infected in its intestines then the disease passes into the internal organs and eventually the disease enters the flea hopper's brain and salivary glands. Once the concentration of the disease reaches a certain level in the flea hopper' s salivary glands the insect can infect the plants that it injects with the disease. Only fully infected adults and nymphs can infect citrus plants. Young nymphs that have hatched from eggs that were laid by infected adults have to go through the feeding and incubation period before they can infest citrus trees. This is another reason for calling this pathogen a STUBBORN disease.

In Arizona nursery trees are grafted from Stubborn-free bud wood. Any infected trees found in a grove or nursery should be removed and burned. In some countries antibiotics are used, but they are only temporary.

Bacterial Citrus Diseases

Bacteria unlike the stubborn disease organism have cell walls, but it also is a one celled organism. Bacteria have DNA, RNA and ribosomes that make proteins out of amino acids.

Citrus Canker *Xanthomonas campestris pv. citri.*

Even though the citrus canker that is caused by this bacteria isn't a problem to citrus in the United States at the present time it is still around and it is being watched and guarded against here in the United States of America. It was first found in Japan and Asia in the year of nineteen ten. Some of the infected nursery citrus trees from Japan wound up in in the state of Florida. The bacterial disease, citrus cancer spread through Florida and the gulf states. Growers had to burn over a quarter of a million orchard trees and three million nursery trees causing loss of revenue and critical expenses for the citrus industry to stop the disease.

They finally eradicated the disease after a period of thirty years or until nineteen forty nine, but in August of nineteen eighty four another outbreak of the citrus canker occurred in Florida, This time by the end of nineteen eighty five seventeen million growing trees and nursery trees combined were destroyed. Citrus canker was eradicated in South Africa, New Zealand and Australia. In nineteen fifty seven citrus canker was found in Brazil and spread to other countries. It has now become established in Brazil. The countries that do not have citrus canker have very strict importation laws against fruit imported from countries that are not citrus canker free.

Lesions are found on young leaves, twigs and fruit. The lesions start out as small slightly raised water-soaked round spots that are darker green than the rest of the leaf. As the lesions grow they become grayish white, rupture and obtain a spongy appearance with crater like centers. The margins of the lesions are defined and often surrounded by a halo that is slightly yellow in color and up to a quarter of an inch in diameter on the leaves and twigs and up to a third of that size on the fruit. The size of the lesion depends on the variety of the citrus. When the infections are severe they will debilitate the tree while the fruit becomes misshapen and full of scabs.

The bacteria that infects the citrus is named *Xanthomonas campestris* pv *citri.* There are at least three strains named by their effect on different species of citrus: strain A, a native of Asia is the worst and most aggressive and affects grapefruit, Mexican lime, sweet orange and lemon; strain B is present in South America and only affects Mexican lime and lemon; strain C is found in Brazil and affects only Mexican lime. There is a possibility of a fourth strain found in Mexico, but it causes a slightly different canker on citrus leaves and twigs of Mexican lime. It is called a citrus bacteriosis to keep it separate from the citrus cankers.

The canker bacteria over winter in the canker lesions. It takes warm, wet weather to have the bacteria ooze out of the lesions where they splash onto the young tissues of the leaves of the citrus trees. The bacteria get inside the leaves through the stomata. On older leaves the bacteria enter through wounds of injured areas. The canker bacteria go through several life cycles on the fruit where the lesions are of many sizes. Moisture and temperatures between sixty eight to seventy seven degrees Fahrenheit is necessary for the spread of the citrus canker. High winds help spread the disease. Areas like Florida and the gulf coast are more ideal for this disease then are our dry hot climates.

This disease is prevented by our strict quarantines that are enforced. When Citrus canker does emerge every effort is carried out to eradicate the disease just like in Florida. We now have and use flame throwers. In areas where the disease is present like Japan and south America citrus that is immune or partially immune to the disease are planted. Copper sprays of six or seven applications, are used in Japan and South America, but this control method gives only partial control. In Japan the moderately effective resistant Unshiu (Satsuma) orange is planted and then wind breaks, pruning out the diseased branches and new shoots plus the application of copper sprays are used.

Bacteria Carrying Asian Citrus Psyllid

When it comes to citrus diseases that are alarming the latest citrus disease called Huanglngbing (HLB) caused by the bacterium, *Candidatus Liberibacter asiaticus* moves into first place. Once a citrus tree is infected with this disease there is no known cure and the only way to prevent the spread of this disease is by destroying the tree. The carrier of this bacteria is an insect called the Asian citrus psyllid, *Diaphorina citri.* The disease and the insect that carries it have co evolved over time so that the insect isn't harmed but the plant that the insect feeds on is damaged by the bacteria to the point of death. The damage includes: loss of citrus production, flavor of the fruit becomes bitter and the tree dies.

The Asian citrus psyllid are insects called jumping plant lice. They are usually found only on specific plants. In this case the citrus plants and a few related plants are where they feed and exist. They are a primitive insect in the same true bug classification with aphids, scale insects and whiteflies. By primitive they have been around this earth for close to two hundred and fifty million years. They were here before the plants that started growing from seeds or so called flowering plants; instead they grow from spores like fern plants. The citrus plant most likely was growing on the earth long before this insect came along, but the plant citrus and the insect Asian citrus psyllid now exist together and the citrus industry is doing everything possible to keep these two apart. The industry has formed an International Psyllid Genome Consortium that is gaining information on how to combat this pest problem using genetic information to discover how to alter the pest's biology thus suppressing the psillid populations in an environmentally friendly way. So we know that there are efforts being made to control this pest problem.

The psyllid has been found in subtropical Asia, Afghanistan, Saudi Arabia, Reunion, Mauritius, locations in South America and Central America, Mexico and the Carribean. This

particular psyllid (Asian Citrus Psyllid) was first found in the United States in Palm Beach County in Florida on an orange jasmine plant in nineteen ninety eight. By the year, two thousand one it had spread through thirty one counties in Florida. Since then this insect has been located in Texas, Louisiana, Georgia, Mississippi, Alabama, South Carolina, California, Arizona, Hawaii and Mexico. It is spread by nursery stock of citrus and ornamentals like the orange jasmine.

The physical damage of Asian citrus psyllid nymphs is to the new growth of the citrus foliage which include the tender knew stems and leaves.l The nymphs produce tubular strings that are made of a wax material that the contains the honeydew that they excrete when they are feeding from the plants sugar rich phloem tissues. These waxy white tubes look similar to white paste when squeezed from a toothpaste container. The tubes are hollow and transfer the honeydew from their bodies. The white waxy tubes will swell into bubble shapes along the tube. These tiny, waxy white tubes curling around the tender new stems and new shoots in citrus trees is one of the signs of an Asian citrus psyllid infestation. The honeydew that escapes from the waxy white tubules collects on the new and mature citrus leaves and attracts sooty mold fungus turning the leaf's surface into a dusty black mess.

As the Asian citrus psyllid feeds it injects a salivary toxin that hinders the growth of the citrus plant by stopping the terminal growth. This causes a malformation of new leaves and shoots. The new tender stems eventually turn black, dry up and drop from the tree. The feathery new citrus flush leaf tips twist up closing tightly. The populations of Asian citrus psyllid when over wintering tend to aggregate on the new growth of individual trees in an orchard. The aggregation and feeding distorts the leaf buds. This distortion increases the number of places for the females to lay their eggs. Newly planted young small trees can be damaged while the older trees that are more mature have enough tree canopy to take care of the larger tree's growing needs. Small newly planted trees will often need pesticide applications to control the pest.

The incomplete life cycle of the Asian citrus psyllid includes the following life stages: adults, eggs, nymphs with no pupal stage.

The adults are only one eighth to one sixth of an inch long. The adults feed with their heads down and their rear end pointing at a forty five degree angle from the leaf surface. The shape of their head requires them to use this position when feeding. They are often referred to as flea hoppers because of the way they leap off of the feeding area when they are disturbed. This is one of the characteristics used to identify them from other citrus feeding insects. They do not fly any distance. They almost just jump instead of actually fly. They feed on the underside of the very young tender leaves. The adults live for a period of one to two months depending on the weather and the host plant they have chosen to feed on. Looking down on them they have a pointed front end, short antennae and red eyes. They have wings that are mottled brown around the edge with a stripe that goes through the pattern. Their abdomens are greenish yellow to orange. When the female has fertile eggs in her body her abdomen is bright orange in color.

The eggs that the female lays are bright yellow-orange on the tips of the plants growing shoots and in the crevices of the unfolded feather flush leaves. The type of citrus decides the number of eggs the female will lay.

The grapefruit trees will receive an average of eight hundred and fifty seven eggs, the rough lemon will get an average of five hundred and seventy two eggs deposited on them. (I don't know who counted.) It takes about four days for the eggs to hatch when temperatures are above seventy seven degrees Fahrenheit.

The nymph that hatch are very small one/one hundredth to one/fourteenth of an inch in length. They are yellowish-orange to brown in color. They specifically feed on the young tender

tissue of the immature stems and leaves of the flush growth. As I mentioned before the nymphs put out a great deal of honeydew and in order to keep this honeydew away from their bodies the nymphs produce waxy white tubules that keep the sticky honeydew away from their bodies. These tubes curl up and have a balloon shaped bulb at the end. When scouting for Asiatic citrus psyllids these white waxy curled up tubes with a bulge on it is one way of identifying this pest.

I planted a citrus hedge in my back yard against the boundary fence four years ago with grapefruits, lemons, tangerenes and oranges. The plants are as high as I want so now I'm constantly cutting the new flush growth out of the tops of these plants and I'm constantly looking for the white waxy, curly tubes along with any forty five degree bugs feeding and hopping around on the leaves. That's when I'm supposed to notify "Plant Services Division of the Arizona Department of Agriculture for more information. In Yuma call (928)341-1680 for all other areas please call (602)542-0955."

Other psyllids like the Eucalyptus, tomato and Eugenia adult psyllids do not have the brown band along the edge of its wing with a clear area and its unique forty five degree tilt to the adult when feeding. The nymphs of these other psyllids do not have the same shape of the waxy tubules with the bulb that the Asian citrus psyllid has. The nymphs grow through five growth stages or instars. Their size increases every time they molt. The last instars have wing pads. The nymphs move in a slow manner and they flick their abdomen up when they are disturbed. They can only feed on the tender new stems and leaves therefore as the stems and leaves harden and age the population of Asian citrus psyllids nymph dies off. The adults move on to other plants like orange jasmine. An ornamental plant that has flushes of growth that Asian citrus psyllids can thrive on until the weather changes back to temperatures that they can exist.

If conditions stay balmy and warm like above the seventy seven degree range the Asian citrus psyllid can have as many as thirty generations per year. Each generation from egg to adult takes sixteen to seventeen days when temperatures are in the seventy seven degree Fahrenheit range. Other conditions also play a role in their survival. Humidity and plant type are also needed for the existence of Asian citrus psyllid. The humidity of fifty three percent is ideal, but reports have been made where the Asian citrus psyllid has existed in the humidity of seven percent. Asian citrus psyllid does not go into a resting stage or diapause, but the density of the populations does go down when new flush growth isn't occurring in the citrus grove.

The bacterial disease that the Asian citrus psyllid carries and infests citrus trees is called, HLB or Huanglongbing. It was first found in the month of March in Southern California. The tree was destroyed to keep the disease from spreading. It can be spread in a number of ways: an infected psyllid insect could fly into the area and infect a tree in an infected seedling citrus tree; a person taking a bud from an infected tree and grafting it to an existing root stock; or an infected seedling could be illegally carried into the area and planted.

The symptoms of an infected tree or plant include: the yellowing of the leaves on a limb or in a sector of the canopy of the tree. Deficiencies from lack of zinc or other nutrients have a pattern of yellowing that is symmetrical or on both sides of a leaf vein or along the leaf vein. The pattern of deficiency has a balance to it; but HLB disease is asymmetrical with a pattern that has no balance. The yellowing is blotchy or mottled. The discoloring will be in patches of green on one side of the leaf and yellow on the other side of the leaf surface. As the citrus fruit grows it becomes smaller than the normal fruit and the color of the fruit may stay green. The name of the disease is referred to as citrus greening. The tree will have fruit that is lopsided, with dark aborted seeds. The juice from the infected fruit has a bitter taste. Infected fruit will drop off of the tree. The tree will have less leaves and the leaves are smaller and point upward. Twig and

limb dieback takes over in the grove. Once the bacteria, HLB, is injected by the psillid the tree will not show these symptoms for two to three years. Eventually the tree stops producing fruit and dies. Antibiotics have been injected into diseased trees and they gave a temporary remission of the disease.

The citrus greening from Asian citrus psyllids is found throughout the citrus growing areas of Asia, India and the Saudi Arabian peninsula. In 2004 the two strains, L. asiaticus and L. americanus isolates of citrus greening disease were found in Brazil in infected citrus orchards in Sao Paulo state. In 2005 L. asiaticus was found in Florida. So far these two types of citrus greening haven't occurred in California.

When you start looking for this insect look for all stages in the new flush of growth on citrus trees and ornamental plants like the orange jasmine. Inspect the new growth for all stages of the Asian citrus psyllid. The life stages include the gray to brownish adults, the brightly yellow orange eggs and the red eyed nymphs. You will need a hand lens to scout the eggs and nymphs. The eggs are found in crevices and folds in the leaf. The nymphs flatten themselves around the new shoots of the tree. The adults hop around and take short flights. The adults can be caught with an aspirator. The yellow sticky card can be used also. The twisted curling shoot tips, black sooty mold on mature leaves and the white tubules are all signs of the Asian citrus psyllid. If and when you think that you have found them place the infected plant parts in a container or put the adults and nymphs in a container with alcohol in it. Then go see your local county ag commissioner.

Upon seeing and detecting this pest or the disease symptoms you should contact your agricultural commissioner so that actions can be taken to prevent any spread of the disease. If you are in an area where the
Asian citrus psyllid is established you should treat your orchard to prevent further infestation. If the area has already been treated as part of an eradication program treatment this may not be necessary.

The government agencies are monitoring for Asian citrus psyllid infestations In California and Arizona. They visually check the citrus groves and also place yellow sticky cards in citrus trees that trap adults. When the authorities find an Asian citrus psyllid they quarantine an area that is twenty miles from the site of the find. Plants and fruit cannot be removed from the site. http://www.cdfa.ca.gov/plant/pe/interiorexclusion/acp_quarantine.html is the web site for California that you can notify. Until scientists find a cure for this problem all citrus growers and nurseries are asked to assist in this program.

In Florida the Asian citrus psyllid has gotten to the point where eradication is no longer possible. Chemical pesticides are being used on the young citrus trees to reduce the damage done to the flush tissue. Young trees, new planting and nursery stock is treated. The mature trees can handle the direct physical damage done by this insect**.** Because the small and young trees can take up Admire, this chemical is being used as the number one material. The broad spectrum pesticides are used to give immediate kill until the slower acting Admire has a chance to kick in.

In Florida the Asian citrus psyllid is attacked as food by several predators. These include: lacewings, syrphids, spiders, hover flies an minute pirate bugs to name a few. The Coccinellid predatory beetles were seen to give the greatest amount of pressure to the Asian citrus psyllids. Both of these lady beetle adults and immature stages feed on the nymph stage of the Asian citrus psyllid. The importation of two wasp parasites of the Asian citrus psyllid to Florida citrus orchards is being used. An investigation for the safety of importing these predators was carried out before releasing them. These two wasps were named: Tamarixia radiata from Taiwan and

Vietnam and one was named Diaphorencyrtus aligarhensis from taiwan. These wasps were released in Florida. The T. radiata did establish itself in the citrus. The wasp lays its eggs underneath the psyllid nymph. After hatching the wasp larvae feeds on the insect, thus killing the psyllid nymph. After going through its life stages inside the psyllid nymph it emerges as an adult after chewing a hole in the body of the psyllid nymph.

Citrus Fungi Diseases

Fungi that attack citrus are like plants except that fungi do not have chlorophyll and cannot carry on photosynthesis. They have cell walls that contain chitin or cellulose and in some cases both; where as the bacteria cell walls are make up of sugars and amino acids. Some fungi only live and die with one host plant and others can live with several diffferent plants. The kind of fungi that depend on one main host are called "obligate". They need or are obligated to one host plant or animal. Other fungi can spend part of their life cycle in one plant and part of it in another host or in rotting organic matter in the soil and they are called "non-obligate". As I stated fungi are like plants in that their bodies are made up of an elongated, branched and chain like body that can be seen with a microscope.

This tube like body is called a "mycelium". And the branches that are attached are called "hyphae". Some of their hyphae are very short and some are extremely long. Usually the thickness of the hyphae have the same diameter.

Fungi can have one cell or many cells. Each cell contains one or two nuclei per cell. Bacteria have only one cell. Cell nuclei are the containers in the cell for the DNA and RNA or genome that controls what happens in the fungi. The rest of the interior of the cell or cells contain the cytoplasm, ribosomes and other vital cell parts. The growth of the hyphae or fungi takes place at the tips or ends of the mycelium.

Reproduction of fungi is by the use of spores. Their spores are specialized reproductive bodies with one or a few cells. The spores of the fungi may be formed asexually without a sexual process. In some situations the spores are produced inside a sac called a sporangium. The spores are released when the sac ruptures or in some cases when they are released out of a hole in the top of the sac. The spores can be mobile with flagella which they use to move for short distances. These movable, emerging spores are called zoospores. They can also swim in water, but they really travel the large distances either by the flow of water or some other movement like wind. Other fungi can produce spores asexually from the end of a terminals on the fungi mycelium. These are called conidia and the spores are called conidiophores.

Fungi reproduce asexually when conditions are good but when conditions are poor for fungi they depend on sexual reproduction. During sexual reproduction genes are changed thus allowing different fungi to be produced. The difference is in the gene mix. If a new type of fungi is produced that can live in poor conditions the fungi overall population will continue to thrive. This can and does happen when resistance to fungi pesticides are experienced. The asexual reproduction of fungi is responsible for the large numbers of spores that grow into vast numbers of fungi during good growing conditions. The large numbers of fungi produced depends on several needs: nutrient availability, carbon dioxide levels and the amount of light that is present. Seasonal conditions may set off the time clock in the fungi DNA that sends signals through the RNA to produce more fungi or in the case of sexual reproduction more and hardier fungi.

The RNA signals that fungi send from their DNA located in the cells' genomes to their ribosomes also produce proteins that make the walls that contain the new fungi spores plus the new cytoplasm along with more ribosomes to build new proteins that include enzymes. As a new fungi is formed the genome and DNA is divided or doubled over and over again. All the parts are

made from the food that the fungi has consumed.

Sexual production of fungi is carried out by mating procedures. When sexual reproduction is to take place the DNA of the fungi will emit signals to its RNA and the RNA will go to the ribosme with the messages needed to build the needed molecules used in sexual reproduction. In some cases like the fungi, zygomycetes, the use of hormones and pheromones are used in mating. These molecules change the tips of the fungi mycelium to attract one another. The two tips now called zygophores fuse together forming four cells. Usually three cells die and the fourth that gained genes that are mixed together becoming a sexually produced new fungi spore. This will grow into a fungi that is different genetically than the other asexually produced fungi. This is only one type of sexual reproductive methods. Just remember that the DNA or genome is where all of this starts. Here are several of the fungi diseases that attack citrus.

Citrus Alternaria Rot

Citrus Alternaria Rot affects naval oranges and lemons named Black rot. It is found every once in a while in lemons and navel oranges in the state of Arizona. California growers first described this citrus disease in eighteen ninety. It is found in most of the citrus growing areas world wide. This fungi citrus disease causes a decay in the fruit after harvest while the citrus is in storage. Black rot is the name given for the disease when it is found on navel oranges. It results in dark brown to black spots that are firm on the bottom half of the fruit. Splits in the fruit provide entrances into the fruit. By cutting the fruit in half the rot can be seen clear to the core of the fruit. During wet weather *Alternaria alternata* grow on dead citrus tissue. This fungi puts out a good deal of the conidia spores that germinate. The fruit will dry out becoming black and mummified. .

So far California has not had the toxin causing strains of Alternaria citri. When trees are in good shape they are more resistant to Altenaria rot. This disease is especially severe on split navel oranges. During the dry, hot weather that we have in Arizona splitting of our fruit encourages the disease. Some growers hold harvest until the infected fruit has fallen. This affects the yield of uninfested fruit. Premature fruit drop is the problem that citrus fruit gets in the field. Another problem is the amount of black fungal material that can contaminate the citrus harvested for juice.

Fungicides haven't been effective. Post harvest treatment with imazalil, 2,4-D has been effective when used by themselves or together. 2,4-D restricts the colonization or spread of the disease by delaying senescence and slowing the growth activity.

Phytophthora citrophthora* and *Phytophora parasitica

The fungi Phytophthora can be found in citrus growing orchards in California and Arizona. The disease exists as spores in the soil. These spores can swim in the water for short distances and are named zoospores. They infect the citrus roots. There are two diseases. One is the Phytophthora citrophthora that is active in the cool time or the year and Phytophthora parasitica that is active during warm times of the year. Phytothora citrophthora is able to move around and attack inactive citrus roots during cool weather and Phytophthora paracitica is active during the warmer time of the year and attacks active growing roots in warm soils.

Phytophthora destroys feeder roots of rootstalks of citrus that is susceptible. The disease destroys the area of the root between the vascular tissue and the epidermis called the cortex. The cortex turns soft and separates from the phloem and xylem. As the disease spreads to the vascular system the uptake of water and nutrients is limited and the plant starts a slow decline. The leaves turn light green or yellow and can drop off the tree. Symptoms of phytophthora disease appear the same as nematode disease infections, salt or even flood damage; therefore a

laboratory analysis is the only way to be sure when and how to treat the problem.

According to the University of California when a tree on the susceptible rootstock looks stressed and you think it might be infected dig up the soil around the plant and have the roots analyzed. If the time of year is during July through September check for Phytophthora parasitica. If the test sample is taken from January through March check the sample for Phytophtota citrophthora. If populations are greater than fifteen to twenty propagules per gram of soil from the root zone, the soil may need treatment.

Fumigation may be needed if the soil is infested with phytophthora or when susceptible rootstock is being planted.

Planting citrus seedlings that have been grafted to Phytophthora disease resistant root stocks and while looking for diseases resistance, rootstocks growers usually consider purchasing rootstocks that are resistant to cold weather, nematodes and other diseases. The rootstocks that have this range of disease resistance include: trifoliate orange, citrange, sour orange, swingle citrumelo, and citrange Alemow.

Chemical control for phytophthora diseases include preplant of the fumigant Metam Sodium at a rate of seventy five to one hundred gallons per acre or Vapam. Metam Sodium at sixteen fluid ounces per tree in a diameter canopy of eight feet. Apply with six to twelve inches of water. Do not plant the citrus tree for at least forty five days. Use only as a last resort after other methods have failed. Fumigants are a major air quality issue. Chloropicrin is used at a rate of four hundred to five hundred pounds per acre or sixteen ounces per tree in an eight foot diameter canopy. Use the low rate on sandy loam and the high rate on heavier soils or high clay soils. Inject seven to nine inches and twelve to eighteen inches apart and tarp immediately. Do not plant for a period of at least three months.

For non bearing trees The following is recommended in California. Mefenoxam at one to one and a half fluid ounces per one hundred gallons of water for a soil drench or Ridomil Gold SL at one to two quarts per acre as a soil surface spray.

For citrus in a nursery these should be applied as a drench at a rate of one hundred to two hundred and fifty gallon mixture per one thousand feet of row on an area wide enough for the root system. As a soil surface spray apply as a broadcast or banded surface spray to seedbeds, liners or bedded stock in enough water to get uniform coverage of their foot system.

For the use on resets or new plantings: Apply at planting and up to three applications at three month intervals to go along with growth flushes during the growing season. As a drench apply five gallons of the mix around the base of the tree within the watering ring. As a soil surface spray apply in sufficient water to obtain coverage of the soil surface that is normally wetted by irrigation. Apply spray to the surface of soil beneath the tree canopy. This should be followed with an irrigation that will wet the soil to a depth of one foot.

Use Fosetyl-Al (Allette) eighty WDG at five pounds per one hundred gallons per acre. For use on trees in nurseries only. Apply in one hundred gallons of water per acre to susceptible varieties as a foliar spray when conditions are favorable for the disease. Trees should be treated at the time of planting. Spray to wet the soil. Do not exceed four applications per year or twenty pounds per acre per year.

On bearing trees Mefenoxam at one to two quarts or (Ridomil Gold at three quarters to one and a half fluid ounces per thousand square feet is the recommendation. Phenylamide (4). Apply two to three times per year to coincide with the flushes of growth. Apply in a banded surface spray under the tree canopy. You can use up to three applications per year.

Mefenoxam (Ridomil Gold) Granules are used as a treatment when applied during March

to April followed by one of two applications at three month intervals to coincide with the trees root flushes. The rate depends on the tree size and the number of applications per year. Apply one half to one inch of water after application. Fosetyl-Al. (aliette) EIGHTY WDG at five pounds per acre. Phosphonate. Apply to susceptible varieties as a foliar spray when conditions favor the disease. Spray to wet. Do not exceed four applications or twenty pounds per acre per year. Do not apply within thirty days of harvest. Do not allow livestock to graze in the treated citrus groves.

Labels change; therefore always read and follow label directions.

Phytophthora Gummosis

The citrus diseased with P. Gummosis produces the largest number of motile zoospores. When I was growing up on a farm in a small town in the California San Joaquin Valley called Ivanhoe we had plenty of citrus groves. While I rode my bicycle on my paper route through the orange groves I saw growers on their knees scraping the bark off of the bottom trunks of citrus trees during the foggy winter weather.

Phytophthora Gummosis is a cool, moist weather fungi disease that attacks citrus groves throughout the world where citrus can grow. Hot weather slows the disease down and the dry heat can help the healing by drying the trunk of the tree. The zoospores that can live and swim in water die off. Rain can splash the zoospores onto the tree trunks allowing the infestation to spread. All grafts are susceptible to this disease when conditions are right for infesting.

Chemical control includes the use of pre-plant Fumigation using: C;hloropicrin, Metam Sodium or Vapam. Post plant applications of copper spray powders added to water making it a consistency of house paint. Spray on the trunk and crown after the infected bark has been removed. The use of copper sprays are also used as preventive measures in known areas where gummosis is a problem. Allette is also applied as spray paint applying the paint from the ground up to a point that is two feet above ground. Use no more than four applications per year. Always follow label directions.

Anthracnose *Colletotrichum gloeosporioides*

Anthracnose damages to citrus trees include twig dieback, leaves the drop before they mature, staining on fruit that is dark colored and fruit decay after being harvested. As the fungi spread, the leaves and twigs become infested with the fungi spores. On the old dead wood, the fruit will produce these symptoms will. Wet weather in the California central valley and fog allow spores from anthracnose to drop on the fruit. These droplets infect the rind causing streaks on the immature fruit that are dull, reddish to green on fruit that hasn't matured and brown to black streaks on the mature fruit.

Septoria fungi will often occur along with the Antrracnose disease. The stains do not wash off in the packing houses, but it is not usually bad enough to condemn the fruit. Sometimes a detrimental condition happens when the use of insecticidal soaps are used that can damage the natural skin was on the fruit peel and this can increase the disease damage.

Chemical controls include Abound. This is a quinone outside inhibitor or Zinc sulfate with copper sulfate/hydrated lime. Use label rates and follow restrictions.

Armillaria root rot *Armillaria mellea*

Armillaria root rot comes from the native woody plants of California. Citrus groves that have been planted on old flood plains,, hillsides, river beds and are subject to overflow are more likely to get this disease. The fungi lives for years in dead or living roots of fruit and nut trees, native and ornamental trees. Places that are old stream beds or near moist soils that harbored stumps which contained the fungi are contaminated areas. This disease is rarely a problem in the

dry desert soils.

This fungus, Armillaria root rot, can kill citrus trees. The symptoms include poor growth, dieback of new shoots, small leaves that start to yellow and leaf drop. The fungi spreads by the root growth into the rhizomorphs (black strings of fungi mycelia). This mycelia can grow and contact the citrus roots. This pathogen invades the crown and roots of the growing plant. These fungi mycelia will get inside the crown and girdle the crown infesting the entire root system of the tree. It spreads into the roots as white mycelial plaques into the cambium which is located between the bark and wood of the tree. This is used to distinguish this fungi disease and other diseases. During the late fall Armillaria will form mushrooms at the base of the tree a few days after a rain. Oak trees have the same disease.

The disease is controlled mainly by locating and removing infected trees. Also remove the healthy nearby trees because their roots are probably infected. Chemical control includes Enzone. This is a fungicide and follow label directions and restrictions.

Botrytis Diseases *Botrytis cinerea*

When the citrus tree is injured it becomes accessible to the Botrytis pathogen. This fungi enters through the injuries and when inside it infects by forming gray, velvety mats of spore tissue. Twigs die back. The blossoms become infected and result in dropped fruit or injury to the fruit. The injury on the fruit causes ridges that reduces the value of the fruit. During post harvest storage the disease is described as "gray mold".

When conditions are wet and cool the disease apppears on twigs, blossoms, leaves and the fruit. Botrytis is a minor problem and can be avoided by preventing injury to the citrus crop. The use of frost protection, avoiding mechanical injury and pruning to allow air movement will help to avoid Botrytis disease. Chemical control includes the use of copper and benzimidazole fungicides before rain or foggy conditions. Also during these moist cool conditions postharvest treatment of the fruit may be required for storage and marketing. For Pre harvest copper fungicides are used and for postharvest treatments Graduate, Fludioxonil, or Penbotec, Pyrimethanil, are used as a dip or a spray.

Citrus Brown Rot, Phytophthora spp.

This is a disease caused by a group of Phytophthora species when conditions are cool and wet. The fruit growing on the lower branches of the citrus trees receive splashes of water containing the disease. Rainstorms can cause the water to puddle up and then the rain drops cause the splashing of the Phytophthora spores to land on the leaves making up the skirt of the tree. The disease builds up on these leaves as long as the weather is wet. The fruit may not show the disease and this will cause an infection to other stored fruit while in storage.

The fruit when nearly mature or mature will show symptoms that have leathery lesions and have a watery soaked look to them. The fruit turn soft and color tan to olive brown with a pungent odor. The diseased fruit eventually drops to the ground. Sometimes the twigs, leaves and blossoms are infected, turn brown and die.

Control includes pruning the skirts of the tree to a twenty four inch level. A spray of copper fungicide with Zinc sulfate for safety can be used in October and December where rain is a problem and this includes fog. Spray the skirts of the tree to a height of four feet, and on the ground beneath the tree. Bordeaux can be used on oranges, grapefruit and lemons where their hasn't been any injury to the trees from copper sprays. When copper damage is a problem the use of Aliette may be needed.

Citrus Nematode *Tylenchulus semipenetrans*

According to surveys on citrus nematode infestations: California and Florida have a range

of fifty to sixty percent and Texas and Arizona have a range of ninety percent. Citrus nematode infestations are a problem disease.

Nematodes have the body of a worm with a distinct head with head shields and lips with teeth in their inner edges. The body is microscopic on the Citrus nematode. The skin or epidermal is composed of single cells with a cuticle that has layers of thickness. The nematode is an animal and its cells are not contained in cell walls like the bacteria and plants. Like other living things the nematode cells contain the living guiding DNA along with its RNA. The nematodes do not have a stomach, but it does have a gut that is lined with digestive glands producing enzymes that break down the food that they consume. In some cases the enzymes are injected into the plant by the fungus when feeding to break down plant systems to liquid which is sucked in by the nematode.

At the rear end of the gut is the rectum. The gut has muscles that controls the movement of the food. Nerves run the length of the body that control the movement control and sensory needs. At the head the nerves form a ring around the pharynx serving as a brain. The body is covered with sensory bristles that aid in the sense of touch. The nematode are usually male and female with the female being the larger. Both have sex organs. Females have ovaries and a vagina. The males have testes and ejaculatory duct to eject sperm. The male has a bent tail to hold the female during sex. The sperm are mobile once they are injected into the vagina. Eggs are laid or may stay in the uterus until they go through the first molt casting off the egg shell; then the first molt skin. They have four molts before becoming adults.

The damage to citrus trees depends on the age and health of the tree. Young trees that are planted in nematode infested soils are more susceptible to nematodes and will shown signs that include decline of the tree. Older trees may not show signs for years and can grow and produce without any signs of infestation. The only firm test for nematode infestation is the use of field soil tests. These tests should be taken before planting especially if it is known that the previous crop had been infested.

In California the use of pre plant applications of fumigants is recommended if the area of planting is approved for fumigant use. Some areas have restrictions. Metam, Vydate and Telon are three of the fumigants that kill nematodes.

Acknowledgements

http://en.wikipedia.org/wiki/Fungus
http://www.wisegeek.com/what-are-viroids.htm
http://ag.arizona.edu/pubs/diseases/az1154/
http://anrcatalog.ucdavis.edu/pdf/8218.pdf
http://www.ipm.ucdavis.edu/PMG/selectnewpest.citrus.html
http://en.wikipedia.org/wiki/Nematode
http://www.azda.gov/psd/acp.htm
http://www.azda.gov/PSD/Asian_citrus_psyllid_info.pdf
http://cals.arizona.edu/PLP/plpext/diseases/fruits/citrus/lemon.html
http://ag.arizona.edu/crop/citrus/diseases/citrusdiseases.html
Agrios,George N., Plant Pathology 1988 by Academic Press Inc.