A Texas Citrus
Pest Management Strategy

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Texas Citrus Pest Management Strategy Summary

Research Needs:

- Microclimates exist in the Texas Lower Rio Grande Valley citrus producing region, generally with an east to west trend. More information is needed on this phenomena's impact on pests and ultimately, pest management strategies.
- Many of the classical examples of biological control are found in US citrus. In Texas there are numerous pests that are held below damaging levels by naturally occurring and imported organisms. This is often a delicate balance and additional work is needed on the establishment and maintenance of biological control organisms in Texas citrus.
- Research is needed on the impact of insecticide applications on non-target organisms with emphasis on recently discovered chemistries with novel and often selective modes of action.
- Many new pesticide chemistries have been developed in the past decade. Work is needed to determine new pest management alternatives for problem organisms in Texas citrus.
- Pest management strategies for aphids may become increasingly important.
- Recognize that a pest management strategy may be crop specific but must contain strategies (sub strategies) for each organism (pest) negatively impacting the crop while continuously being respondent to the needs and demands of a modern society.
- Funding is needed for nonchemical pest management research strategies, such as: biocontrol programs (predators, parasites, pathogens, and biocontrol materials), habitats of beneficials, mating disruption, and resistant varieties.
- Critical to the Texas citrus industry is the availability of certified, virus-free budwood for citrus cultivars that are commercially important.
- Improved sampling techniques are needed for early detection of melanose.
- Improved methods for detecting CTV infected citrus, particularly at the field level.
- More work is needed on citrus psorosis transmission.
- Increase the number of certified viroid free budwood sources.
- Investigate the potential for using commercially available coverings to keep citrus row middles clean.

- Research is needed on quick acting post emergence herbicide to help control unexpected flushes of weeds in citrus groves.
- Entomopathogenic nematodes could be an important root weevil biological control. Texas research in this area is needed.
- The role fire ants play in root weevil mortality needs to be investigated.
- Improved control of leaf cutter ants is needed.
- Work is needed on the management of vines in citrus groves.
- Sampling methods for citrus pests needs to be improved, especially for minor pests.
- Research and demonstration work is needed on modern crop oils, their impact on citrus trees and role when used in conjunction with newer classes of pesticides.
- Investigations are needed into citrus mites' natural mortality factors to determine impact on population dynamics focusing on situations that occur during outbreaks and relationship(s) to damage.

Extension (Education) Needs:

- It is critical that knowledgeable individual(s) be available that can study, analyze and react to citrus pest management needs.
- There is a need for an organized system of crop managers that keeps pace with day to day field level crop pest dynamics.
- The use of remote sensing technology is helpful in detecting blackfly infestations.
- It is critical that growers have a ready source of pest management information. On-line computer-based bulletin boards or world wide web sites can provide this. Some readily available printed material should also be available through county Extension offices.
- It is important to make available an annual citrus production educational program that discusses the latest industry needs, trends and research developments.

Regulatory Needs:

- A system is needed that has the capability of responding to regulatory issues that could potentially impact citrus pest management implementation.
- Regulations and procedures are needed to prevent exotic pests from entering Texas citrus producing areas.
- Quarantines to help prevent root weevil movement into non-infested areas are important.
- A control for the pathogenic fungus, *Mycosphaerella citri* which causes the disease greasy spot is needed. A combination of affective materials is important because of potential resistance. Registration of Enable is important.
- An adequate control for “root weevils” is needed. There is a current Section (18) for bifenthrin (Capture 2EC).
- Registration for fipronil for leaf-cutter ants is needed. Regulatory officials are encouraged to move on this issue.
- An affective vine control method is needed for Texas citrus.
- Pipeline materials for citrus mite control include spirodiclofen (Envidor®) and milbemectin (Mesa™).
- A promising pipeline material for armored scales is the insect growth regulator (IGR) (pyriproxyfen).
- Pipeline material for leaf miners in citrus is the insect growth regulator (IGR) (pyriproxyfen) and a mite fat metabolism antagonist, spirodiclofen (Envidor®).

Preface

This is an attempt to organize into one document material related to managing pest organisms that currently cause problems during a production cycle of Texas citrus. The information contained herein is based on information found in agricultural literature and through personal communication with individuals associated with the Texas citrus industry. All of the technical material is on the world wide web or in printed media. The basic component in this treatment of pest management in Texas citrus is the pest by pest discussions of each respective pest and suggested strategies for management. The steps followed in the development of a Texas pest management strategy were: gathering technical material, writing a rough draft, faculty review of draft, grower evaluation and comment of draft, then a final document.

Introduction

Texas Citrus:

Citrus production in Texas is believed to have begun in 1849 near Brazoria, Texas. Later in 1882 citrus trees, planted as seed, were grown near Edinburg and this is the earliest production record in the Texas Lower Rio Grande Valley. By 1910, Texas citrus had expanded to 883,406 trees or about 6,000 acres. Another expansion in the 1940s brought the State's acreage to over 100,000 acres, the all time high. Texas currently has approximately 32,000 acres of commercial citrus.

The overall limiting factor in citrus tree survival is extreme cold. Major frost in the late 1940s, 1951, 1962, 1983 and 1987 have caused significant fluctuations in Texas tree inventory. The industry is still rebuilding from 1983 and 1989 freezes that not only reduced acreage significantly, but also impacted grower interest, market confidence and reliability.

Today, the Texas citrus industry is found principally in the Rio Grande Valley's Hidalgo, Cameron, and Willacy counties. Approximately 70 percent of this acreage is grapefruit with the balance mainly in oranges. Hidalgo county has 83 percent of the total Texas citrus acreage followed by Cameron and then Willacy counties. Annual Production is approximately 350,000 to 400,000 tons ranking Texas third in US citrus.

With the discovery of the seedless and brightly colored Ruby Red and Rio Red grapefruits, Texas citrus has become world renowned. The State's acreage is now nearly all comprised of Rio Red and the Texas citrus industry focuses on marketing 'high eye appeal' packaged fruit. This "fresh market" product requires a much higher quality fruit than for processing. Texas oranges, even though not as physically attractive as those grown in other areas, like grapefruit are well known for low acidity and thin peel.

Freezing temperatures have impacted Texas citrus pest management by releasing pests that were apparently previously maintained at acceptable levels by naturally occurring organisms. Following the 1983 freeze, citrus blackfly populations have become more widespread than pre-freeze levels and after the 1989 freeze, the California and Florida red scale have become more devastating.

The concept of a pest management strategy is nothing new to Texas citrus. Three publications, <u>Concepts of Pest Management</u> and <u>Pest Management Guidelines</u> by Leon Smith, Harold Browning and Bob Cartwright along with <u>Development of Integrated Pest Management in Texas Citrus</u> by H. A. Dean, J. Victor French and Dave Meyerdirk have addressed the subject, presenting ideas and considerations for implementing pest management in Texas citrus. These publications used time-tested techniques developed out of a need to have a sustainable Texas citrus industry that is compatible with modern society. The following discussion is a contemporary view of Texas citrus pest management based on the impact regulations have on pest control options and integration.

Pest Management:

Pest management strategies have always been dependent on the knowledge that certain chemical intervention methods of pest control would be available as the need arose. A part of basic pest management research involves specific pesticide controls. Known chemicals would provide a specific level of control for each given pest as discovered through research. When pest counts reached treatable levels, known pesticides would provide a level of control for a certain period of time.

As different pesticides come on the market, research is needed to determine the level and duration of control that could be expected for each respective chemical. Additional research is needed to determine effects on non-target organisms. Chemical control agents have varying effects and these influences on natural controls ultimately impact pest management strategies.

The purpose of a pest management program is to achieve satisfactory long-range pest control through an integration of techniques that will maximize net profit to growers in a social, environmental and ultimately ecosystem compatible manner. A general understanding of a respective pest/host/crop interaction and the subsequent identification of pests and beneficials and definition of pest status would be important considerations in the early developmental phases of a sound PM program. This objective is approached through the “integration” of various PM tools, generally with emphasis on preventive methods and preservation of natural control agents. Ideally, this objective is achieved with minimum chemical intervention. The integrated components include: Regulatory, quarantines, cultural control, biological control, chemical control and education.

Regulatory:

As noted, a pest management program or strategy first line of defense is often some form of chemical pest control. Regulations through label changes or product cancellation can limit or alter the availability of certain pest management tools and potentially have serious impact on the prevailing pest management strategy. The contemporary approach to pesticide regulation is for the regulatory community to pay very close attention to pest control needs in the field and thus insure as regulations are developed critical pest managements needs are not overlooked. This approach to pesticide regulation necessitates a very thorough understanding by the regulatory community of day to day field level pest problems. Communication between regulators, producers, commodity groups and research and agricultural education organizations are extremely important.

The Food Quality Protection Act (FQPA) was enacted in August of 1996 with a legislative intent of better protecting the American public from dietary and non-dietary pesticide exposure. Provisions in the law included single health-based standards for food, explicit language on children’s exposure to residues in food and the concept of aggregate exposure or a single ‘risk cup’.

Following the enactment of the FQPA, the Environmental Protection Agency established new pesticide registration standards. Among these actions was the ruling that certain classes of pesticides may be a public health hazard. These targeted pesticides include the organophosphate and carbamate insecticides and ‘B2' listed suspected carcinogens-mostly fungicides. Many of the chemicals currently used in citrus are directly impacted by Food Quality Protection Act regulatory actions and could potentially have use limitations.

Quarantine:

A wide variety of pests occur in areas outside this country but are not found in any of the states. These organisms survive on a host suitable to each one's respective need and a suitable host are often common in the United States. Keeping these potential pests from crossing borders is an ongoing component of pest management.

Cultural Control:

Cultural control employs the management of horticultural production techniques to prevent pest problems. These can include all phases of production but should be a major consideration during the orchard establishment process. The goal is to create an environment that is as unsuitable as possible to potential pests while optimizing production potential. Selection of a rootstock with pest tolerance, orchard site selection and planting schemes are all cultural management options.

Biological Control:

Most of the citrus biological control work has involved insects. Some biological control research on weeds has been done in other crops and opportunities exist in citrus. Successes include the control of St. Johnswort in rangeland using the beetle, Chrysolina quadrigemina and a beetle Phytophthora palmivora for control of strangler vine (Morrenia odorata) in citrus. Classical examples of biocontrol often refer to success in controlling a citrus insect, the cottony cushion scale, during the late 1800s in California.

Predators and parasites are the most notable biocontrol agents of mites in Texas citrus. However, based on current understanding, diseases that affect mites are probably as important. Chemical treatments for the Florida red scale, the purple scale, clover scale and citrus mealy bug are generally not required because of parasitic and predatory insect biological actions. Satisfactory biological controls exist but often to a lesser extent for the California red scale, the chaff scale, the brown soft scale and the barnacle scale which can rise to pest status following a broad spectrum insecticide application.

Because of the variety of citrus pests either partially or completely controlled by natural or biological means, and as newer narrow spectrum insecticides are developed, the prospects for sustainable biological control in citrus are better than ever before. New emphasis should be placed on this aspect of a citrus pest management strategy, taking a close look at the impact of newer insecticide chemistries and their subsequent influence on citrus biological control. Many new opportunities probably exist.

Chemical:

The mainstay of modern agricultural pest control has been agricultural chemicals. As technology has advanced, particularly since World War II, the availability of effective and economical pesticides has helped produce the abundance of food and fiber that society has come to enjoy and expect. The screening of pesticide products for efficacy against citrus pests will continue to be a major part of any citrus pest management strategy. While the need for new citrus pesticides may be argued in some circles, it is important that we understand not only efficacy against pests but the role and impact each pesticide compound will have in the citrus ecosystem.

Education:

Providing pest management information to producers should be a key component of any pest management strategy. Field level scouting and timely communication with a respective grower is the cornerstone to implementing crop level pest management. The accuracy and timelessness of field level pest situations delivered to decision makers facilitates pest management implementation. Knowing the severity of a particular pest’s infestation allows for the most judicious use of pest management tools and will ultimately lead to minimal environmental disruptions including impact on non target organisms.

Texas Citrus Pest Management Strategy

The following is a discussion of pest problems in Texas citrus and the components that should be addressed in the development of strategies for dealing with each problem organism. The material will focus on classical pest groupings- insects, diseases/nematodes and weeds. The management components will be pest monitoring, natural control (includes biological, resistant varieties), physical control (cultivation, sanitation etc.), chemical control and grower/public education. Most of the important citrus pests will be examined in light of each of the management components along with current knowledge relevant to each species and potentials for significant research.

Texas Citrus Pest Management

There are many citrus pest management strategy components that are shared across pest lines. The following is a listing of 'shared' approaches that are often applicable for more than one pest.

- Key to pest management success is field level day to day knowledge of pests' status where grove monitoring or sampling provides the basic information for most pest management related decisions.
- The use of rootstock with acceptable disease tolerance and good horticultural characteristics is an important 'first-step' in the implementation of citrus pest management.
- Orchard site selection is important because of influences on irrigation, ease of pesticide application and to minimize cold damage.
- It is important to take steps to preserve beneficial organisms and monitor their status.
- When chemical applications are warranted, use products that are economical and efficacious that will have a minimal off-target impact.

TEXAS CITRUS PEST MANAGEMENT

PEST BY PEST

Pest:

Citrus Blackfly, *Aleurothrixus woglumi*

Citrus Rust Mites, *Phyllocoptruta oleivora* (Ashmead)

Texas Citrus Mite, *Eutetranychus banksi (McG.*)

Citrus Red Mite, *Panonychus citri* (McG.)

False Spider Mite, *Brevipalpus phoenicis* (Geijskes)

California Red Scale, *Aonidiella aurantii*

Chaff Scale, *Parlatoria pergandii*

Florida Red Scale, *Chrysomphalus aonidium*

Purple Scale, *Cornuaspis beckii*

Brown Soft Scale, *Coccus hesperidium*

Texas Leafcutting Ant, *Atta texana* (Buckley)

Fire Ants, *Solenopsis* spp., *Solenopsis geminata*

Root Weevils, *Diaprepres* spp., *Pachnaeus* spp.

Thrips, *Frankliniella* sp.

Greasy Spot, *Mycosphaerella citri*

Melanose, *Diaporthe citri*

Phytophthora, *Phytophthora* spp.

Tristeza (citrus tristeza virus)

Psorosis

Citrus Exocortis Viroid

Cachexia Viroid

Weeds

Citrus Pest Management Strategies

Citrus Blackfly

The citrus blackfly feeds and develops on a leaf's undersurface where it's nymphal stages suck sap and secrete honeydew. This honeydew serves as a growth media for a sooty mold fungus that over time will blacken leaves and fruit. Feeding and the often associated sooty mold can cause fruit yield reductions. However, because of what is believed to be affective biological control, the citrus blackfly is only an occasional pest.

Monitoring: There is little definitive information available on sampling techniques for the citrus black fly other than those for the whiteflies in general. It is important to observe for the presence of sooty mold development plus inspect the underside of leaves for black fly larvae and pupal cases. Yellow sticky cards are attractive to blackfly adults. An absence of noticeable parasite and predator populations coupled with an increase in black fly numbers and honeydew may warrant insecticidal treatments.

Natural Control: Blackflies are attacked by a number of parasites and predators. These include several very small wasps, lady beetles, lacewings, thrips, mites and ants. Two of the most affective blackfly biological control organisms are the parasites *Amitus hesperidum* and *Encarsia opulenta*. Both species are blackfly specific internal parasites that when emerging as adults leave the infested pupae via characteristic exit holes.

Physical Control: Helpful blackfly cultural control techniques include keeping orchards clean from weeds and pruning diseased and dried tree branches. Activities that will promote healthy trees such as fertilization and moisture management are a plus as well.

Chemical Control: Materials available for citrus blackfly outbreaks in Texas include: aldicarb (Temik® 15G), chlorpyrifos (Lorsban™ 4E), ethion (Ethion 4M), fenpropathrin (Danitol® 2.4E), imidacloprod (Provado®1.6F, Admire® 2F), methidathion (Supracide® 2E), petroleum oil, pyridaben (Nexter® 75W), pyriproxyfen (Esteem® 0.86EC). See Table 1 for use and performance information.

Citrus Blackfly Pest Management Strategy:

< Monitor for blackfly adults and immatures on the undersurface of leaves and check for sooty mold. Yellow stick traps can give an advanced warning of population increases.

< Additional research on blackfly sampling and damage thresholds is needed.

< The use of remote sensing technology is helpful in detecting blackfly infestations and continued availability of this information is important.

< Use latest chemical treatments where biologically, environmentally and economically feasible.

< To minimize chemical resistance alternate chemicals attempting to use a specific material only once a year.

< Explore blackfly natural mortality factors to determine impact on population dynamics.

< Remain current on chemical pest control alternatives documenting not only efficacy but impact on non-target organisms and the implementation of citrus pest management.

< Make available to growers daily field observations on blackfly development during generally excepted outbreak periods.

< TO DO: Research on the population dynamics of the citrus blackfly to determine basis for occasional outbreaks. Investigate the interactions of the blackfly and biological control organisms to determine if parasite/host balance is related to pest outbreaks. Stay abreast of new chemical control options.

Citrus Rust Mites:

The Citrus Rust Mite feeds on fruit and foliage. Feeding is on fruit surfaces causing cell destruction and ultimately a russeting appearance. On severely damaged fruit the rind will crack.

<u>Monitoring</u>: Because of seasonal citrus rust mite population peaks and variations in these peaks it is critical in a citrus pest management strategy to know mite abundance at any point

in time. Sampling procedures and action thresholds are currently available that are based on mite density and number of infested fruit. Dynamic treatment levels are often used because of pest reaction to moisture which is impacted by irrigation schedules and weather. The citrus rust mite is often more damaging in dryer years even though higher humidity favors population increases.

Natural Control: Natural and biological control of the citrus rust mite is not well understood. Under favorable weather conditions naturally occurring entomopathic fungi can influence mite population levels but this can be retarded by some citrus disease sprays, particularly those containing copper. There are known predators but the influence on mite populations is not well documented.

Physical Control: Removing of tree limbs and trash can help reduce overwintering populations and hamper the following seasons' mite population buildup. Citrus mites appear to distribute themselves in citrus trees, orienting away from the light. Investigating the citrus rust mite aversion to light may lead to inexpensive management options.

Chemical Control: Materials available for citrus rust mite outbreaks in Texas include: abamectin (Agri-mek® 0.15EC), aldicarb (Temik® 15G), chlorpyrifos (Lorsban™ 4E), dicofol (Kelthane™ 4MF), diflubenzuron (Micromite® 25WS), ethion (Ethion 4M), fenbutatin-oxide (Vendex® 50WP), fenpropathrin (Danitol® 2.4E), formetanate hydrochloride (Carzol® 5P), petroleum oil, oxamyl (Vydate® L), propargite (Comite®), and pyridaben (Nexter® 75W). A pipeline material is spirodiclofen (Envidor). See Table 1 for use and performance information.

Citrus Rust Mite Pest Management Strategy

< Avoid using copper-based fungicides where possible

< Use Chemicals with proven efficacy.

< Early season control is important to allow for adequate fruit sizing.

< In scouting programs include occurrence of fungi infected mites.

< Monitor population levels and use established treatment thresholds being sensitive to known mite spacial clumping patterns. Sample more frequently post bloom, in the fall and when relative humidity is above 70 percent.

< Make decisions on market, fresh vs. processed, early in the season so tolerances to higher mite populations can be established.

< Use latest chemical treatments where biologically, environmentally and economically feasible.

< To minimize chemical resistance, alternate miticides attempting to use a specific material only once a year.

< Explore mite natural mortality factors to determine impact on population dynamics.

< Use orchard planting schemes that are least favorable to mite development. More trees per acre create a favorable mite environment.

< Use blemished fruit in fresh market sales when possible to demonstrate that damaged fruit is not inferior.

< Make available to growers daily field observations on mite development during generally excepted mite outbreak periods.

< Remain current on chemical pest control alternatives documenting not only efficacy but impact on non-target organisms and the implementation of citrus pest management.

< TO DO: Additional information is needed on treatment timing and chemical compatibility. A better understanding of mite aversion to light could be important.

Texas Citrus Mite:

Texas citrus mite feeding injury is characterized by minute chlorotic spots that gradually become so abundant that infested leaves appear 'silvered'. Heavy damage can cause defoliation, which is generally most severe in early fall. These mites are often found on the upper leaf surface congregating near the midrib and along leaf margins.

Monitoring: Because of seasonal citrus rust mite population peaks, and variations in these peaks, it is critical to a citrus pest management strategy to know mite abundance at any point in time. Sampling procedures and action thresholds are currently not well known for the Texas citrus mite but chemical treatments should be based on mite occurrence, not a calendar date or neighboring orchard activities. Note reference to predicious mites in the natural control section. These mites(Texas citrus) are known to feed primarily on upper leaf surfaces and seldom on fruit.

Natural Control: Natural and biological control of the Texas citrus mite is not well understood. However, there is some indication that predacious mites may reduce citrus mite populations. There are other known predators but the influence on mites is not well documented. Under favorable weather conditions naturally occurring entomopathic fungi can influence citrus mite population levels but this can be retarded by some citrus disease sprays particularly those containing copper. The higher humidity which offers a favorable development environment for pathogenic fungi also favors the development of certain citrus diseases. Hence, the need for sprays that control the citrus diseases but at the same time are detrimental to mite attacking fungi.

Chemical Control: There are a number of new miticides currently being developed by the Agriculture Chemical industry. Efficacy/impact (relative toxicity against target and non-target species) of these in the citrus ecosystem is not well documented. This is an area that needs attention. Current pest management alternatives include: abamectin (Agri-mek® 0.15EC), aldicarb (Temik® 15G), dicofol (Kelthane™ 4MF), ethion (Ethion 4M), fenbutatin-oxide (Vendex® 50WP), fenpropathrin (Danitol® 2.4E), petroleum oil, propargite (Comite®), pyridaben (Nexter® 75W) and pyriproxyfen (Esteem® 0.86EC). See Table 1 for use and performance information.

Texas Citrus Mite Pest Management Strategy:

< Avoid using copper based fungicides where possible.

< In scouting programs include occurrence of fungi infected mites.

< Monitor population levels by using established treatment thresholds and sampling techniques, being sensitive to known mite spacial clumping patterns.

< Make decisions on market, fresh vs. processed, early in the season so mite treatment level tolerances can be planned.

< Use latest chemical treatments where biologically, environmentally and economically feasible.

< Take precautions to avoid high mite numbers during periods of low moisture.

< To minimize chemical resistance alternate miticides attempting to use a specific material only once a year.

< Explore mite natural mortality factors to determine impact on population dynamics.

< Remain current on chemical pest control alternatives documenting not only efficacy, but impact on non-target organisms and the implementation of citrus pest management.

< Use orchard planting schemes that are least favorable to mite development.

< Use blemished fruit in fresh market sales when possible to demonstrate that damaged fruit is not inferior.

< Make available to growers daily field observations on mite development during generally excepted mite outbreak periods.

< TO DO: Research on sampling for Texas citrus mites is needed.

Citrus Red Mite:

Citrus red mite feeding can result in a pale stippling on the upper surface of leaves and in severe infestations, the stippled becomes dry and necrotic followed by leaf drop and twig dieback. If heavy feeding occurs on nearly mature fruit, a persistent silvering will often result.

<u>Monitoring</u>: Management thresholds for the citrus red mite is 3-5 mites per cm^2. This is the standard for the citrus mite complex and takes into consideration circumstances that generally occur getting control measures into place after an infestation is detected. The

citrus red mite is distinguished by its purplish-red body that has numerous bristly red tubercles. Females have a globoid shaped body and the males are some what smaller with a more pointed abdomen. These mites are usually most abundant on the upper surface of newer leaves.

Natural Control: The citrus red mite is known to be attacked by several species of predaceous mites, green lacewings, brown lacewings, lady beetles and the parasitic fungus Entomopthora spp.

Physical Control: Applications of oil sprays to citrus trees have been shown to have little effect against the red mite. Good orchard sanitation may delay mite infestation build ups in some situations.

Chemical Control: Chemical control of the citrus red mite has been generally successful to date. However, there have been concerns that the use of certain broad spectrum insecticides in citrus pest management programs may contribute to an increase in pest status of the red mite because of a possible impact on non-target organisms. Currently there is a heavy reliance on organophosphate and carbamate insecticides for red mite control. Pest management alternatives include: abamectin (Agri-mek® 0.15EC), aldicarb (Temik® 15G), dicofol (Kelthane™ 4MF), ethion (Ethion 4M), fenbutatin-oxide (Vendex® 50WP), fenpropathrin (Danitol® 2.4E), petroleum oil, propargite (Comite®), pyridaben (Nexter® 75W) and pyriproxyfen (Esteem® 0.86EC). See Table 1 for use and performance information.

Citrus Red Mite Pest Management Strategy:

< Avoid using copper based fungicides where possible

< In scouting programs include occurrence of fungi infected mites.

< Monitor population levels by using established treatment thresholds and sampling techniques being sensitive to known mite spacial clumping patterns.

< Research on sampling for citrus red mites is needed.

< Make decisions on market, fresh vs. processed, early in the season so mite treatment level tolerances can be planned.

< Use latest chemical treatments where biologically, environmentally and economically feasible.

< To minimize chemical resistance, alternate miticides attempting to use a specific material only once a year.

< Use orchard planting schemes that are least favorable to mite development.

< Use blemished fruit in fresh market sales when possible to demonstrate that damaged fruit is not inferior.

< Make available to growers daily field observations on mite development during generally excepted mite outbreak periods.

< TO DO: Explore mite natural mortality factors to determine impact on population dynamics focusing on situations that occur during outbreaks.

False Spider Mite:

False spider mites feed on fruit and leaves causing undesirable blemishes, commonly referred to as ‘nail head’ rust. On fruit the spots are often raised and variable in size ranging from pin points up to 1/4 inch.

Monitoring: Scouts should be alert to the probability of false spider mite populations in high density plantings and most citrus increases usually occur more on leaves and fruit toward the inside of the tree before being on outside leaves and fruit.

Natural Control: Little is known about natural enemies of the false spider mite. However there is some indication that predaceous mites common to Texas citrus survive on false spider mites Brevipalpus Spp. Insecticide use in citrus can influence the occurrence of predaceous mites particularly Galendromus helveolus. Predatory mites can keep populations in check except during wet weather.

Physical Control: Orchard sanitation may help create an unfavorable environment for false spider mites, however it could also influence the abundance of predatory mites.

Chemical Control: Chemical control of the false spider mite has been generally successful to date. However, there have been concerns that the use of certain insecticides in citrus pest management programs has contributed to an increase in pest status of the false spider mite possibly because of an impact on non-target organisms. Current pest management alternatives include: abamectin (Agri-mek® 0.15EC), aldicarb (Temik® 15G), dicofol (Kelthane™ 4MF), ethion (Ethion 4M), fenbutatin-oxide (Vendex® 50WP), fenpropathrin (Danitol® 2.4E), petroleum oil, propargite (Comite®), pyridaben (Nexter® 75W) and pyriproxyfen (Esteem® 0.86EC). A pipeline material is spirodiclofen (Envidor). See Table 1 for use and performance information.

False Spider Mite Pest Management Strategy:

< Focus research on false spider mite reproductive biology including haploid/diploid female phenomenon and the infrequent occurrence of males. Also evaluate the impact citrus control programs have on false spider mite outbreaks

< Closely monitor orchards receiving early season organophosphate applications.

< Monitor population levels by using established treatment thresholds and sampling techniques being sensitive to known mite spacial clumping patterns.

< Scouts should take care to sample interior of trees, looking at scared areas.

< The presence of predaceous mites is an important part of false spider mite management.

< Make decisions on target markets, fresh vs. processed, early in the season so mite treatment level tolerances can be planned.

< Use latest chemical alternatives where biologically, environmentally and economically feasible.

< To minimize chemical resistance alternate miticides, attempting to use a specific material only once a year.

< Use orchard planting schemes that are least favorable to mite development.

< Use blemished fruit in fresh market sales when possible to demonstrate that damaged fruit is not inferior.

< Make available to growers daily field observations on mite development during generally excepted mite outbreak periods.

- TO DO: Explore mite natural mortality factors to determine impact on population dynamics focusing on situations that occur during outbreaks and possible relationship(s) to mite numbers.

California Red Scale (Armored Scale):
The California Red Scale, damages citrus by feeding that may cause yellowing of leaves, leaf drop and a reduction in tree growth.

Monitoring: A damage threshold for the California Red Scale on Texas citrus is suggested to be when 5 percent or more fruit have 10 or more live scales. Care must be taken to take a sample from both east and west tree quadrants. Research strongly suggests that this pest is generally controlled by parasites and predators but can become a problem under extremely dusty or dry conditions. Orchards that have high populations of this pest followed by a mild winter are suspect for recurrent problems. Young trees are more susceptible to the California Red Scale than older ones.

Natural Control: The California Red Scale is generally controlled by several parasites including Aphytis lingnanensis. However, research suggests that untimely insecticide applications can alter this balance by killing natural enemies.

Physical Control: Orchard sanitation is important. Oil sprays have a 'physical' mode of action (suffication) and are easier on beneficials than other materials.

Chemical Control: Current insecticides registered for the California Red Scale in Texas citrus includes the following: aldicarb (Temik® 15G), carbaryl (Sevin® 80S), ethion (Ethion 4M), imidacloprod (Provado®1.6F, Admire® 2F), methidathion (Supracide® 2E), petroleum oil and pyriproxyfen (Esteem® 0.86EC). A promising pipeline material for armored scales is the insect growth regulator (IGR) (pyriproxyfen). See Table 1 for use and performance information.

California Red Scale Pest Management Strategy:

- Monitor population levels by using established treatment thresholds and sampling techniques being sensitive to known scale spacial clumping patterns.

< Monitor for males with yellow pheromone sticky traps when a noted abundance of crawlers are found after population peaks.

< Summer sprays are important, targeting crawlers.

< Investigate the role pheromone trapping may play in red scale management particularly in situations with and without organophosphate use.

< Begin monitoring in late spring to early summer and began treatments when crawlers are present from May through October.

< Make decisions on market, fresh vs. processed, early in the season so scale treatment level tolerances can be planned.

< Use latest chemical alternatives where biologically, environmentally and economically feasible.

< To minimize chemical resistance, alternate chemicals where possible attempting to use a specific material only once a year.

< Explore scale natural mortality factors to determine impact on population dynamics focusing on situations that occur during outbreaks.

< Use orchard planting schemes that are least favorable to scale development.

< Use blemished fruit in fresh market sales when possible.

< TO DO: Investigate proper timing of oil treatments.

Chaff Scale (Armored Scale)**:**

Chaff scales affect the entire tree by sucking plant sap. This can ultimately can cause leaf-drop, fruit drop, twig die back, failure too mature and green spots on fruit.

Monitoring: Monitoring for chaff scale is suggested during pre-season and biweekly scouting for rust mite. The damage threshold is when 5 percent or more fruits have 10 or more live scales. Females, eggs and crawlers of the Chaff Scale are purple and may be particularly abundant under the calyx(button) of the fruit and rind pits.

Natural Control: Several species of parasites are known natural control agents. This includes Aphytis hispanicus, Prospaltella fasciata, Aphytis lingnanensis and Aphytis comperei.

Physical Control: Orchard sanitation is important.

Chemical Control: Current insecticides available for the chaff scale include the following: aldicarb (Temik® 15G), carbaryl (Sevin® 80S), ethion (Ethion 4M), imidacloprod (Provado®1.6F, Admire® 2F), methidathion (Supracide® 2E), petroleum oil and pyriproxyfen (Esteem® 0.86EC). See Table 1 for use and performance information.

Chaff Scale Pest Management Strategy:

< Monitor population levels by using established treatment thresholds and sampling techniques being sensitive to known scale spacial clumping patterns.

< If grove chemical applications for other pest are limited be on alert for a chaff scale outbreak.

< It is important to know the impact of natural enemies such as Aphytis hispanicus.

< Make decisions on market, fresh vs. processed, early in the season so scale treatment level tolerances can be planned.

< Use latest chemical alternatives where biologically, environmentally and economically feasible.

< Dry weather is more favorable for chaff scale development than its parasites.

< To minimize chemical resistance, alternate chemicals where possible attempting to use a specific material only once a year.

< Use orchard planting schemes that are least favorable to scale development.

< Use blemished fruit in fresh market sales when possible. Fruit destined for processing generally can tolerate continued greening caused by chaff scale.

< TO DO: Explore scale natural mortality factors to determine impact on population dynamics focusing on situations that occur during outbreaks

Florida Red Scale (Armored scale):

Florida red scale feeding damage causes large yellow chlorotic spots on fruit and leaves. There is a noted preference for fruit over leaves. Does not attack limbs or twigs.

Monitoring: Orchards treated with sevin and/or sulfur may have problems with this pest. Damage symptoms include large yellow chlorotic spots on fruit and leaves. Began control when crawlers are present from May through October. Orchard history is important because this scale tends to recur in previously infested places.

Natural Control: This pest has been held in check for a number of years by the parasite Aphytis holoxanthus.

Physical Control: Orchard sanitation is important.

Chemical: Available chemicals for armored scales are as follows: aldicarb (Temik® 15G), carbaryl (Sevin® 80S), ethion (Ethion 4M), imidacloprod (Provado®1.6F, Admire® 2F), methidathion (Supracide® 2E), petroleum oil and pyriproxyfen (Esteem® 0.86EC). See Table 1 for use and performance information.

Florida Red Scale Pest Management Strategy:

< Check for Florida Red Scale during routine scouting activities.

< Initiate treatments when crawlers found on fruit, in May through October.

< Evaluate biological control before making chemical applications.

< Remain current on Florida Red Scale biology, habits and control through available information sources such as grower and Extension programs.

< TO DO: Remain current on chemical pest control alternatives documenting not only efficacy but impact on non-target organisms and the implementation of citrus pest management.

Purple Scale (Armored scale):

Sometimes called the comma scale, purple scales cause a cosmetic injury to fruit but populations can get large enough to cause plant damage. The purple scale Lepidosaphes beckii (Newman) is currently believed to be held at low population levels by the parasitic wasp Aphytis lepidosaphes (Compere). At one time this was one of the most harmful scale insects in Texas Citrus.

Current insecticides include: aldicarb (Temik® 15G), carbaryl (Sevin® 80S), ethion (Ethion 4M), imidacloprod (Provado®1.6F, Admire® 2F), methidathion (Supracide® 2E), petroleum oil and pyriproxyfen (Esteem® 0.86EC). See Table 1 for use and performance information.

Purple scale Pest Management Strategy

< Monitor for the purple scale being aware of the importance of the parasitic wasp, Aphytis lepidosaphes. Damage is similar to chaff scale, chlorotic spotting on fruit, leaves often followed by fruit/leaf drop.

< Remain current on area wide purple scale infestations through Extension educational programs and contact with other citrus interest.

< It is important to have chemical control options should an outbreak of purple scale occur.

< TO DO: Improve purple scale monitoring techniques and attempt to better define the impact environmental conditions have on population increases.

Brown Soft Scale:

The Brown soft scale is the most common scale in Texas citrus where it causes damage by sucking sap from plants. In addition the scale's 'honey dew' production provides a medium for sooty mold.

Monitoring: Brown soft scales (Coccus hesperidum L.) are primarily serious in younger groves where trees may die as a result of feeding and from the presence of sooty mold growing on scale secreted honey dew.

Natural Control: Natural enemies can help keep populations of the brown soft scale under control but orchard monitoring is important. These include Coccophagus lycimnia (Walker) and Microterys flavus (Howard). World wide there are over 30 known natural enemies of this scale.

Physical Control: Brown soft scale populations are hindered by cooler seasons. Scale migration from crops in adjacent fields can lead to problems.

Chemical Control: Chemical controls are available but care must be taken to avoid disrupting natural enemies of the brown soft scale. Timing is critical and tank mixing with oils is important but care should be taken to prevent photo toxicity. Oils should not be applied if humidity is less than 30%. Commonly used insecticides are: aldicarb (Temik® 15G), carbaryl (Sevin® 80S), chlorpyrifos (Lorsban™ 4E), ethion (Ethion 4M), imidacloprod (Provado®1.6F, Admire® 2F), methidathion, (Supracide® 2E), petroleum oil, and pyriproxyfen (Esteem® 0.86EC). See Table 1 for use and performance information.

Brown Soft Scale Pest Management Strategy.

- Monitor for the brown soft scale throughout the season but be on the alert for outbreaks in May.
- Watch young groves closely for brown soft scale. Infestations can lead to a sooty mold problem.
- A program that continually screens for new insecticide control agents is important.
- Research on the impact of chemical control agents on the natural enemies of the brown soft scale is critical to long term scale management needs.
- Lady beetles and lacewings are important predators of the brown soft scale.
- More information is needed on this scale's ability to encapsulate the eggs of attacking parasites.
- When sampling pay particular attention to old wounds in the tree bark. Scales may have a similar coloring and be difficult to spot.
- TO DO: Investigate the impact of insecticides on biological control agents.

Texas Leafcutting Ant:

Leaf cutter ants damage citrus by removing foliage from trees.

Monitoring: The Texas Leafcutting Ant, Atta texana(Buckley), builds dome-shaped nest in sandy well-drained soils. These ants cut irregular pieces of leaf which are carried to underground caverns and used as a medium for a fungi that is the ant's mainstay diet. Ant colonies may be a distance from citrus trees.

Natural Control: Texas Leafcutting ants have a number of natural enemies, generally other insects- parasites and predators. However, little is known about the impact natural enemies may have on leaf cutter ant population dynamics.

Physical Control: Physical disruption of ant colonies by mechanical means is possible but generally believed not to be practical. This method of control is a time consuming and expensive operation that to be affective must be repeated several times during a season.

Chemical Control: Products registered for citrus that will kill leafcutter ants include the following: chlorpyrifos (Lorsban™ 4E), chlorpyrifos (Lorsban™ 15g), fenoxycarb (Logic®) and acephate (Orthene 75SP). See Table 1 for additional information.

Texas Leafcutter Ant Pest Management Strategy

< TO DO: An insecticidal bait that will control the leaf cutter ant is needed.

< A methyl bromide alternative for leaf cutter ants would be a useful pest management tool. Fipronil has been shown to be the best performing material.

< Research on the impact of fungicides on leaf cutter ants is needed.

< Orchard parameter treatment with approved insecticides could help reduce leafcutter ant populations.

Fire Ants in Citrus

Fire ants can be a problem in citrus by tending insects that secrete honey dew which in turn provides a medium for sutty mold. These ants can damage tree bark and provide an entry way for disease causing organisms. Because of the ability to sting fire ants are often a nuisance to citrus production workers. Species include the tropical fire ant, *Solenopsis geminata*, along with the imported fire ants, *Solenopsis invicta* (Buren) and *Solenopsis richteri* (Forel). Chemicals include: chlorpyrifos (Lorsban™ 4E), chlorpyrifos (Lorsban™ 15g), and acephate (Orthene 75SP). See Table 1 for additional information.

Pest Management Strategy for Fire Ants In Citrus

< Fire ant mound treatment products include sevin, orthene and Lorsban.

- Remain current on chemical pest control alternatives documenting not only efficacy but impact on non target organisms and the implementation of citrus pest management.
- TO DO: Investigate the role fire ants play in root weevil mortality.

Root Weevils

There are at least 8 species of root weevils, some in the genus Diaprepes, that are known to attack citrus and other related plants. *Diaprepes abbreviatus*, the sugarcane rootstalk borer and the blue-green citrus root weevil, *Pachnaeus* spp. have been found in Texas. Damage is by larval feeding on roots resulting in girdling and a subsequent inability of infected plants to take up water and nutrients. Injured roots can become susceptible to infectious fungi such as Phythophora.

Monitoring: Root weevil infestations are detected by examining orchards for the presence of adults and feeding damage. Populations can also be detected by traps similar to those used to monitor the pecan weevil. However, damage thresholds have not been determined. Another trapping method is to shake trees, catching falling weevils on a ground cloth.

Natural Control: Entomopathogenic nematodes are known to prey on root weevil larvae however additional work is needed before this control technique is a viable pest management alterative. Under controlled conditions entomopathogenic nematodes have been shown to kill 50% of root weevils within a certain area. Birds and other insects such as the imported fire ant, prey on root weevil adults and larvae.

Cultural Control: It is helpful to keep equipment clean as it enters and leaves groves and to limit access to orchards known to be infected with root weevils. Packing equipment should be kept clean, taking care to remove and destroy any citrus tree material.

Chemical Control: Materials include Capture as a soil application and Dimilin for foliar feeding adults. Other compounds are: carbaryl (Sevin 80S), diflubenzuron (Micromite® 25WS), fenpropathrin (Danitol® 2.4E) and pyridaben (Nexter® 75W). See Table 1.

Pest Management Strategy for Root Feeding Weevils In Citrus

- Monitor orchards for root weevils adults using traps and whole tree inspection.
- When monitoring, pay close attention to rainy periods and subsequent growth flushes.
- Sanitation is important. Limit movement into and out of known weevil infested areas.
- Quarantines can help prevent root weevil movement into non infested areas.
- Citrus packing areas should be kept free of materials that may harbor root weevils.
- TO DO: Additional information is needed on chemical and biological control options. Entomopathogenic nematodes could be an important root weevil biological control.

THRIPS

Thrips' damage in citrus is characterized by an off color halo of the rind around the "button" or stem end of the fruit. In Texas the only thrips species identified to date in citrus is the western flower thrip, *Frankliniella occidentalis*. The citrus thrips *Scirtothrips citri* has not been found.

Monitoring: Begin checking for thrips as petal fall begins. Fruit is most susceptible when small, usually less than 1.5 inch in diameter. Take samples from trees several rows in from borders.

Natural Control: Thrips are attacked by predaceous mites, spiders, minute pirate bugs and lacewings. In other citrus areas of the country some predatory species are highly thrip specific and are often used as an indicator of this pest presence.

Cultural Control: There is no documented method of thrips cultural control in Texas citrus.

Chemical Control: In other citrus regions of the Country sabadilla sprays are an organically acceptable method of limiting thrips damage in citrus. Available chemicals include: abamectin (Agri-mek® 0.15EC), chlorpyrifos (Lorsban™ 4E), fenpropathrin (Danitol® 2.4E), formetanate hydrochloride (Carzol® 5P), imidacloprod (Provado®1.6F, Admire® 2F) and oxamyl (Vydate® L). See Table 1 for additional information.

Pest Management Strategy for Thrips in Texas citrus:

- Monitor early season for thrips. Continue from petal fall through 1.5 inch diameter fruit. Take samples several rows inside orchard border.
- If predatory mites are present look closely for thrips. In other citrus producing states this is considered a good indicator of thrips occurrence.
- Rotate chemicals and use only as needed. Resistance is always a possibility.
- To Do: Research is needed on thrips occurrence in Texas citrus, particularly at the species level. At present the citrus thrips has not been identified in Texas yet thrips like damage is appearing in some orchards.

Texas Citrus Diseases

Plant diseases are generally managed by preventing potential pest causal organisms from contacting host material. This can be facilitated by quarantines, inspections, chemical applications and certification programs. Host or crop plants that are resistance to diseases are often a first line plant disease pest management option. When a disease is present in an area, site selection, planting time and soil type, can impact the probability of host and disease contact. Rotation, sanitation, heat treatment and eliminating of alternate host are important in disease management. In some situations where diseases are known to develop, properly timed chemical applications are needed to insure crop protection.

The American Phytopathological Society "Compendium of Citrus Diseases" (2nd Edition) list over 70 infectious diseases of citrus. Many of these exist in Texas, however the ones discussed on the following pages are the most troublesome.

Greasy Spot:

Greasy spot of citrus is a fungal infection that causes spotting of leaves and a blotch on fruit rind.

Monitoring: Recognizing factors that foster the growth stages of Mycosphaerella citri (the causal agent of greasy spot disease) is an essential part of greasy spot diseases' management strategy. Under rainy or irrigation conditions the Mycosphaerella fruiting bodies are harbored in decaying leaf litter and ultimately release ascospores which then find their way to stomal openings on the under surface of leaves. This fungal growth inside leaf tissue develops yellow spots, which later has a 'greasy' appearance. Rust mite injury may aid infection.

Natural control: There are no biological agents affective against greasy spot in citrus.

Physical Control: Remove fallen, greasy spot infected leaves by discing them into the soil. A clean orchard floor can help prevent the occurrence of greasy spot.

Chemical Control: Copper treatments are effective against greasy spot. Applications will include: copper complex (Copper-Count®-N), copper hydroxide (Kocide®101, Champion® WP, etc.), copper sulfate (Basicop™, Top Cop Tri... etc.), fenbuconazole (Enable™ 2F) and propiconazole (Banner® EC). See Table 2.

Greasy Spot Pest Management Strategy.

- Inspect grapefruit orchards first for symptoms of greasy spot. Orchards with heavy defoliation should be watched closely. Orchards with a history of greasy spot infection should be treated at the earliest signs of yellow spots on upper leaf surface of leaves. Improved, inexpensive sampling techniques would be helpful in insuring early detection of greasy spot.
- Keep groves free of decaying citrus plant material.
- Continue to maintain world wide web based disease descriptions, photographs and up-to-date control options. Printed summaries of control options are helpful.

- Use latest chemical alternatives that are biologically, environmentally and economically feasible. Copper-based fungicides can be phytotoxic. Use of spray oils increase protection from greasy spot. The fungicides Abound 2.08F, Headline and Enable 4F are effective. Treatments following heavy rain and/or irrigation are useful. High spray volume and slow tractor speeds improve fungicide applications.
- Use blemished fruit in fresh market sales when possible.
- TO DO: Improved sampling techniques would be helpful to insuring early detection of greasy spot.

Melanose:

Melanose of citrus is caused by a fungus that will blemish leaves and fruit.

Monitoring: Melanose symptoms on leaves are small, round, off-color depressions with a yellow margin on fruit and leaves. Stems will often have raised spots. Damage is often confused with rust mite blemishes, however the latter are smoother than the rough pustules of melanose.

Natural control: Biological agents are generally not a factor in the occurrence of Melanose.

Physical Control: Removal of dead plant material from orchards is an effective melanose deterrent and often a primary line of defense.

Chemical Control: Melanose is controlled with copper-based products applied after bloom or petal fall. Materials will include: copper complex (Copper-Count®-N), copper hydroxide (Kocide®101, Champion® WP, etc.) and copper sulfate (Basicop™, Top Cop Tri... etc.). See Table 2 for additional information.

Melanose Pest Management Strategy:

< Examine fruit, stems and leaves. Note any history of disease occurrence in the orchard. Spring rains and freezing temperatures can foster the occurrence of this disease.

< Improved sampling techniques would be helpful in insuring early detection of melanose.

< Continue to maintain world wide web based disease descriptions, photographs and up-to-date control options.

< Make decisions on market, fresh vs. processed, early in the season so treatment level tolerances can be planned. Melanose damage is generally cosmetic with the exception of post harvest stem and end rot.

< Use latest chemical alternatives that are biologically, environmentally and economically feasible. Strobilurin type fungicides are effective against melanose. Copper-based fungicides, if used improperly, can be phytotoxic but offer adequate control when used as directed.

< An ongoing fungicide screening program is important in keeping the latest chemical control tools available to growers.

< Use blemished fruit in fresh market sales when possible.

< TO DO: Improved sampling techniques would be helpful in insuring early detection on melanose.

Phytophthora:

There are more than 50 species of phytophthora fungi. In citrus phytophthora organisms cause root disorders, brown rot, gumosis and a blight disease of leaves.

Monitoring: Checking trees for wounds and damage can provide information on possible Phytophthora invasion routes. Areas of groves with a history of Phytophthora that have weak or stressed trees may be more susceptible.

Natural control: Naturally occurring bacteria may be affective in reducing the incidence of Phytophthora.

Physical Control: Planting orchards in locations not previously planted too citrus is important. Rootstock should be free of phytophora.

Chemical Control: Fosetyl-Al (Aliette® WDG) and metalaxyl (Ridomil) are effective fungicides available for Phytophthora on citrus; however, some resistance to Ridomil has been noted. See table 2.

Phytophthora Pest Management Strategy

< Check orchards for evidence of Phytophthora. Look for presence of Diaprepes spp. and other root weevils in the soil around trees, tree foliage and traps (Tedders).

< Before replanting citrus following citrus allow at least on year fallow. Select root stock with known Phytophthora resistance. Manage water applications, limiting use to that necessary for optimal tree growth. Keep base of the tree dry.

< Limit use of Ridomil in situations where Phytophthora appears insensitive. Use only 1-2 Ridomil treatments per year in cases of insensitivity. Rotate materials in chemical application programs. Fumigation is an option. However, research on effective materials is needed.

< TO DO: More information is needed on phytophora management including chemical controls.

Tristeza:

Tristeza is a term used to describe similar viruses attacking citrus. Seedling yellows, sour orange decline, stem pitting on grapefruit and stem pitting on sweet orange are all expressions of the Tristeza viral strains capable of invading citrus. In Texas it is vectored by three species of aphids: *Aphis gossypii, A. spiraeola, and Toxoptera aurantii*.

Monitoring: Expressions of the citrus tristeza virus (CTV) are generally mild in Texas. The current pest management strategy for CTV relies heavily on maintaining innoculum at low levels with virus free nursery stock and preventing disease movement within orchards. One of the most feared CTV vectors, the brown citrus aphid, is currently not found in Texas; however, it is present in Mexico and Florida.

Texas Citrus Tristeza Virus Pest Management Strategy

- An aggressive campaign to use virus-free budwood.
- Diligent monitoring is important for the brown citrus aphid and other know CTV vectors.
- Regulate/prevent inter and intrastate movement of CTV infected citrus.
- Identification of CTV resistant citrus and make them available for commercial use.
- Do not allow the importation of non-certified citrus cultivars or budwood.
- Keep citrus trees healthy and without stress.
- TO DO: Improved methods for detecting CTV infected citrus, particularly at the field level.

Psorosis:

Psorosis, or scaly bark, is a viral-based disease in citrus that causes tree trunk and branch bark shelling.

Monitoring: Psorosis in citrus is caused by a complex of viral pathogens. Bark scaling (a typical symptom) coupled with chlorotic flecking in younger leaves, indicate presence of psoroosis in citrus. Precise diagnosis is by graft inoculation of Mexican lime indicator seedlings followed by observation for leaf flecking and vein clearing in new growth flushes.

Natural control: Citrus psorosis, is a viral disease. It is not directly susceptible to attack by other biological species. Transmission of virus by organisms such as the fungus *Olpidium* and other living material associated with citrus may be possible.

Physical control: Avoiding the use of contaminated budwood is the best policy to manage this disease problem.

Chemical Control: Aside from disinfection and control of potential vectors, chemicals are not directly useful in limiting citrus psorosis.

Pest Management Strategy for Citrus Psorosis.

< Use trees certified free of psorosis virus like diseases.

< Do not allow trees to become stressed.

< TO DO: More work is needed on citrus psorosis transmission.

Citrus Exocortis viroid & Cachexia viroid:

A citrus exocortis viroid (CEV) infection is generally indicated by scaly bark and tree stunting. The expression of symptoms is dependent on host susceptibility and stress factors such as poor growing conditions. Transmission is usually via infected budwood and budding/pruning tools.

Pest Management Strategy for Exocortis viroid (and Cachexia viroid)

< Use budwood sources that are certified viroid free.

< Avoid viroid sensitive root stocks.

< Keep budding tools clean.

< Disinfect hedging equipment.

< As orchards mature those reaching 4-8 years old should be monitored closely for evidence of viroid infections

< TO DO: Increase the number of certified viroid free budwood sources.

Texas Citrus Weeds

Weed management in citrus is often most important in younger orchards where trees are becoming established and do not tolerate competition. In mature orchards, keeping vegetation in check is critical to productivity and overall pest management success. Weed management is also considered very important in, or prior to, winter where orchard floor vegetation can increase the possibility of tree damage given cool enough temperatures. Each citrus grove will often have a unique pest management strategy for dealing with unwanted vegetation, dependent on factors such as watering practice, soil types, orchard location, weed species, insect pest, target citrus markets and owner preference. Vines are often the most difficult ‘weed’ to deal with in Texas citrus.

Monitoring: All well managed citrus groves are managed for the presence of floor vegetation. As a groves season progresses different types of weeds will dictate the management strategy and need. It is important to keep good records.

Natural Control: There is generally no biological control of weeds that occurs in citrus.

Physical Control: Cultivation, in some form, in orchard row middles is a common method of eliminating troublesome plants or weeds.

Chemical Control: Herbicides are used in most Texas citrus orchards to control unwanted vegetation. The decision to use chemical weed control often hinges on orchard watering needs and methods. Generally all irrigation methods in citrus will in some way or another hinder mechanical weed control. Whether it be gates used to facilitate flood irrigation or the hoses and tubes of drip irrigation the only way to get adequate weed control is with herbicides. See Table 3 for use data and information on specific chemicals.

Citrus Weed Pest Management Strategy:

- Cultivation in citrus is an important weed management option.
- Chemical control of weeds in citrus is important and may be the only control option when water is being applied.
- Keeping citrus weed free in the winter is important in helping to prevent free damage during marginal temperature periods.
- An on going citrus herbicide screening program is important.
- Consideration should be given to the need for orchard floor vegetation cover during certain times of the year to afford habitats for certain parasites and predators of citrus insect pests.
- Weed control in young establishing orchards is essential.

< It is important to keep records of orchard weed management practices to provide information on species cycles and presence.

< The grower should remain in close contact with Extension educational programs to keep abreast of area pest problems, trends, regulatory needs and management opportunities.

< The availability of a quick acting, post emergence citrus herbicide is important to help control unexpected flushes of weeds.

< Overall citrus grove weed management would be improved if unwanted weeds are not allowed to become established.

< TO DO: Investigate the potential for using commercially available coverings to keep row middles clean.

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Table 1. Citrus Insect and mite control - Texas

Control		Efficacy										
Chemical	Acres Treated (%)	Fire Ants	Armored Scale[1]	Aphid	Black/ White Flies	Leaf Miner	Leaf Cutter Ants	Root Weevils	Rust Mite	Soft Scale[2]	Spider Mites[3]	Thrips
abamectin[4] (Agri-mek® 0.15EC)	40	0	0	0	0	3	0	0	3	0	2	2
aldicarb (Temik® 15G)	30	0	2	3	2	2	0	0	3	2	2	0
carbaryl (Sevin® 80S)	10	0	2	0	0	0	0	3	0	3	0	0
chlorpyrifos (Lorsban™ 4E)	50	3	3	2	2	0	2	0	2	2	0	2
chlorpyrifos (Lorsban™ 15g)	5	3	0	0	0	0	2	0	0	0	0	0
dicofol (Kelthane™ 4MF)	25	0	0	0	0	0	0	0	3	0	3	0
diflubenzuron (Micromite® 25WS)	10	0	0	0	0	2	0	3	3	0	0	0
ethion (Ethion 4M)	10	0	3	0	2	0	0	0	2	2	2	0
fenbutatin-oxide (Vendex® 50WP)	55	0	0	0	0	0	0	0	3	0	3	0
fenpropathrin (Danitol® 2.4E)	10	0	0	0	2	0	0	2	2	0	3	3
formetanate hydrochloride (Carzol® 5P)	0	0	0	0	0	0	0	0	3	0	0	3
imidacloprod (Provado®1.6F, Admire® 2F)	20	0	3	3	3	2	0	0	0	3	0	2
methidathion (Supracide® 2E)	20	0	3	0	2	2	0	0	0	2	0	0
petroleum oil	25	0	3	0	2	2	0	0	2	2	2	0
oxamyl (Vydate® L)	10	0	0	0	0	0	0	0	3	0	0	3
propargite (Comite®)	5	0	0	0	0	0	0	0	2	0	3	0
pyridaben (Nexter® 75W)	35	0	0	2	2	0	0	2	3	0	3	0
pyriproxyfen (Esteem® 0.86EC)	25	0	3	0	2	2	0	0	0	2	0	0

[1]/ Armored scales= California red scale, Purple scale, Florida red scale, Chaff scale
[2]/ Soft scales=Brown soft scale, Cottony cushion scale, Barnacle scale, Black scale
[3]/ Spider mites= Texas citrus mite, citrus red mite, false spider mite
4/Petroleum oil can be added to enhance effacicy
efficacy rating - 0 = no control; 1= poor control; 2= moderate control; 3 = good control.
leaf cutter ants materials include Logic, Lorsban, and Orthene for non-bearning citrus. All are effective
Fire Ants Clinch is available for fire ants and is effective.others are mentioned above

Pipeline materials for citrus mite control include spirodiclofen (Envidor®) and milbemectin (Mesa™).
A promising pipeline material for armored scales is the insect growth regulator (IGR) (pyriproxyfen).
Pipeline material for leaf miners in citrus is the insect growth regulator (IGR) (pyriproxyfen) and a mite fat metabolism antagonist, spirodiclofen (Envidor®).

Table 2. Texas Citrus Disease Matrix

Chemistry		Efficacy				
	% Acres Treated	Nematodes	Foot Rot	Greasy Spot	Melanose	Phytophthora
aldicarb (Temik®)	2	2	0	0	0	0
copper complex (Copper-Count®-N)	5	0	0	3	3	0
copper hydroxide (Kocide®101, Champion® WP, etc.)	5	0	3	3	3	0
copper sulfate (Basicop™, Top Cop Tri... etc)	5	0	0	3	3	0
copper sulfate + sulfur (Top Cop™ w/Sulfur)	5	0	0	0	3	0
fenamiphs (Nemacur® 15%G)	1	2	0	0	0	0
fenbuconazole (Enable™ 2F)	65	0	0	3	0	0
fosetyl-Al (Aliette® WDG)	60	0	3	0	0	3
oxamyl (Vydate® L)	2	2	0	0	0	0
propiconazole (Banner® EC)	2	0	0	3 (non bearing only)	0	0
azoxystrobin (Abound)	10	0	0	3	0	0
metalaxyl (Ridomil Gold)	5	0	0	0	0	3
pyraclostrobin (Headline)	10	0	0	3	0	0
trifloxystrobin (Gem)	10	0	0	3	0	0

Rating 0 = No control 1 = Some Control 2 = Moderate Control 3=Good Control

Table 3. Weed Control in Texas Citrus

Chemistry	% Acres Treated	Timing	Target Weed(s)
EPTC (Eptam 7-E)	2	apply after cultivation or prior to weed emergence	Suppresses nutsedge.
fluazifop-butyl (Fusilade)	5	postemergence	For emerged grasses. (Non-bearing only)
paraquat (Gramoxone)	3	Post directed	Burn down existing weeds.
bromacil (Hyvar X)	30	Pre or post emergence	Annual weeds such as barnyard grass, crab grass and mustard.
diuron (Karmex)	20	pre or post emergence	Annual weeds such as johnson grass.
bromacil + diuron (Krovar I DF)	50	preemergence	Annuals and prennials such as bermuda, johnsongrass, thistle and goatweed.
sethoxydim (Poast)	5	postemergence	For emerged grasses such as bermuda, johnson and barnyard grass.
simazine (Princep 4L)	75	Preemergence	For annuals such as morningglory, crab grass, pigweed and Russian thistle.
glyphosate (Roundup)	20	Postemergence	For actively growing grasses and broadleaf weeds.
norflurazon (Solicam DF)	5	Preemergence	For broadleaf weeds such a mustard, ragweed, velvetleaf, grasses and sedge weeds
oryzalin (Surflan A.S.)	5	Preemergence	Weeds and grasses controlled include barnyard grass, crabgrass, pigweed and purslane.
glyphosate (Touchdown)	2	Postemergence	Controls a broad spectrum of emerged annual and perennial grasses and broadleaf weeds.