Crop Profile for Citrus in Arizona

General Production Information

- Arizona is one of only four states in the U.S. with significant citrus Production in 1999. Arizona shares **lemon** production with California, with 18% of the total national production.
- Arizona produces 13% of the U.S.'s **tangerines** and is ranked third.
- Arizona **orange** and **grapefruit** production are both ranked fourth behind Florida, California and Texas with .5 and 1 percent of overall national production.
- Between 1994 and 1999 **Lemon** harvested acreage declined from 15,300 acres to 13,100 acres. Average yield was 485 cartons per acre.The value of production ranged from $24 million to $46 million. **Tangerine** and tangelo harvested acreage declined from 5,600 acres to 5,200 acres.Average yield was 295 cartons per acre.The value of production ranged from $7.5 million to $17.5 million. **Grapefruit** harvested acreage declined from 5,400 acres to 3,600 acres.Average yield was 436 cartons per acre.The value of production ranged from $2.4 million to $7.8 million. **Orange** harvested acreage (Valencia, navel, and sweet) declined from 5,600 acres to 5,200 acres. Average yield was 262 cartons per acre. The value of production ranged from $5.3 million to $20.8 million.
- For lemons, tangerines and oranges, despite the declining acres, the 1998/99 crop was the most valuable of the period and the 1997/98 crop was the least valuable. 1994/95 was the most valuable crop for grapefruit and 1996/97 was the least valuable.
- Citrus budgets from 1994 report operating costs ranging from $789 to $871 per acre in Yuma county(2) and from $597 to $648 in Maricopa county(3).These costs are probably still realistic today. The rising costs of harvest and land ownership are not included in these figures.Water costs have not changed much and improved pest management practices have lowered chemical costs.
- Arizona citrus is marketed both domestically and internationally.The majority of groves are contracted with Sunkist packinghouses.

Cultural Practices

Citrus groves may be spaced from 20 by 20 feet to 30 by 30 feet. Some groves use "hedgerow" spacing that is close (12 feet) within the row with a wider spacing (24 feet) between rows.Flood and furrow irrigation are still the most common forms of irrigation. Approximately 15 to 20% of Arizona citrus has been converted to microsprinkler irrigation.Hand pruning is necessary when trees are young, especially with lemon trees, and groves are mechanically topped and hedged when mature.

Three rootstocks are commonly used in Arizona citrus production.*Citrus volkameriana* and C.*macrophylla* are vigorous rootstocks commonly used for lemon production and also for some ‘Minneola’ tangelos.Carrizo rootstock is most commonly used for other varieties of citrus because of its positive effect upon fruit quality and yield. Dwarf rootstocks have not been tested under

desert growing conditions.

Several strains of ‘Lisbon’ lemon are commonly planted, including ‘Limoneira 8A’, ‘Corona Foothills’ and ‘Frost Nucellar’.‘Eureka’ lemons are also grown.‘Parent Washington’ and ‘Fukumoto’ are the most commonly planted navel oranges; other oranges grown include ‘Valencia’ and several others commonly grouped under the name ‘Arizona Sweet’.‘Rio Red’ and ‘Redblush’ are the most common grapefruit varieties, and ‘Minneola’, ‘Orlando’, and ‘Fairchild’ are the most common tangerines grown in Arizona.

Production Regions

Citrus production in Arizona is limited to areas in Yuma, Maricopa, Pinal and Mohave counties that are relatively frost-free, where sufficient inexpensive water is available. Land is sometimes taken out of citrus production and converted to cotton, grain or vegetable production because of the greater returns and greater flexibility of these alternative crops. Urban encroachment also limits citrus production.In 1999,Yuma accounted for more than 90% of lemon acreage but Maricopa and Pinal county acreage has remained steady while Yuma county acreage has declined slightly in the last five years.70% of grapefruit acres, 71% of orange acres and 62% of tangerine acres are in Maricopa (1).

Insect Pests

CITRUS THRIPS

Scirtothrips citri

Damage: Citrus thrips is the most economically damaging insect pest of Arizona citrus . On fruit, the citrus thrips punctures epidermal cells, leaving scabby, grayish or silvery scars on the rind .Second instar larvae do the most damage because they feed mainly under the sepals of young fruit.As the fruit grows, damaged rind tissue moves outward from beneath the sepals as a conspicuous ring of scarred tissue. This damage renders the fruit unsuitable for fresh market.

Description of Pest: Adult citrus thrips are small, orange yellow insects with fringed wings.First instar larvae feed actively on tender leaves and fruit, especially under the sepals of young fruit.Third and fourth instar thrips do not feed and complete development on the ground or in the crevices of trees.When adults emerge, they move actively around the tree foliage.They can produce up to eight generations during the year.

Cultural controls: There are no specific cultural control techniques utilized for citrus thrips.

Biological controls: A number of natural enemies attack citrus thrips including predaceous mites, spiders, lacewings, minute pirate bugs, etc. However, during most years, citrus thrips densities are too high to be adequately controlled with natural enemies, thus making insecticide use unavoidable.

Chemical controls: Citrus thrips is less of a problem in groves that receive minimal pesticide treatments than in groves that are heavily treated. Thrips populations tend to increase after treatments with organophosphates and carbamates.Citrus thrips has a history of rapidly developing resistance to chemicals that are used repeatedly and frequently for its control. With the limited number of pesticides available for control of citrus thrips, growers monitor citrus thrips levels carefully.

> **Abamectin.**7 day PHI.Abamectin (AGRI-MEK) is applied at a rate of 0.01 lb ai per acre. It is occasionally used in the Yuma area. It is not applied pre-bloom, during bloom, in nurseries, or to nonbearing trees.It is always applied in combination with a narrow range oil.

Abamectin is relatively nontoxic to beneficial insects and mites. It is most effective if substantial numbers of predators are present.Do not exceed three applications per year, and allow at least 30 days between applications.The restricted entry interval for abamectin is 12 hours.

Cyfluthrin.0 day PHI.Cyfluthrin (BAYTHROID) is a broad spectrum pyrethroid insecticide that is occasionally used. Some citrus thrips resistance to pyrethroids have been reported in Yuma.Only one application per crop per season is permitted. Cyfluthrin is toxic to both beneficial mites and beneficial insects, and disrupts biological control.The restricted entry interval for cyfluthrin is 12 hours.

Dimethoate.15 day PHI.Dimethoate is an organophosphate that is widely used to control citrus thrips, and is the product of choice in areas other than Yuma. It is currently used under a FIFRA 24(c) registration in Arizona at a rate of 2 lb ai per acre (1999 average rate from ADA PUR, 1.8 lbs ai per acre).Use of Dimethoate is prohibited during any time of day when the grove has 10% or more open blooms until there has been at least 75% petal fall on the north side of the trees. Dimethoate may be used during the time between one hour after sunset until three hours before dawn under the following conditions: before petal fall when less that 10% of the blooms have opened, after the initiation of petal fall when there are less than 25% open bloom remaining in the grove, and it is between the calender dates of February 15 and May 1.Dimethoate is toxic to both beneficial mites and beneficial insects and disrupts biological control. The restricted entry interval for Dimethoate is 4 hours.

Fenpropathrin.1 day PHI.Fenpropathrin (DANITOL) is a broad spectrum pyrethroid insecticide that has recently been registered for use in citrus.It is used at 0.3 to 0.4 lbs ai per acre, and may be applied only once per season. Fenpropathrin is toxic to both beneficial mites and beneficial insects and disrupts biological control. The restricted entry interval for fenpropathrin is 12 hours.

Formetanate Hydrochloride.7 day PHI.Formetanate hydrochloride (CARZOL) is a carbamate that is commonly used in Yuma and occasionally in other parts of the state. Most applications of formetanate hydrochloride range from 0.9 to 1.2 lbs ai per acre (1999 average rate from ADA PUR, .8 lbs ai per acre). Formetanate hydrochloride is a broad spectrum insecticide that is persistent unless washed off by rain. No more than 1 application can be made perseason, and it may not be applied once the fruit is greater than 1.0 inch in diameter.It is toxic to both beneficial mites and beneficial insects and disrupts biological control. The restricted entry interval for formetanate hydrochloride is 48 hours.

Kaolin.0 day PHI.Kaolin (SURROUND) is a highly refined clay mineral product that disrupts citrus thrips feeding and behavior.Kaolin is a new product and is not yet widely used.Kaolin has little knockdown activity, so is best when used preventively. Kaolin is applied prior to heavy thrips pressure at rates of 50-100 lbs per acre. Good coverage is essential to maximize control. Kaolin is non-toxic to bees, but little is known regarding its impact on predaceous insects. The restricted entry interval is 4 hours.

Spinosad. 1 day PHI.Spinosad (SUCCESS) is a macrocyclic lactone isolated from the soil microorganism *Saccharopolyspsora spinosa*.It is normally applied to citrus at rates of 0.06 to 0.15 lbs ai per acre (ADA PUR average rate, 0.11 lbs ai per acre).Spinosad is highly effective towards citrus thrips and is a product of choice in Yuma. Spinosad is relatively nontoxic to beneficial insects and mites.Spinosad may not be applied more than twice per year, and may not be used in nurseries. The restricted entry interval is 4 hours.

CITRUS FLAT MITE

Brevipalpus lewisi

Damage: Citrus flat mite is often an economically important pest of Arizona citrus. Feeding results in a scarring of the rind.The flat mite is fairly heat tolerant, so populations persist during the hot summer.

Description of Pest: The flat mite adult is extremely small, barely visible to the naked eye. It is flat, and usually amber in color with dark markings.Immature flat mites are red.The flat mite is usually a secondary invader, feeding on rind tissue damaged by thrips oviposition or wind.

Cultural control: There are no common cultural practices designed specifically to impact citrus flat mite.

Biological control: There are a number of predacious mites that prey on citrus flat mites as well as lady beetles, lacewings and *Orius*.

Chemical control:

Wettable Sulfur.0 day PHI.Wettable sulfur is applied to thoroughly cover foliage as soon as mites are detected or as additive when treating for citrus thrips.It is intended for use on all varieties of citrus. Applications are not made when temperatures are high or within 2 months of a previous oil spray.The 1999 average rate from ADA PUR is 9.4 lbs ai per acre The restricted entry interval for wettable powder is 24 hours.

Dicofol.7 day PHI.Dicofol is an organochlorine which is applied at label rates to all varieties of citrus. It has a narrow range of activity, but is efficacious towards mites, and is persistent. The 1999 average rate from ADA PUR was .95 lbs ai per acre. Dicofol is of intermediate selectivity because it acts primarily against mites with minimal impact on beneficial insects such as lacewings, lady beetles, and *Aphytis melinus*, which help control scales, thrips, mealybugs and other pests. It is however, toxic to predaceous mites because of its persistence.The restricted entry interval is for dicofol is 12 hours.

Abamectin.7 day PHI.Abamectin (AGRI-MEK) is a macro-cyclic lactone which is applied at label rates to all varieties of citrus.It has a narrow range of activity, but is efficacious towards mites. It is always applied in combination with a narrow range oil. Abamectin is relatively nontoxic to beneficial insects and mites.It is most effective if substantial numbers of predators are present. Do not exceed three applications per year, and allow at least 30 days between applications. The restricted entry interval for abamectin is 12 hours.

CITRUS MEALYBUG

Planococcus citri

Damage: Citrus mealybug is a sporadic pest of citrus, occurring primarily in older, well-shaded groves planted on heavy soils.These pests extract plant sap, reducing tree vigor, and excrete honeydew. Citrus mealybugs will feed on the bark, foliage, and fruit. Heavy infestation of the fruit may cause discoloration, splitting, and fruit drop. Damage is most severe in the summer.

Description of Pests: Mealybugs are soft, oval, flat, and distinctly segmented. They are pinkish in color and usually covered with a thick waxy coating.Females are flightless and move from tree to tree via walking, birds, or equipment. Newly hatched nymphs are free of wax, but soon start to excrete a waxy cover. There are two to three overlapping generation a year.

Cultural control:

Hedging. Hedging tree to prevent touching between trees will help prevent within grove spread of infestations.

Equipment Sanitation. Thorough cleaning of equipment will help prevent the spread of mealybug from infested groves to others.

Biological control:

General Predators and Parasitoids. Parasitoids provide excellent control of the citrus mealybug if they are not destroyed by insecticide treatments for other pests.Native predators include lady beetles, lacewings, and syrphid flies.

Mealybug Destroyer. An introduced predator of the citrus mealybug, the mealybug destroyer, *Cryptolaemus montrouzieri*, is a voracious feeder of this pest in both the larval and adults stages.Its larvae resemble a mealybug but are about twice as large as the adult citrus mealybug females.The adult is a small beetle with dark brown elytra and a light brown head and prothoracic shield. It does not winter well and therefore commercial releases are sometimes necessary where citrus mealybugs were a problem the previous year.Growers release about 500 *Cryptolaemus* per acre.

Chemicals control: Treatment is rarely recommended for mealybugs.Use of selective insecticides for citrus thrips control will often prevent problems with mealybugs by preserving natural enemies. If a heavy population of mealybugs must be reduced quickly, a treatment can be applied, but it is recommended to release *Cryptolaemus* or lacewing larvae after about 2 weeks to reestablish biological control.

Chlorpyrifos.28 day PHI.Chlorpyrifos (LORSBAN) is an organophosphate that is used to suppress citrus mealybug. Chlorpyrifos is applied at an average rate of 4 to 6 lb ai per acre. Thorough coverage is needed to be most effective, but will still only provide suppression of citrus mealybug. Inclusion of a narrow range oil will aid in efficacy. Chlorpyrifos is toxic to bees and should not be applied during daylight hours during bloom. The restricted entry interval for chlorpyrifos is 0 days.

CITRUS PEELMINER

Marmara salictella

Damage: The citrus peelminer is a commonly occurring pest of citrus throughout Arizona, but infrequently reaches economically damaging levels. Peelminers have traditionally been more damaging to citrus in central Arizona than in the Yuma area, and heavy infestations appear to be associated with heavy use of broad spectrum insecticides in nearby cotton (an alternate host forcitrus peelminers).Citrus peelminers prefer to infest grapefruit and navel oranges over other varieties. Citrus peelminers mine the rind of citrus fruit leaving a serpentine patterns which prevents the fruit from being sold for fresh market.Damage is most severe in late summer and early fall.

Description of Pests: Citrus peelminer is a very small dark gray moth, about the size of a mosquito. The adult female lays her eggs of the fruit surface where the hatching larva immediately begin mining beneath the epidermal cell layer of the peel.The larvae are small and are reddish-brown in color.

Cultural control:

Multicrop program. Avoid using multiple applications of broad spectrum insecticides for whitefly control in cotton adjacent to citrus.These applications destroy the parasitoids that normally maintain peelminer populations below damaging levels.

Biological control:

Parasitoids. Parasitoids provide excellent control of the citrus peelminers if they are not destroyed by insecticide treatments for other pests.

Chemical control:

Chlorpyrifos.28 day PHI.Chlorpyrifos (LORSBAN) is an organophosphate that is has been used to suppress citrus mealybug. Chlorpyrifos is applied at an average rate of 4 to 6 lb ai per acre.Thorough coverage is need for chlorpyrifos to be most effective, but will only provide suppression of citrus mealybug. Inclusion of a narrow range oil will aid in efficacy. Chlorpyrifos is toxic to bees and should not be applied during daylight hours during bloom. The restricted entry interval for chlorpyrifos is 0 days.

Spinosad.1 day PHI.Spinosad (SUCCESS), a macrocyclic lactone isolated from the soil microorganism *Saccharopolyspsora spinosa*.It is normally applied to citrus at rates of 0.06 to 0.15 lbs ai per acre. Spinosad is highly effective towards citrus peelminer but inner-canopy coverage is essential. Spinosad is relatively nontoxic to beneficial insects and mites. Spinosad may not be applied more than twice per year, and may not be used in nurseries. The restricted entry interval is 4 hours.

CALIFORNIA RED SCALE

Aonidiella aurantii

Damage: California red scale attacks all parts of the tree including twigs, leaves, branches, and fruit.Heavily infested fruit may be downgraded in the packinghouse and, if population levels are high, serious damage can occur to trees.Severe infestations cause leaf yellowing and drop, dieback of twigs and limbs, and occasionally death of the tree.Tree damage is most likely to occur in late summer and early fall when scale populations are highest and moisture stress on the tree is greatest.

Description of Pest: California red scale are armored scales, occurring in isolated pockets in Maricopa County, primarily in the Phoenix area.Although California red scale can sporadically be found in Yuma, because of abatement efforts, Yuma County is considered a scale free area.These scales appears as small reddish-brown spots, and are clearly visible when on the fruit.

Regulatory control: The Arizona Department of Agriculture and The Yuma County Citrus Pest Control District both have programs to monitor for California red scale and abate infestations. All control efforts are currently being administrated through these agencies, and have been highly successful.

Chemical control:

Chlorpyrifos. 28 day PHI.Chlorpyrifos (LORSBAN) is an organophosphate that is has been used to control California red scale, although it is no longer considered the product of choice. Chlorpyrifos is applied at an average rate of 4 to 6 lb ai per acre.Thorough coverage is need for chlorpyrifos to be most effective.It is toxic to bees and should not be applied during daylight hours during bloom.The restricted entry interval for chlorpyrifos is 0 days.

Pyriproxyfen.1 day PHI.Pyriproxyfen (ESTEEM) is an insect growth regulator which has is highly active towards California red scale, and is currently the product of choice for abatement efforts. The product is used at a rate of 0.1 lb ai per acre and is limited to three applications per season and the same acreage may not be treated twice in a 21 day period. The restricted entry interval is 12 hours.

COTTONY CUSHION SCALE

Icerya purchasi

Damage: Cottony cushion scale is an occasional pest of citrus throughout Arizona.Cottony cushion scale extracts plant sap from leaves, twigs, and branches, thus reducing tree vigor.If infestations are heavy, leaf and fruit drop can occur along with twig dieback. It also secretes honeydew, which promotes the growth of sooty mold that may discolor fruit and block photosynthesis.

Description of Pest: First and second instars feed on twigs and leaves, usually along the veins. Third instars and adults are found mainly on branches and the trunk, rarely the fruit. There are three generations a year.

Cultural control: There are no common cultural practices designed specifically to impact citrus flat mite.

Biological control: Natural enemies such as the vedalia beetle and lacewings can effectively control cottony cushion scale.The vedalia beetle, *Rodolia cardinalis*, was introduced from Australia

in the early 1890s. The adult and larva feed on all stages of the scale.Female beetles lay eggs underneath the scale or attached to the egg sac. Young larvae move into the egg mass and feed on eggs. Later, larvae feed on all scale stages. The vedalia beetle is susceptible to pyriproxyfen and broad spectrum insecticides.

Chemicals control: Although a commonly occurring pest, chemical treatment is rarely needed for cottony cushion scale in Arizona.Use of selective insecticides for citrus thrips control will often prevent problems by preserving natural enemies.If a heavy population of cottony cushion scale occurs and few biological control agents are present, insecticides may be necessary.A release of vedalia beetles or lacewing larvae 2 weeks following the last application is recommended to reestablish biological control.

Chlorpyrifos. 28 day PHI.Chlorpyrifos (LORSBAN) is an organophosphate and can effectively suppress cottony cushion scale populations.Chlorpyrifos is applied at an average rate of 4 to 6 lb ai per acre. Thorough coverage is need for chlorpyrifos to be most effective. Inclusion of a narrow range oil will aid in efficacy.Chlorpyrifos is toxic to bees and should not be applied during daylight hours during bloom. The restricted entry interval for chlorpyrifos is 0 days.

Pyriproxyfen. 1 day PHI.Pyriproxyfen (ESTEEM) is an insect growth regulator used to control cottony cushion scale, although it may require several months to achieve. Pyriproxyfen is also highly active towards the vedalia beetle, a predator of scale.It is applied at rates of 0.11 lbs ai per acre.The restricted entry interval for pyriproxyfen is 12 hours.

OMNIVOROUS LEAFROLLER

Platynota stultana

Damage: The omnivorous leafroller is a frequent pest of citrus nurseries in Arizona.The larvae attack leaves of the terminal growth, rolling the outer edges inward and fastening it with silken strands.Once a leaf is largely destroyed, the larvae will move to another. Several larvae can complete destroy the terminal growth of seedling trees. Damage to mature trees is inconsequential, while damage to young trees can retard growth.

Description of Pest: Omnivorous leafroller's eggs are greenish in color, and are flat and elliptical in shape.This pest can best be identified by the distinctive leaf rolling performed by the larvae. Omnivorous leafrollers can complete as many as six generations per year in Arizona.

Cultural control: There are no cultural practices that are commonly used to specifically impact omnivorous leafroller.

Biological control: There are a number of predators and parasitoids that prey on omnivorous leafrollers, but they usually do not occur in sufficient number provide adequate control.

Predators. Reduviidae, *Nabis* spp., and *Orius* spp. have all been noted preying on omnivorous leafroller in Arizona.

Parasitoids. Parasitoids reported attacking omnivorous leafroller in Arizona include: *Apanteles* spp., *Goniozus platynotae*, *Meteorus dimidiatus*, *Angitia ferrugineliae*, and *Cremastus* sp.

Chemical control

Chlorpyrifos. 28 day PHI.Chlorpyrifos (LORSBAN) is an organophosphate that is has been used to control California red scale, although it is no longer considered the product of choice. Chlorpyrifos is applied at an average rate of 4 to 6 lb ai per acre.Thorough coverage is need for chlorpyrifos to be most effective.It is toxic to bees and should not be applied during daylight hours during bloom. The restricted entry interval for chlorpyrifos is 0 days.

Methomyl. 1 day PHI.Methomyl (LANNATE) is an oxime carbamate that is applied at rates

of about 0.8 lb ai per acre. It kills beneficial insects, such as mites.It is toxic to bees and during bloom is applied from 1 hour after sunset until 2 hours before sunrise. The restricted entry interval for methomyl is 3 days.

TEXAS CITRUS MITE

Eutetranychus banksi

Damage: The Texas citrus mite is a common pest of citrus occurring throughout Arizona. This mite primarily feeds on the upper surface of leaves and is prevalent from February to May under cool temperatures, but will disappear with the onset of high temperatures. Feeding can cause leaf discoloration, and under high populations, they will often move to the fruit where feeding may result in rind scarring.

Description of Pest: Texas citrus mites vary in color from tan to brownish green with dark and greenish spots.The females have a round and flattened body, compared to the smaller males in which the body is elongated with very long legs.

Cultural control: Dust Reduction. Growers minimize dust within the groves that have frequent infestation of Texas citrus mites by compacting roads or using water trucks to wet dirt roads that are in high use.

Biological control

General Predators: There are a number of predators prey on Texas citrus mites including: six-spotted thrips, lady beetles, lacewings, *Orius*, and a number of predacious mites.

Pathogens. There is an unidentified fungi that will often infect and control Texas citrus mite.

Chemical control: Generally damage from Texas citrus mites is not severe enough to warrant treatment. Only after large number is found on the fruit should chemical control be considered.

Wettable Sulfur .0 day PHI.Wettable sulfur is applied to thoroughly cover foliage as soon as mites are detected. It is intended for use on all varieties of citrus.Applications are not made when temperatures are high or within 2 months of a previous oil spray. The restricted entry interval for wettable powder is 24 hours.

Dicofol. 7 day PHI.Dicofol is an organochlorine which is applied at label rates to all varieties of citrus. It has a narrow range of activity, but is efficacious towards mites, and is persistent. Average application rates are about 3 lbs ai per acre. Dicofol is of intermediate selectivity because it acts primarily against mites with minimal impact on beneficial insects such as lacewings, lady beetles, and Aphytis melinus, which help control scales, thrips, mealybugs and other pests. It is however, toxic to predaceous mites because of its persistence.The restricted entry interval is for dicofol is 12 hours.

Abamectin. 7 day PHI.Abamectin (AGRI-MEK) is a macro-cyclic lactone which is applied at label rates to all varieties of citrus.It has a narrow range of activity, but is efficacious towards mites. Average application rates are about 0.012 lbs ai per acre. It is always applied in combination with a narrow range oil.Abamectin is relatively nontoxic to beneficial insects and mites. It is most effective if substantial numbers of predators are present.Do not exceed three applications per year, and allow at least 30 days between applications. The restricted entry interval for abamectin is 12 hours.

TWOSPOTTED SPIDER MITE

Tetranychus urticae

Damage: The twospotted spider mite is the second most economically important mite species to Arizona citrus. These mite infest the underside of leaves and between adjoining fruit where they

can produce profuse webbing. Feeding results on the leaf causes yellowing and browning usually beginning around the mid-vein, while feeding on the fruit may result in scarring to the rind.Two spotted spider mite is fairly heat tolerant, so populations persist during the hot summer.

Description of Pest: The twospotted spider mite adults are medium sized mite and vary in appearance but are generally yellow to reddish-pink in color with two dark spots located on each "shoulder".The eggs are spherical and translucent to opaque in appearance and are laid under the webbing.

Cultural control: There are no common cultural practices designed specifically to impact twospotted spider mite.

Biological control

Predators. There are a number of predacious mites that prey on twospotted spider mites and their eggs as well as lady beetles, lacewings and *Orius*.

Chemicals control

Wettable Sulfur. 0 day PHI.Wettable sulfur is applied to thoroughly cover foliage as soon as mites are detected or as additive when treating for citrus thrips.It is intended for use on all varieties of citrus. Applications are not made when temperatures are high or within 2 months of a previous oil spray.The restricted entry interval for wettable powder is 24 hours.

Dicofol. 7 day PHI.Dicofol is an organochlorine which is applied at label rates to all varieties of citrus. It has a narrow range of activity, but is efficacious towards mites, and is persistent. Average application rates are about 3 lbs ai per acre. Dicofol is of intermediate selectivity because it acts primarily against mites with minimal impact on beneficial insects such as lacewings, lady beetles, and *Aphytis melinus*, which help control scales, thrips, mealybugs and other pests. It is however, toxic to predaceous mites because of its persistence.The restricted entry interval is for dicofol is 12 hours.

Abamectin. 7 day PHI.Abamectin (AGRI-MEK) is a macro-cyclic lactone which is applied at label rates to all varieties of citrus.It has a narrow range of activity, but is efficacious towards mites. Average application rates are about 0.012 lbs ai per acre. It is always applied in combination with a narrow range oil.Abamectin is relatively nontoxic to beneficial insects and mites. It is most effective if substantial numbers of predators are present.Do not exceed three applications per year, and allow at least 30 days between applications. The restricted entry interval for abamectin is 12 hours.

WOOLLY WHITEFLIES

Aleurothrixus floccosus

Damage: Woolly whiteflies suck phloem sap, causing leaves to wilt and drop when populations are large. Nymphs collects dust and supports the growth of sooty mold; large infestations blacken entire trees, reducing photosynthesis and contaminating the fruit.

Description of Pest: The woolly whitefly is a relatively new pest to Arizona, and is currently restricted to the Yuma area, and appears to be most prevalent in the Yuma alley. Adult woolly whiteflies are small, flying insects that derive their name from the mealy white wax covering their wings and body. The immature stages resemble scales and cover themselves with "woolly" white waxy filaments.Woolly whiteflies prefer to colonize the underside of newly expanded leaves. Honeydew excreted by the immature stages will accumulate in the waxy filaments appearing as small translucent beads.Among citrus varieties, woolly whiteflies prefer grapefruit and minneolas as hosts, and are capable of building large populations on these trees. While adult whiteflies are similar in appearance, the immature stages are more distinctive.

Cultural control: Pruning. To enhance the natural parasites and predators in the grove, growers

use alternate row pruning which provides refuge for parasites.

Biological control

General Predators and Parasitoids. Several natural enemies attack the immature stages of woolly whiteflies and will often provide partial to complete biological control.*Eretmocerus* spp. and *Encarsia* spp. are two parasitoids that have proven to be important natural enemies of woolly whitefly, particularly during late fall and early winter. There are also a number of predacious insects that aid in suppressing woolly whitefly. Conservation of whitefly natural enemies by utilizing selective insecticides for citrus thrips control will often prevent large outbreaks of woolly whitefly.

Chemical control: Since woolly whitefly is a relatively new pest in Arizona, chemical control has only been necessary in a few cases.

Pyriproxyfen. 1 day PHI.Pyriproxyfen (ESTEEM) is an insect growth regulator used to control whiteflies though control is slow, taking several months.It is applied at rates of 0.05-0.07 lbs ai per acre.It is very selective, and although it will not disrupt parasitoid activity, it can negatively impact vedalia and other lady beetle populations. The restricted entry interval for pyriproxyfen is 12 hours.

YUMA SPIDER MITE

Eotetranychus yumensis

Damage: The Yuma spider mite is an occasional pest of citrus primarily occurring in the Yuma area.This mite primarily feeds on the underside of leaves and may cause some leaf drop.

Description of Pest: The Yuma spider mite is oval in shape and is light straw to dark pink colored and produces substantial webbing on the underside of leaves.It feeds and lays peach-colored eggs under the webbing.

Cultural control:

Dust Reduction. Although reducing the incidence of dust by watering dirt roads adjacent to frequently infested groves may minimize an infestation of Yuma spider mites, this technique is rarely cost effective.

Biological control:

General Predators. There are a number of predators that prey on Yuma Spider mites including: six-spotted thrips, lady beetles, lacewings, *Orius*, and a number of predacious mites.

Chemical control: Generally damage from Yuma spider mites is not severe enough to warrant treatment. If monitoring indicates a treatment is necessary it may only be necessary to treat rows adjacent to dusty roads.

Wettable Sulfur. 0 day PHI.Wettable sulfur is applied to thoroughly cover foliage as soon as mites are detected. It is intended for use on all varieties of citrus.Applications are not made when temperatures are high or within 2 months of a previous oil spray. The restricted entry interval for wettable powder is 24 hours.

Dicofol. 7 day PHI.Dicofol is an organochlorine which is applied at label rates to all varieties of citrus. It has a narrow range of activity, but is efficacious towards mites, and is persistent. Average application rates are about 3 lbs ai per acre. Dicofol is of intermediate selectivity because it acts primarily against mites with minimal impact on beneficial insects such as lacewings, lady beetles, and Aphytis melinus, which help control scales, thrips, mealybugs and other pests. It is however, toxic to predaceous mites because of its persistence.The restricted entry interval is for dicofol is 12 hours.

Abamectin. 7 day PHI.Abamectin (AGRI-MEK) is a macro-cyclic lactone which is applied at label rates to all varieties of citrus.It has a narrow range of activity, but is efficacious towards mites. Average application rates are about 0.012 lbs ai per acre. It is always applied in combination with a narrow range oil.Abamectin is relatively nontoxic to beneficial insects and mites. It is most effective if substantial numbers of predators are present.Do not exceed three applications per year, and allow at least 30 days between applications. The restricted entry interval for abamectin is 12 hours.

OTHER PESTS

Rarely of economic importance

- Angular-winged katydid,*Microcentum retinerve*
- Brown garden snail, *Helix aspersa*
- Brown soft scale, *Coccus hesperidum*
- California orangedog, *Papilio zelicaon*
- Citrus leafminer, *Phyllocnistis citrella*
- Citrus looper, *Anacamptodes fragilaria*
- Fuller rose beetle, *Pantomorus cervinus*
- Melon aphid, *Ahis gossypii*
- Navel Orangeworm, *Amyelois transitella*
- Potato leafhopper, *Empoasca fabae*
- Spirea aphid, *Aphis citricola*

Citrus Insecticide Usage:

The Arizona Department of Agriculture (ADA) pesticide use reporting system provides an incomplete but useful picture of insecticide use in Arizona citrus (for more details, see section on the ADA PUR at the end of the profile). Citrus thrips are presently the greatest concern for producers(Table 1). Formetanate-hydrochloride is the most common active ingredient employed for control.Dimethoate and spinosad are also commonly used for control of thrips.

Diseases

PHYTOPHTHORA
ROOT ROT AND GUMMOSIS

Phytophthora citrophthora
Phytophthora parasitica

Phytophthora fungi are present in almost all citrus orchards. Under moist conditions, the fungi produce large numbers of motile zoospores, which are splashed onto the tree trunks.*Phytophthora citrophora* is a winter root rot that also causes fruit rot and gummosis. It is most active during cool seasons when citrus roots are inactive and their resistance to infection is low. *Phytophthora parasitica* is a warm weather root rot that is active when roots are growing. *Phytophthora* root rot destroys feeder roots of susceptible rootstocks causing a slow decline of trees and can also cause gummosis.The leaves turn light green or yellow and may drop, depending on the severity of

infection. The pathogen infects the root cortex, which turns soft and separates from the stele. If the destruction of feeder roots occurs faster than their regeneration, the uptake of water and nutrients will be limited. The trees will grow poorly and production decline.

The *Phytophthora* species causing gummosis develop rapidly under moist, mild conditions. Hot summer weather slows disease spread and helps drying and healing of the lesions caused by *P. citrophthora*, but not *P. parasisitica*. Secondary infections often occur through lesions created by *Phytophthora*. These infections kill and discolor the wood deeper than gummosis itself.An early symptom of *Phytophthora* gummosis is sap oozing from small cracks in the infected bark.Decline may occur rapidly within a year, especially under conditions favorable for disease development, or may occur over several years.

Monitoring: For root rot, growers should inspect the orchard several times a year for disease symptoms, digging up soil and checking feeder roots if a tree looks stressed. Symptoms are often difficult to distinguish from nematode, salt or flooding damage and can only be confirmed through laboratory analysis. When *Phytophthora* populations are greater than 15 to 20 propagules per gram of root zone soil, treatment may be warranted.

Late stages of *Phytophthora* gummosis are distinct, but early symptoms are often difficult to recognize.Growers should inspect the orchard several times a year for disease symptoms looking for signs of gumming on the lower trunk and crown, and for soil buildup around the crown

Cultural control: For root rot, growers should provide adequate soil drainage and avoid over-irrigation. If destruction of feeder roots is minimal, growers may take corrective actions by increasing irrigation intervals, switching to alternate middle row irrigation or minisprinklers. For gummosis, trees are planted on a berm or high enough so that the first lateral roots are just covered with soil and bud unions well above the soil. During irrigation, care is taken not to spray the scion with water.Correcting any soil or water problems is essential for tree health. Preliminary research indicates that preplant fallow with no irrigation might reduce the present of *Phytophthora* in the soil.On the contrary, an irrigated preplant period with or without plants (alfalfa) did not appear to reduce *Phytophthora* presence.(6)

Resistant Rootstock: When establishing new planting or replanting, growers should choose resistant rootstocks, such as trifoliate orange, when possible.Extension research demonstrates that classifying citrus rootstocks as susceptible or resistant to *Phytophthora* cannot be accomplished without defining the specific *Phytophthora* disease (root rot or gummosis) and pathogen (*P. citrophthora* or *P. parasitica*)

Chemical control: Systemic fungicides can control *Phytophthora* root rot and gummosis. Copper sprays can be used to protect against infection due to gummosis.When planting or replanting in soil infested with *Phytophthora*, or when a susceptible rootstock has to be used, fumigation may be useful.

Preplant Fumigation

Chloropicrin. Chloropicrin is applied as a preplant fumigant that is injected at a rate of 400 to 500 lbs/acre.The site is tarped immediately after treatment.The treated site is not planted for at least 3 months. Lower rates are applied on sandy loam and higher rates are used on heavier soils with high clay content. The restricted entry interval for chloropicrin is 48 hours.

Metam Sodium. Metam sodium is a preplant fumigant.It is typically applied at a rate of about 150 lbs ai/acre. The site is not planted for at least 45 days after application. The restricted entry interval is for metam sodium 48 hours.

1,3-Dichloropropene. 1,3-Dichloropropene (TELONE) is is applied at label rates. The restricted entry interval for 1,3-dichloropropene is 5 days.

Nonbearing Trees

Fosetyl-aluminum. 30 day PHI.Fosetyl-aluminum (ALIETTE) is applied at a rate of about 5 lbs ai/acre to nursery trees. Trees are treated at the time of planting and are sprayed to wet.The restricted entry interval for fosetyl-al is 12 hours.

Mefenoxam .0 day PHI.Mefenoxam (RIDOMIL GOLD) is applied as a soil drench or a surface spray with sufficient water for soil penetration.For citrus trees in nurseries, Mefenoxam is applied as a drench at planting and at 3 month intervals to coincide with root growth flushes during the growing season. This product replaces metalaxyl, which has recently been phased out. The restricted entry interval for Mefenoxam is 48 hours.

Bearing Trees

Fosetyl-aluminum. 30 day PHI.Fosetyl-aluminum (ALIETTE) is applied at a rate of about 5 lbs ai/acre. It is a foliar treatment sprayed to wet. Four application or 20 lb/acre/year may be made. The restricted entry interval for fosetyl-al is 12 hours.

Mefenoxam. 0 day PHI.Mefenoxam (RIDOMIL GOLD) is applied in the spring followed by 1 to 2 applications at 3 month intervals to coincide with root flushes, depending on the tree size. The orchard is irrigated with 0.5-1 inch water after application.This product replaces metalaxyl, which has recently been phased out. The restricted entry interval for Mefenoxam is 48 hours.

Metalaxyl. 0 day PHI.Metalaxyl (SUBDUE) is being phased out and replaced by the more specific Mefenoxam. The restricted entry interval for metalaxyl is 12 hours.

SOOTY CANKER(7)

Sooty Canker is caused by the fungus *Hendersonula toruloidea*. It is most common on smooth bark trees such as citrus that can be easily sunburned.The fungus invades wounded sites in the bark of limbs and trunks and causes sunken lesions that break open with a black mass of spores under the bark. Individual limbs that are infected may die and should be pruned away. Once the trunk becomes infected, the tree usually dies.

Control: The only controls are good pruning practices, good sanitation by removing all infested material, and maintenance of tree vigor with proper fertilizer and water.

ALTERNARIA FRUIT ROT

Alternaria fruit rot caused by the fungus *Alternaria citri*, is commonly found in many navel orange groves in Maricopa County. Minneola tangelos in Maricopa County are also affected. *Alternaria* rot is a fungal disease that affects mainly navel oranges and lemons. Fruit infected wtih *Alternaria* change color prematurely. The decay is softeron lemons than on oranges and develops mostly during storage. On navel oranges, the disease is also called black rot, and results in dark brown to black, firm spots or areas at the stylar end or in the navel.If you cut the fruit in half, you can see the rot extending into the core.(8)

Control: Healthy, good quality fruit are more resistant to Alternaria rot than stressed or damaged fruits, especially oranges with split navels. Preventing stress can reduce the incidence of splitting and Alternaria rot(8).Consistent reduction of Alternaria fruit rot by timely application of fungicides has yet to be achieved.

BROWN WOOD ROT(5)

Brown wood rot, caused by *Antrodia sinuosa* and *Coniophora eremophila,* has caused extensive destruction in mature lemon plantings in Yuma County. Both fungi grow best at temperatures that occur during the summer in Arizona.All major types of citrus can be attacked by this pathogen; however, disease development is most severe on lemon.There does not appear to be a significant effect of rootstock on disease development in lemon trees. Natural infection is associated with

wounds on lemon trees, including stress fractures where branches are cracked but not completely severed from the tree.

Control: Propiconazole and azoxystrobin can suppress the development of disease in inoculated lemon tree branches.Products are registered on citrus in Arizona but neither compound is registered for brown wood rot management.

BROWN ROT(9)
Phytophthora

Brown rot is caused by *Phytophthora* fungi when conditions are cool and wet. It develops mainly on fruit growing near the ground when *Phytophthora* spores from the soil are splashed onto the tree skirts during rainstorms. Brown rot is often seen in the Desert Valley regions after summer rains.Infections develop under continued wet conditions. Fruit in the early stage of the disease may go unnoticed at harvest and infect other fruit during storage.

Monitoring: Symptoms appear primarily on mature or nearly mature fruit. Initially, the firm, leathery lesions have a water-soaked appearance, but they soon turn soft and have a tan to olive brown color and a pungent odor. Occasionally, twigs, leaves, and blossoms are infected, turning brown and dying.

Cultural control: Brown rot management relies on prevention.Tree skirts are pruned 24 or more inches above the ground to prevent infection from *Phytophthora* spores that are splashed up from the soil during rain storms.

Chemical control

Zinc Sulfate - Copper Sulfate - Hydrated Lime. Applied to oranges, lemons and grapefruit at a rate of 10 to 24 gallons/tree.This treatment is applied from October through December, or just after the first rain.Where danger of copper injury is severe, these products are modified to make them safer by adding 0.33-1 lb of hydrated lime/lb of dry copper fungicide.

Copper Sulfate. 0 day PHI.Copper sulfate (BORDEAUX MIXTURE) is applied at rates of 10 to 24 gallons/tree to oranges, lemons and grapefruit where there is not history of copper injury. Tree skirts are sprayed about 4 feet above ground, which does not harm natural enemies. Spraying the ground underneath the trees also reduces brown rot infections. The restricted entry interval for copper sulfate is 48 hours.

Fosetyl-aluminum. 30 day PHI.Fosetyl-al (ALIETTE) is applied at a rate of 5-lbs/acre to all susceptible citrus varieties. It is applied when conditions favor disease development. Fosetyl-al is not applied within 30 days of harvest. Tree skirts are sprayed about 4 feet above ground. The maximum number of applications per year is 4. The restricted entry interval for fosetyl-al is 12 hours.

STUBBORN DISEASE
Spiroplasma citri

Stubborn disease is a mycoplasma which is spread by leafhopper (primarily beet leafhopper) feeding and by grafting and budding. Treatment of leafhoppers in the field does not prevent the spread of the mycoplasma. Stubborn disease is often difficult to diagnose.Stubborn disease does not kill trees, but stunts growth and inhibits fruit production.

Cultural control: Management of stubborn disease focuses on preventing the disease and avoiding its spread. Preventative measures mainly apply to nursery practices, such as maintaining stubborn-free mother trees for budwood.In an established orchard, trees are observed carefully for any signs of stubborn disease in late fall or early winter.A sparse crop, which is an indicator of this disease, becomes apparent as fruit color changes to orange.Growers map or flag the trees

suspected of being infected and recheck the orchard several times during the year to confirm the diagnosis.

TRISTEZA VIRUS

Tristeza virus is present but not a serious problem in Arizona. Tristeza virus is spread through budding and grafting or by aphids feeding on citrus.Trees infected with tristeza show light green foliage, poor growth flushes, and some leaf drop.

Cultural control: Management of the tristeza complex depends largely on preventative measures, such as using tolerant rootstocks and tristeza-free propagation material. Quarantine restrictions are in place. Only certified, virus-free budwood are used when grafting or topworking.

DRY ROOT ROT

*Fusarium*spp.

Dry Root Rot damage usually starts in larger roots and spreads into the crown. Patches or large areas of bark on the underground portion of the crown show a moist, dark decay, which later dries and adheres to the wood. In some cases, dry bark may also be seen aboveground. Unlike *Phytophthora* gummosis, dry root rot does not produce gumming, and the lesion extends deep into the wood.Once the crown region is girdled, the tree collapses.

Although the disease is normally a chronic problem affecting only a few scattered trees in a grove, it can develop into an epidemic in some orchards. The exact cause of dry root rot has not been established, but a *Fusarium solani* is most often isolated from diseased wood. All common rootstock including trifoliate and Troyer citrange are susceptible to dry root rot.

Monitoring: Growers check regularly for signs of *Phytophthora* root rot or vertebrate damage that may provide entry sites for dry root rot.

Cultural controls: Good orchard management, especially careful irrigation, is essential for preventing dry rot. If the soil around the tree crowns and roots is saturated for long periods of time, the chances for injury and subsequent fungal infection increase.When establishing furrows, growers provide berms along the trees so that the crowns are protected from the water. Sprinklers are adjusted so that water does not hit the trunks.

During cultural operations, care is taken to avoid injury to the lower trunk, crown and/or feeder roots in the top soil, especially during the cool and wet season. Care is taken to avoid overdosing the trees and burning root tissue when applying fertilizers, herbicides, and nematicides.

When the disease is present, growers may expose the crown region allowing it to dry which may slow the progress of the disease.Tree skirts are pruned to allow the circulation of air around the crown region. Trees that have become unproductive because of severe infection are removed from the orchard.

Chemical controls: No effective chemical treatments are available.

EXOCORTIS(9)

Exocortis viroid

Description of Disease. Exocortis is widespread in older plantings, but it is a mild disease that causes only moderate stunting and some loss of production.Exocortis is of minor importance in Arizona today because strict regulations on budwood sources have kept new plantings largely free of this viroid disease. Infected trees rarely die, but growth is retarded and productivity slowly declines. The viroid kills the bark, which dries, cracks, and may lift in thin strips.

Cultural controls: Infected trees are removed from the orchard because pruning clippers and saws can transmit exocortis unless thoroughly disinfected with hypochlorite (bleach); heat does not kill the viroid.For planting or replanting, viroid-free budwood is grafted onto rootstock.

Chemical controls: There are no chemical treatments for exocortis.

PSOROSIS(9)

Psorosis is a graft transmissible disease, caused by a virus, most often found in old citrus plantings.Infected trees, mostly orange and grapefruit, slowly decline. It is transmitted in infected budwood or possibly with contaminated grafting tools.During early stages, patches of bark on the trunk or scaffold branches show small pimples or bubbles.In advanced stages, deep layers of bark and the wood become impregnated with gum and die.

Cultural controls: As with other graft transmissible diseases, the use of disease-free budwood is the major method for preventing damage from psorosis. Generally, a psorosis-infected tree will produce less, and replacement is the best option.

Nematodes

CITRUS NEMATODE

Tylenchulus semipenetrans

Description of Pests. Plant parasitic nematodes are microscopic, unsegmented roundworms that live in soil and plant tissues and feed on plant roots.The predominant species parasitic on citrus in Arizona is the citrus nematode, *Tylenchulus semipenetrans*.This nematode is reported to be present in most citrus orchards and in all soil types. Citrus nematode attacks roots by burrowing its anterior end deep inside the root cortex while the posterior end remains outside in the soil

Damage caused by a citrus nematode infestation depends on the age and vigor of the tree and the nematode population.In Arizona populations on newly planted trees do not increase rapidly until the tree has produced a canopy to shade the soil.Mature trees can tolerate a considerable number of these nematodes before yield is affected.The damage is greater when trees are predisposed by other factors such as *Phytophthora* root rot and water stress

To make management decisions, growers need to identify the nematode species present within the orchard and the estimated population.Soil samples are sent to a diagnostic laboratory for identification.

Cultural control:

Sanitation. Good sanitation practices are essential to avoid nematode infestations. Certified nematode-free planting material is used. No rootstocks resistant to Citrus Nematode are suitable for use in Arizona.

Chemical control:

Preplant Fumigation

Metam Sodium. Metam sodium can control nematodes at a rate of 100 gallons/acre if applied properly. Pre-application steps must be taken because metam sodium does not penetrate plant roots very well and is very difficult to get 4-5 feet down from the surface. Before applying this material, growers must thoroughly cultivate the area to be treated to break up clods and deeply loosen the soil.The restricted entry interval is 48 hours.

1,3-Dichloropropene. 1,3-Dichloropropene (TELONE) is a restricted use material that is applied at label rates. The restricted entry interval for 1,3-dichloropropene is 5 days.

Postplant

Oxamyl. 7 day PHI. Oxamyl is applied at rates of 1 to 4 quarts/acre by metering into flood irrigation water or into drip irrigation systems. It is applied to less than 0.2% of citrus. The restricted entry interval of oxamyl is 72 hours.

Fenamiphos. 30 day PHI. Fenamiphos (NEMACUR) may be applied by injections into the irrigation system (33.3 gallons/season) or by band application (67 lbs/season) with sufficient irrigation to wet the root zone. The restricted entry interval for fenamiphos is 48 hours.

Citrus Disease and Nematode Pesticide Usage

Both diseases and nematodes are regular concerns for Arizona citrus producers. Reported use of fungicides and fumigants is not extensive. This could result from the limited coverage of the ADA 1080 pesticide use reporting (see ADA PUR explanation).Trends indicate a general decrease in usage of both fungicides and fumigants with the exception of the most commonly reported fosetyl-aluminum. Fosetyl-aluminum is the only reported active ingredient that provided a target pest after this data became available starting in 1999. 75% of fosetyl-al reports listed root rot as the target pest.No distinction was made between *phytophthera* and dry root rots.

Weeds

Managing weeds on orchard floors in irrigated Arizona citrus groves can be accomplished by disking, mowing, applying pre-emergence and post-emergence herbicides, or by growing a cover crop.

Disking:
Weeds in Yuma county lemon groves have traditionally been managed by frequent disking of the orchards. Disking adequately controls weeds on the orchard floor except underneath the tree canopies where bermudagrass (*Cynodon dactylon*), purple nutsedge (*Cyperus rotundus*), and other weeds survive. Disking orchards occasionally damages tree branches, may incorporate plant debris into the surface soil that creates a breeding habitat for eye gnats (on the Yuma Mesa), and may damage shallow tree roots.

Recent research found that population levels of broadleaf weeds such as common purslane (*Portulaca oleracea*) in the summer, and London rocket (*Sisymbrium irio*) and annual sowthistle (*Sonchus oleraceus*) in the winter, rapidly increased between disking operations.These and other broadleaf weeds were favored over grass type weeds in the disk treatment because of their taller stature and fast growth rates that allowed them to shade grasses and other plants growing closer to the soil surface.

Mowing:
Mowing weeds on the orchard floor has not been widely practiced.Mowing favors grasses and nutsedge species because these plants have growing points (*i.e.*, meristems) close to the soil surface at the base of their leaves in contrast to broadleaf weeds that have meristems at shoot terminals. In recent research, bermudagrass became the dominant weed in the mow treatment and would have completely covered the ground if the experiment had been continued. Field sandbur (*Cenchrus pauciflorus*) and purple nutsedge also increased in number although their population numbers were still low.

Pre-emergence herbicides

Pre-emergence herbicides have not been widely used in Yuma County because flood irrigation of sandy soils, especially on the Yuma Mesa, can leach some herbicides such as bromacil (*e.g.*, Hyvar X and Krovar I), diuron (*e.g.*, Karmex, Krovar I), and simazine (*e.g.*, Princep) into the tree root zone causing injury. Maricopa County citrus growers have long used pre-emergence herbicides but some suspect that this long-term herbicide use, especially the use of Krovar I, may be partly

responsible for declines in grove yields.

Post-emergence herbicides

Post-emergence herbicides, especially glyphosate (*e.g.*,Roundup), have been widely used in Arizona citrus groves and occasionally some foliar injury symptoms from glyphosate can be found in the skirts of trees.Low rate, chemical mow applications of Roundup are not effective in controlling many weed species.Research found lower rates allowed the populations of several undesirable weed species such as bermudagrass and purple nutsedge to increase.

Cover crops:
Cover crops may suppress weeds, increase the complement of beneficial microorganisms in the soil, decrease soil compaction, increase water infiltration, and improve root growth by increasing soil organic matter.Increasing soil organic matter content improves nutrient availability to plants by increasing both the cation exchange capacity and buffering capacity of the soil. Irrigated cover crops are known to decrease soil temperature, may decrease canopy temperatures and have the potential to harbor beneficial predatory insects. Legume species that can be adapted to citrus production practices appear to have greater potential benefits than covers of non-legume broadleaf and grass species or resident weed species because legumes add nitrogen to the soil. This legume-derived nitrogen may increase the nitrogen available for fruit production and decrease the requirement for nitrogen fertilizer inputs. Non-legume species and resident weeds will consume nitrogen and other nutrients as well as water.

Potential disadvantages of using cover crops in citrus orchards include unfavorable shifts in insect (*e.g.*,thrips, whiteflies, and aphids) and nematode populations, difficulty in irrigating the citrus and cover crops in flood irrigated systems, and orchard cooling in the winter which increases the risk of freeze damage.

Research at the Arizona Citrus Agricultural Center using a 'Salina' strawberry clover found that the cover crop reduced yields and canopy volumes of Navel orange trees. Yield efficiency was the same as the clean culture plot (i.e., no weeds) indicating that competition for water was the probable cause of reduced yields in the cover crop plot.(11)

Chemical Controls:
Herbicide usage in Arizona citrus orchards, as reported to the Arizona Department of Agriculture, is overwhelmingly oriented toward glyphosate. In 1998 and 1999, glyphosate reports outnumbered all other herbicide reports by 14 to one.Under certain conditions other active ingredients were still used. Norflurazon, a preemergence herbicide, is used to control purple and yellow nutsedge, bermudagrass and summer grasses. Sethoxydim, a post-emergence herbicide, is used to control bermudagrass and other grasses growing under the canopy of the trees. Simazine, a pre-emergence herbicide, is used against broadleaves (horseweed, pigweeds, purslane, nettleleaf goosefoot, sunflower, thistles).Trifluralin is a pre-emergent that is used against small seeded broadleaves, bermudgrass and summer grasses.Glyphosate is a non-selective postemergence herbicide effective against all of these weeds.

Arizona pesticide use reporting

The state of Arizona mandates that records be kept on all agricultural pesticide applications. Submission to the Arizona Department of Agriculture (ADA) of these pesticide use reports is mandated for all commercially applied pesticides, pesticides included on the Department of Environmental Quality Groundwater Protection List (GWPL) and section 18 pesticides.

Commercial applicators licensed through the state must submit Arizona Department of Agriculture Form 1080 Pesticide Use Reports for all applications. The use of commercial applicators varies across crops. All Aerial applications are considered commercial applications.

The GWPL is a list of active ingredients determined by the Department of Environmental Quality to potentially threaten Arizona groundwater resources. Enforcement of this list is difficult. Only

specific types of soil application of GWPL active ingredients must be reported.Inclusion on the GWPL should indicate a higher level of reporting but without further research no useful distinctions can be drawn.

Section 18 active ingredients should have 100% reporting.There have been no Section 18 active ingredients in Arizona citrus since the 1996 growing season.

Voluntary reporting does take place.Anecdotal evidence indicates some producers submit records of all applications.

Reported pesticide usage provides a solid lower bound of acres treated and, with a reasonable number of reports, a good estimate of the mean application rate. Relative magnitude of reported acres is useful for rough comparison but could reflect a bias among commercial applicators or differing reporting rates as a result of inclusion on the GWPL. Finally, while the quality of data from the ADA 1080 forms has improved dramatically in recent years, there is still the possibility of errors

Resource Note:
The California citrus profile insect pest, disease and nematode sections were used as templates for those sections in this profile.David Kerns revised insect information to make it Arizona specific. Mike Matheron revised the disease section. Michael McClure revised the nematode section. While extensive changes were made in most instances, the California profile was extremely helpful to development of this Arizona citrus profile.

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