Pest Management Strategic Plan

FOR

Citrus Production

IN

California

December 2003

The purpose of this document is to provide the citrus industry, state and federal regulatory agencies, and pesticide manufacturers with the current status of pest management for citrus in California. The Citrus Pest Management Strategic Plan will be an ever-evolving document which will be modified as pest management strategies change.

The California Citrus Quality Council coordinated the development of the Citrus Pest Management Strategic Plan, in cooperation with:

- *Citrus Research Board*
- *Grower and packing house personnel*
- *Citrus growers*
- *University of California Cooperative Extension and research personnel*
- *Pest control advisors*
- *USDA ARS federal research personnel*

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Production. California produces 80% of the United States lemons, 28% of the tangerines, 21% of the oranges, and 10% of the grapefruit commercially grown in the United States. "Tangerines" include Tangerines, Mandarins, Tangelos, and Tangors.

In 2002**,** California was first in the nation in the production of lemons and second in the nation in the production of oranges, grapefruits and tangerines. Overall, California is second in citrus production. Florida is first, Texas is third, and Arizona ranks fourth (1, 2).

Acreage. In 2002, citrus were harvested in California from a total of about 266,250 acres, statewide, as follows (3):

Oranges	193,000 acres	(72%) (66% navel and 34% Valencia)
Lemons	49,500 acres	(18%)
Grapefruit	14,000 acres	(5%)
Tangerines	9,000 acres	(3%)
Limes	750 acres	(<1%)

Production Value. In 2002, the value of California's overall citrus crop was about $889,292,000 (3). The short ton values were as follows:

Crop	Short Tons	Value
Oranges	1,931,300	$514,460,000 (58%)
Lemons	695,400	$287,026,000 (32%)
Grapefruit	197,700	$ 47,485,000 (5%)
Tangerines	82,500	$ 38,821,000 (4%)
Limes	5,500	$ 1,500,000 (<1%)

Fresh-Market. The primary end-product of citrus grown in California is fresh-market. For oranges, 82% of the market is fresh compared to Florida where only 5% of the crop is fresh market oranges. For tangerines and grapefruit, about 70% of the market is fresh. For lemons, about 50% of the market is fresh (2).

Exports. California exports approximately 40% of the citrus harvest to other countries. The value of these exports in 2002 was $**298** million for oranges, $**75** million for lemons, and $**39** million for grapefruit (4). Major export markets include Japan, Canada, Hong Kong, Korea, and France.

Cost Per Acre. The total cost to produce an acre of citrus ranges from $5,000 to $10,000 per acre with production in the San Joaquin Valley region the most costly (8, 9). Production costs prior to harvesting are around $1,000 to $3,000 per acre. In 2002, there were approximately 6,500 citrus growers (9).

Integrated Pest Management. Citrus production in California is one of the strongest integrated pest management (IPM) systems in the state.

Production Regions.

- The San Joaquin Valley Region
- The Coastal-Intermediate Region
- The Interior Region
- The Desert Region

In addition, there is a small citrus growing area in the Northern Sacramento Valley where a majority of the tangerines are grown (8).

San Joaquin Valley Region. More than half the acres of citrus are grown in the San Joaquin Valley region (about 65% of the state's acreage)(3). This region has summers that are hot and dry and winters that are typically cold and wet (8). Most of the state's navel orange production, about 94%, is grown in this region as well as about 65% of the Valencia orange production. About 72% of the state's tangerines are grown in the San Joaquin Valley. Lemon acreage is 17% and grapefruit acreage is 6% of the state's total (3).

Coastal-Intermediate Region. The coastal-intermediate region, from Santa Barbara County south to the San Diego/Mexico border, has a milder climate influenced by marine air (8). The region differs from the Interior Region in climate, cultivars grown, and pest problems. The Coastal Intermediate and Interior regions account for the majority (about 66%) of the state's lemon production. (3). Over 90% of the state's lime production comes from these regions, primarily from the southern coastal areas (3). Approximately 23% of the grapefruit production is from the coastal- intermediate region. For oranges, the coastal-intermediate region emphasizes Valencia production (about 24% of the state's acreage) with only limited acreage producing Navel oranges (about 1% of the state's acreage)(3). Only limited acres are devoted to tangerine production.

Interior Region. The interior region includes western Riverside and San Bernardino counties, inland portions of San Diego, Orange, and Los Angeles Counties and other growing regions that are only marginally affected by coastal climatic influence, in contrast to the coastal intermediate district, which is significantly influenced by the moderating influence of the coastal climate (8). The interior district tends to be warmer and dryer in the summer and colder in the winter than the coast

Desert Region. The desert region, primarily the Coachella Valley and Imperial Valley, produce citrus under conditions where temperatures fluctuate widely between day and night with low humidity most of the year (8). The desert region is the primary location for production of grapefruit, with about 66% of the state's production being produced in a region that represent only about 20% of the state's citrus growing acreage. About 22% of the state's tangerine production comes from the desert region.

Citrus Crops. Oranges, lemons, grapefruit, tangerine, kumquats, and various other citrus crops are grown in California. For purposes of this Pest Management Analysis, tangerines refer not only to tangerines, but also mandarins, tangelos, and tangors. Lime production and pest management issues are included with those discussed for lemons, since lemons and limes are produced in the same regions within California.

Varieties. There are a few varieties of citrus that dominate California's production. The primary varieties are as follows:

Washington Navel Oranges are predominantly grown in the San Joaquin Valley where it takes about 9 months for fruit to mature (8). About 94% of the state's navel orange acreage is in this region (3). The main harvest is from late fall through early spring and sometimes into early summer.

Valencia Oranges are typically grown in the coastal-intermediate and interior areas for the fresh market. Valencia oranges mature in 12 to 15 months and are harvested from spring through late fall (8). About 24% of the Valencia oranges are grown in the coastal-intermediate and interior regions, and 65% in the San Joaquin Valley region (3).

Eureka Lemons are the most common cultivar on the coastal-intermediate region, where approximately 65% of the state's lemon acreage is (3, 8).

Lisbon Lemons are better adapted to the Desert, Interior and San Joaquin Valley regions. Mature fruit are harvested over a 9-month period (8). About 35% of the state's lemon acreage is in these growing regions (3).

Marsh Grapefruit are grown in the desert valley regions where it is harvested in the winter and early spring (8). About 66% of the state's grapefruit acreage is in the desert region (3).

Tangerine varieties are also primarily grown in the desert region (22%) and the San Joaquin Valley region (72%)(3, 8).

All growing regions have some acreage of nearly all major cultivars.

THE DISTRIBUTION OF CITRUS COMMODITIES WITHIN THESE REGIONS IS SUMMARIZED IN TABLE 1 BELOW:

TABLE 1 – Most recent data available.

Region	Lemons	Navels	Valencias	Grapefruit	Tangerines
Interior	1%	2%	3%	5%	0%
Coastal	65%	1%	24%	23%	5%
San Joaquin Valley	17%	94%	65%	6%	72%
Desert	17%	3%	8%	66%	22%

FOUNDATION FOR PEST MANAGEMENT STRATEGIC PLAN

In the subtropical climate of California, trees of all citrus cultivars except coastal lemons stop growing during the winter. During this period, the tree maintains a base level of water transport and starch consumption. The main growth flush appears in late February and March. Leaves stay on the tree for 1 to 2 years. They are replaced continually, although leaf drop is greatest during the spring flowering period. Citrus usually bloom abundantly but most flowers and young fruit drop (early drop). A combination of environmental and physiological factors seems to determine which flowers develop into fruit that persist to harvest. Unlike deciduous fruit, citrus fruit have no clearly identifiable point of maturity. Color can serve as an approximate guide but is generally not reliable because color development depends largely on temperature, especially low night temperature, and the mineral nutrition of the tree.

Citrus production in California is one of the state's best examples of an integrated approach to pest management. In an effort to maximize the appropriate control of economically important pests, California's citrus industry recognizes that a cost-effective program must ensure that pest management tools are not lost due to the onset of resistance. Pest levels are monitored closely to ensure that pest management decisions are initiated prudently and carefully coordinated. As a result, all growers use a mixture of cultural, biological, and chemical control practices to control economically important pests.

This document is an analysis of those pests, regional and seasonal occurrences, agronomic practices, and pest management tools used during the major stages of the citrus production season. In some cases, certain sections will be divided by area or season to describe regional differences. In addition, critical issues facing the citrus industry in California will be prioritized. These issues may be regulatory, educational, or research in nature.

STAGES OF CITRUS PRODUCTION BY GEOGRAPHIC AREA

Major Stages of the Citrus Production Season -- San Joaquin Valley

	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov
Pre Bloom				C	C							
Bloom				C	C							
Petal Fall					C	C						
Growing Season (June-Sept)							C	C	C	C		
Growing Season (Oct thru Jan)	C	C									C	C
Harvest	N, L, G, T	N, L, G, T	N, L, G, T	N, L, G, T, V	N, L, G, T, V	N, V,	N, V	V	V	V	N, V, G, T	N, V, G, T
In-Field Post Harvest	C	C	C	C	C	C	C	C	C	C	C	C

Major Stages of the Citrus Production Season -- Southern Interior

	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov
Pre Bloom			C	C								
Bloom				C	C							
Petal Fall					C	C						
Growing Season (June-Sept)							C	C	C	C		
Growing Season (Oct thru Jan)	C	C									C	C
Harvest	N, L, T	N, L, T	N, L, , T	N, L, T, V	N, L, G, T, V	N, V, G	G, V	V, G	V, G	V, G	V, G,	V
In-Field Post Harvest	C	C	C	C	C	C	C	C	C	C	C	C

Major Stages of the Citrus Production Season -- Coastal

	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov
Pre Bloom			C	C								
Bloom				C	C							
Petal Fall					C	C						
Growing Season (June-Sept)							C	C	C	C		
Growing Season (Oct thru Jan)	C	C									C	C
Harvest	N, L, V	N, L,	N, L,,	N, L,	N, L,	V, L	V, L	V, L	V, L	V, L	V, L	V, L
In-Field Post Harvest	C	C	C	C	C	C	C	C	C	C	C	C

Key: N = Navel Oranges, V = Valencia Oranges, L = Lemons, G = Grapefruit, T = Tangerine, C = All Citrus Varieties

Footnote: For lemons grown on the coast, there are 3 major blooms per year, resulting in a year-round harvest.

Major Stages of the Citrus Production Season -- Desert

	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov
Pre Bloom			C	C								
Bloom				C	C							
Petal Fall					C	C						
Growing Season (June-Sept)							C	C	C	C		
Growing Season (Oct thru Jan)	C	C									C	C
Harvest	G, L, T	G,L, T, V	G, L, T, V	L, T, V, G	G, T, V	V, G	G			L	L, G, T	L, G, T
In-Field Post Harvest	C	C	C	C	C	C	C	C	C	C	C	C

Key: N = Navel Oranges, V = Valencia Oranges, L = Lemons, G = Grapefruit, T = Tangerine, C = All Citrus Varieties

Pest Management Prior to or at Planting

The best method for an IPM program is those that enable development of a strong root system, prevent pest outbreaks and provide long-term and economical control. Preventative methods include following quarantine regulations, removing sources of new infection, choosing scion cultivars and rootstocks less susceptible to pest damage, installing an appropriate irrigation system, providing conditions that enhance the activities of natural enemies of pests, and carrying out various management activities correctly.

Citrus is grown on soils with widely differing texture and depth but it performs best on medium to deep soil that drains well. One of the key pests causing damage to the citrus industry is the citrus nematode. It is reported to be present in most citrus orchards and in all soil types. Citrus nematodes attack roots by burrowing their anterior end deep inside the root cortex while the posterior end remains outside the soil. Good sanitation practices are essential to avoid nematode infestations. Use certified nematode-free material for planting. Rotation with annual crops for 1 to 3 years before replanting citrus reduces the replant problem and helps to reduce citrus nematode populations. Using a resistant rootstock is recommended whether or not nematodes are present. If the site was previously infested with nematode pests of citrus, pre-plant fumigation may be necessary to reduce nematode population levels. When replanting a citrus orchard, a pre-plant treatment is recommended even if a resistant rootstock is used. In established orchards (post-plant), consider treatment treat when sampling indicates more than 400 female citrus nematodes are present in 1 gram of roots in February to April or more than 700 in 1 gram of roots during May and June.

Pre-plant treatments

1. Methyl Bromide: This is the best product for finer-textured soils that have been dried deep before application. It is expensive, however, and will be unavailable after 2005 unless industry is granted a Critical Use Exemption.
2. 1,3-Dichloropropene (Telone II, Telone C-35, or In-Line): This is a good soil fumigant but the current rate of 332 lbs./acre is too low for optimal performance in finer textured soils. 1,3-D is an effective replacement for deeply dried sandy loam soils where it can correct much of the replant problem and can control nematodes to 5 feet deep at 99.9% level.
3. Chloropicrin: Effective as a nematicide in citrus however the rate (approximately 300 to 350 lbs./acre) needs to be further evaluated. Pic is a relatively poor root penetrant but citrus roots are relatively small. It moves better through the soil than the same amount of Telone.
4. Methyl isothiocyanate liberators (Vapam HL, K-Pam, or Sectagon): Can be effectively applied as a soil drench to moist soils that are porous. Equipment to accomplish a good treatment without odors is not available to growers. The smaller and shallower roots of citrus lend themselves to this treatment. These products will not perform well where clods (blocky soil structure) are large.
5. Enzone: Is a poor root penetrant and should not be considered as a pre-plant treatment unless good field data are available.

Post-plant treatments

1. Nemacur: At 1 gallon per acre, it has been the most used post-plant nematicide for citrus. It can provide 50 to 75% reduction of citrus nematode for 6 months. There has been some concern regarding its performance after several years. Purchases of new stocks will be disallowed in the US after May 2005.

2. Enzone: Is applied at 750 to 1000 ppm via microsprinkler or drip. This product should be applied between March and May or October and December. Control of citrus nematode should be 50 to 75% for 6 months. The impact on citrus roots and level of phytophthora control afforded is unclear. Yield data following repeated treatments still needs some research. Use of this product has been slow to develop within the citrus industry.
3. Ditera: Has been sold as an EC and more recently as DF formulations. The general recommended rate of application is 20 lbs/acre several times per year although this treatment regimen may not be best for citrus. This product can be applied during the summer months.
4. Vydate 4L: Product is expensive and has shorter half-life than Nemacur. Does not perform as well as Nemacur but does stimulate carbamate growth responses.
5. Recent nematode sampling has revealed some nematode control value attributable to Admire insecticide applications. Studies are underway.

Non-registered (botanicals/mineral derivative) products with potential for use by the citrus industry

1. Integrate: This is a humic acid derivative used as a soil amendment. Trials have been initiated.
2. Agroneem: A Neem product that moves better through soil when added to Integrate. Trials have been initiated.
3. Walnut Tea: A new botanical product from ground walnut trees. Trials have been initiated.
4. Sincocin: Previous tests at 20 lbs/acre show good performance on citrus nematode but chemical mixtures like this need quality assurance.

PRE-HARVEST DISEASES

**** Includes that period between planting & harvest ****

Phytophthera Root Rot:

- Cultural: Need to be practiced season-long. Avoid over irrigation, need for good soil drainage. Practice good sanitation. Plant resistant, certified, nursery rootstock when possible.
  Practice mulching which has a positive effect on young tree plantings and increases biological activity in the soil. Use non-ionic surfactants to improve soil drainage and improve disease control.
- Biological Controls: None currently available.
- Chemical (Fumigants) (pre-plant):
  - Methyl Bromide: Highly effective, available through 2005 via Critical Use Exemption process on a case-by-case basis.
  - Chloropicrin: Applied pre-plant by means of injection. Lower rates are applied on sandy loam and higher rates are used on heavier soils. Does not provide consistent control of soil borne pathogens and is weak on several weed species.
  - Metam sodium (Vapam): Pre-plant fumigant with most applications being made in the San Joaquin Valley. The site may not be planted for at least 45 days after application. Does not provide long term, deep control of nematodes and movement in the soil profile is limited to the wetted front of the fumigation zone.
  - Basamid: Difficult to achieve uniform application of this material because it is in a granular form. The rate is inconsistent and soil penetration is poor for effective management of the disease.
  - 1,3-D (Telone): Is a restricted-use material that may only be applied with a permit from a county agricultural commissioner. Township caps are in place for this material. 1,3-D generally controls nematodes in shallow, light soils and does not control nematodes effectively unless the soil moisture is less than 12%. Fumigation in soils this dry is difficult to achieve in dry, heavy soils.
  - Sodium Tetrathiocarbonate (Enzone): Sodium tetrathiocarbonate is generally considered to be less efficacious than the other registered alternatives as it is a poor root penetrant of dead roots. It is the most suitable of the soil fumigants for post-plant treatments. Product needs further testing.

Fungicides:

- Mefenoxam (Ridomil Gold) Post-planting application. 2-3 applications per year. For 2 applications, generally make an application in the spring, (May or prior to first root flush), and August (prior to second root flush) and in the summer (August or prior to second root flush). When making 3 applications, one application should be in April, followed by one in late May, and one in August. Highly effective, however, there is documented resistance.
- Fosetyl-al (Alliete): Highly effective. No known documented resistance. Limitations: expensive. Same timing of application as Ridomil Gold.
- Metalaxyl: Same timing of application as Ridomil Gold.
- Enzone: Has shorter residual period. Cannot be used as a stand-alone fungicide.

Phytophthera Gummosis

- Cultural: Avoid standing water around trunk; prevent sprinkler water from hitting trunk, prevent wounding of tree while pruning suckers (limit use of weed eaters). Plant on birms to help drainage. Propagate with bud union 6-8 inches above soil line.
  Resistant rootstock – Avoid planting susceptible rootstocks such as rough lemon.
- Biological: None currently available.
- Chemical: Same fumigation treatments (both pre and post-plant application) as that for Phytophthera root rot.

Dry Root Rot: Caused by fusarium spp

- Cultural: Avoid injury to trunk and crown. Employ good irrigation practices. Practice mounding which increases soil drainage around the tree. Use healthy, non-injured rootstock. Aerate around diseased trees. Practice sanitation by removing any diseased trees.
- Biological: None available at this time.
- Chemical: None available at this time.

Armillaria Root Rot:

- Cultural: Select disease free sites whenever possible. Avoid sites that were previously oak woodland areas. Practice year-round irrigation and drainage management. Employ mitigation measures. Remove infected trees including roots larger than pencil thickness. Use physical barriers if needed.
- Biological: None available at this time.
- Chemical:
  - Methyl Bromide
  - Enzone
  - Metam Sodium
  - Chloropicrin

Brown Rot/Fruit Rot: complex of Phytophthera species

- Cultural: Skirt pruning, Practice year-round irrigation and drainage management. Plant cover crops to prevent splashing and therefore spread of disease.
  Sanitation: Avoid picking from lower part of the tree immediately after a rain.
- Biological: None currently available.
- Chemical: Use copper based materials (use as a preventative applied in the late fall/winter season). Limitations: Some phytotoxicity (burns fruit and leaves). Coppers must be safened with hydrated lime. Highly effective
  Alliete: Timing – applied together with a fall (Sept. October, November) spray for bud mite. 30 day PHI which can make use of this product problematic. Highly effective though expensive product.

Septoria Spot:

- Cultural: Prune back dead and dying branches to remove source of inoculum. Plant lemon varieties that have less thorns; i.e. Eureka as opposed to Lisbon.
- Biological: None available at this time.

- Chemical:
  Use copper based materials. Use as a preventative applied in the late fall/winter season. Limitations: Some phytotoxicity (burns fruit and leaves). Coppers must be safened with hydrated lime. Highly effective on septoria. Has shorter residual period under wet condition. Applications should cover entire tree.

Botrytis Rot: *Preharvest problem (primarily coastal regions)*

- Cultural: Avoid mechanical injuries. Avoid wind damage by planting windbreaks. Employ frost protection.
- Biological: None currently available.
- Chemical: None currently available.
  Use copper based materials. Use as a preventative applied in the late fall/winter season. Limitations: Some phytotoxicity (burns fruit and leaves). Coppers must be safened with hydrated lime. Highly effective. Has shorter residual period under wet conditions. Applications should cover entire tree.

Bacterial Blast:

- Cultural: Avoid wind injury. Prune out dead/dying wood. Maintain healthy trees. Proper timing of fertilizer is important as you should avoid succulent growth prior to the wet periods of the year; i.e. late fall. Sanitation is also critical prior and during the rainy season.
- Biological: None available at this time.
- Chemical: Use of copper mixtures which have limited efficacy against this disease. High rates are needed which may result in phytotoxicity and discoloration.

Tear Stain: *Generally only occurs under very wet weather conditions. Seen more often on grapefruit and navels. This disease is seen sporadically.*

- Cultural: Prune back dead or dying branches to remove source of inoculum.
- Biological: None available at this time.
- Chemical:
  Copper materials, have little efficacy.
  Azoxystrobin (Abound) – efficacious but with planned registration of this material as a post harvest tool, the potential exists for resistance to develop (single site mode of action presents problems). Use season: Apply in late December to January when disease develops.

Clear Rot: *(Infrequent pre harvest disease)*

- Cultural: None available at this time as it is a ubiquitous organism.
- Biological: None available at this time.
- Chemical:
  Azoxystrobin (Abound) – Efficacious but with planned registration of this material as a post harvest tool, the potential exists for resistance to develop (single site mode of action presents problems). Use season: 3 weeks pre harvest.

Viral Diseases:

Exocortis:

- Cultural: Remove infected trees. Avoid cross contamination when pruning by thoroughly disinfecting pruning clippers and saw with hypochlorite.

- Biological: None available at this time.
- Chemical: None available at this time.

Psorosis:
- Cultural: Use disease-free budwood. Remove infected trees. Avoid cross contamination when pruning by thoroughly disinfecting pruning clippers and saw with hypochlorite.
- Biological: None available at this time.
- Chemical: None available at this time.

Tristeza: *Transmitted by aphids*
- Cultural: Plant tolerant rootstocks and tristeza-free propagation material. Use only virus-free budwood when grafting or topworking. Remove infected trees only when they become unproductive.
- Biological: None available at this time.
- Chemical: None available at this time.

Stubborn Disease: *Transmitted by leafhopper*
- Cultural: Management of stubborn disease focuses on preventing the disease and avoiding its spread. Plant only stubborn-free budwood.
- Biological: None available at this time.
- Chemical: None available at this time.

1. Important Research Needs (as they relate to pre-harvest diseases):
- Biological & chemical controls for Armillaria (tree injections)
- Need for more research on Septoria and effective treatments.
- Birming/Mounding and its effectiveness
- Need for further basic research on the biology and epidemiology of dry root rot. Specifically, predisposition factors that lead towards disease.
- Resistance management when same tools become available for both pre and post harvest use. Example: Tear stain.

2. Important Educational Needs *(as they relate to pre-harvest diseases)* :
- Irrigation: Alternate row middle irrigation
- Resistance management when same tools become available for both pre and post harvest use. (Tear stain)

3. Important Regulatory Needs *(as they relate to pre-harvest diseases)*:
- Expedite registration of Topsin (expected by 2006)

Pre Bloom (February thru March)

I. Activities Occurring During this Time Period

- Pruning
- Scouting
- Snail control
- Fertilizing
- Foliar nutrition
- Weed Control
- Irrigate (dependent on weather)
- GWSS treatments in some areas
- Worm treatments
- Frost protection
- Harvest
- Check for vertebrate damage (rats, gophers, coyotes)

Pest(s) that need to be controlled during this period

- Red Scale: Occasional early season Lepidoptera pest.
- Treatment: Biological: *Aphytis melinus* releases. Very effective when used in areas not treated for GWSS.

II. Important Research Needs

- Need a better understanding of the impact of the GWSS program on natural enemies.
- Research winter/fall treatments for GWSS vs. spring treatments (level of disruption of natural enemies).
- Find GWSS treatments that are more compatible with IPM.
- Cutworm indigenous biological control
- Continue research efforts on biological control of GWSS, citrus peelminer and citrus leafminer. (citrus leafminer has not yet been detected in the San Joaquin Valley but is predicted to be here soon)
- Continue research to establish thresholds for GWSS treatment requirements. Population threshold for GWSS is zero in the eyes of the grape growers.
- Citricola Scale (biology and control)
- Argentine Ant (control)
- Citrus Bud Mite (control)
- Non target organism effects (infertility, repellency) of new chemistries on beneficial insects

III. Important Regulatory Needs

- There is a need for Codex MRLs for insecticides for all foreign markets: (examples include: Assail, Esteem, Applaud, Provado, Baythroid, Danitol, Success)
- Expedite registration of Platinum for GWSS
- Allow orchard floor uses of ant controls as an incentive for broader registrations (in an attempt to get exemption from tolerance)
- The PHI for Applaud is 60 days thus making it unusable on Valencias. Applaud is a good IPM tool. There is a need for a shorter PHI to make this available to growers.
- Quarantine issues: GWSS issues for harvest and movement and protection from invasive pests.

IV. Important Educational Needs

- Continue existing educational programs, including mobile lab, citrus industry booklet on GWSS (update), and grower seminars.
- Educate regulatory community. Recent EPA/CDPR citrus tour, as an example.
- Need better understanding of the impact of invasive pests
- Educate regulators with respect to the proper timing of GWSS treatments.
- Educate citrus industry regarding new insecticides and their proper use and compatibility with existing Integrated Pest Management Programs.

Control of Weeds during this period

1. Chemical Controls

- Simazine: ground water/surface water issues. Use may be retained but use patterns will likely change.
- Diuron: Ground water issues/surface water runoff issues.
- Glyphosate: Important weed – malva - is resistant.
- Paraquat: Worker safety issues associated with its use.
- Krovar (bromacil/diuron): Ground water issues/surface water runoff issues.

2. Cultivation as a means of control

- Burning/torching: Not frequently used but is effective. Use by organic growers.
- Disc middles: There exists the potential to damage tree roots.
- Mowing

3. Important Research Needs

- Weeds may serve as host for Glassy-Winged Sharpshooter (GWSS) nymphs to complete their life cycle in the second generation.
- Weeds serve as hosts for beet leafhoppers who transmit “stubborn” disease
- Vegetation on the orchard floor during the frost season adds to the risk of frost damage; this vegetation may be in the form of weed species or a seeded cover crop. Dense stands of vegetation pose a greater risk of lowering nighttime temperatures. Where cover cropping is practiced, planting in late fall (November) reduces the risk because of minimal growth of the cover during the frost season.
- Emerging weed problems include flax leaf fleabane, malva, and common groundsel, which are becoming more of a problem in the San Joaquin Valley.

4. Important Regulatory Needs

- Impact of regulations surrounding ground and surface water runoff. Great need for consistency between agencies at all levels, i.e. county, state, and federal.

5. Important Education Needs

- Citrus IPM Manual needs to be updated, especially in the weed section.
- Pictures need to be included.

Bloom (March thru April)

I. Activities Occurring During this Period

- Fertilizing
- Some frost protection initiated
- Snail control
- Ant control
- Harvest navels, mandarins, lemons
- Weed control
- Scouting
- Foliar nutrition
- Prune navels, mandarins and lemons after harvest and no frost
- Irrigation
- Pesticide applications with consideration given to issues surrounding bee toxicity
- Check for vertebrate damage (rats, gophers, coyotes)

Insect pest control during this period

Cutworm

- Cultural controls: None available
- Biological controls: No commercial natural enemies available. Some native natural enemies exist. Growers should avoid broad-spectrum insecticides.
- Pesticide controls:
  - Bt is effective on small instars. Timing is important and warm weather can improve efficacy of this product because the larvae are more actively feeding.
  - Kryocide is effective on small instars. Timing of application is important. Warm weather improves efficacy because the larvae are more actively feeding.
  - Lannate, Lorsban, and Dibrom are occasionally used, however, they are much more disruptive to natural enemies and there are label restrictions associated with use around bees.

GWSS

- Cultural controls: None available
- Biological controls: Inoculative releases of parasitoids are being evaluated in the Kern County Suppression Area.
  Some areas of California are under quarantine restrictions, which prohibit movement of fruit from infested or quarantined areas into non-infested areas
- Chemical controls:
  - Treatment with Admire (imidacloprid) for nymphs is generally 85% effective, however it is disruptive to cottony cushion scale and reduces natural enemies. There are also label restrictions associated with the use of Admire during bloom due to bee toxicity. Admire is expensive and probably will only be used on a limited basis unless growers are reimbursed for suppression control.

- Treatment with Assail, or various pyrethroids, for immature GWSS, may take place in March. While they are more effective and less expensive than Admire, they are also more disruptive to beneficials and only last one generation. Conversely, Admire lasts 6 months thereby covering 2 generations. Assail also has label restrictions associated with its use in the presence of bees.

Other worms (fruittree leafroller in SJV)

- Infrequent pest. Worms generally not a problem in coastal areas.
- Cultural controls: None available
- Biological controls: No commercial natural enemies available. Some native natural enemies exist. Growers should avoid broad-spectrum insecticides when possible.
- Pesticide controls: Bt is effective on small instars. Timing is important and warm weather can improve efficacy of this product because the larvae are more actively feeding.
    - Kryocide is also effective on small instars. Timing of application is important. Warm weather improves efficacy because the larvae are more actively feeding. Lannate, Lorsban, and Dibrom are occasionally used, however, they are much more disruptive to natural enemies and there are label restrictions associated with use near bees.

Citrus red mite *(typically not a problem in coastal areas; can be a major problem in the southern California interior in the fall with Santa Ana winds, leading to leaf drop)*

- Cultural controls: Implement dust reduction measures and proper irrigation of the trees.
- Biological controls: Methods include avoidance of broad-spectrum pesticides to encourage natural enemies (predatory mites/beetles)
- Pesticide controls: Oil is moderately effective. Efficacy is rate dependent. Oils are less expensive than miticides. The use of VOCs is gaining the attention of the Air Resources Board. This is definitely an emerging issue that needs to be watched.
    - Nexter is sometimes used. It is more efficacious while being less selective, i.e. more disruptive to beneficials.
    - Other miticides such as Omite, Vendex, and Kelthane can be used if weather is warm. There are some problems w/ resistance in Kelthane. Omite and Vendex are more compatible with natural enemies than Kelthane and Nexter. Omite has long REI and is a Minimal Exposure Pesticide (MEP).

Two spotted spider mite *Infrequent pest and rarely a problem this time of year.*

- Cultural controls: Methods include dust reduction.
- Biological controls: Include avoidance of broad-spectrum insecticides to encourage natural enemies (predatory mites/beetles)
- Pesticide controls: Oil is moderately effective. Efficacy is rate dependent. Oils are less expensive than miticides. The use of VOCs is gaining the attention of the Air Resources Board. This is definitely an emerging issue that needs to be watched.
    - Nexter is sometimes used. It is more efficacious while being less selective, i.e. more disruptive to beneficials.
    - Other miticides such as Omite, Vendex, and Kelthane can be used if weather is warm. There are some problems w/ resistance in Kelthane. Omite and Vendex are more compatible with natural enemies than Kelthane and Nexter. Omite has a long REI and is a Minimal Exposure Pesticide (MEP).

Citrus Bud Mite or Silver Mite *(Rust Mite on oranges and grapefruit) (lemons only – primarily coastal issue)*

- Cultural controls: None available
- Biological Controls: None available at this time
- Chemical: Oil, very effective, need good coverage. Expensive. Not effective on Silver mite.
  - Agri-Mek + oil: very effective, expensive.
  - Sulfur: very effective, better with warm temperatures. Can be phytotoxic in hot weather. Do not use with oil.
  - Lorsban + oil: very effective. Not preferred timing. Can cause fruit ridging.

Red Scale *Under excellent biological control in southern California, except when disrupted by ants, dust, or pesticides. Under annual eradication in the Coachella Valley*.

- Cultural controls: Dust suppression.
- Biological controls: *Aphytis* wasp releases are effective. Avoid broad-spectrum pesticide applications, as well as, GWSS treatments, which generally reduce or eliminate this natural enemy.
- Pesticide controls: Chemical treatments are generally not made at this time of the year.

Cottony Cushion Scale *Under excellent biological control in southern California, except when disrupted by ants, dust, or pesticides*

- Cultural controls: None available
- Biological controls: Ants protect scale insect pests from parasites and predators and so ant control can help biological control be more effective. (The only registered product for the sugar-feeding ants is Lorsban).
  - Vedalia Beetle is the most effective natural enemy of cottony cushion scale. It is critical that it be present during March – April to gain full control of cottony cushion scale. Vedalia beetles are not commercially reared. Growers find vedalia beetles in their orchards and move them to where they are needed.
- Pesticide controls: Insecticide sprays are generally made later in the year for this pest, i.e. May thru August

Brown Garden Snail *See restriction on Decollate in the Citrus Crop Profile*

- Cultural controls: Skirt pruning. Snails attack fruit that is close to the ground. Skirt pruning helps to lift up the skirts so that snails cannot reach the fruit.
- Biological controls: Move decollate snail (predatory snail) into orchard. Spread of decollates throughout an orchard can require 5 years to complete. Chemical treatments for slugs are incompatible with decollates.
- Pesticide controls: Metaldehyde, Iron Phosphide (Sluggo)

Citrus Peelminer *Primarily found in the desert and San Joaquin Valley*

- Cultural controls: Orchard sanitation which includes sucker removal and a clean harvest. Remove all fruit. Clean orchard floor.

Ants

- Cultural controls: Skirt pruning
- Biological controls: None available
- Pesticide controls:
  - Lorsban for Argentine black ants.

- Clinch Ant Bait or Esteem Ant Bait for red ants. These treatments work best when ants are active which tends to be later in the season.

Angular-winged Katydid

- Cultural controls: None available at this time
- Biological controls: None available at this time
- Pesticide controls: Kryocide is used but is only effective on small instars when applied in warm weather. Kryocide is preferred because of bee issues on other labeled products.

II. Important Research Needs (as they relate to insect management during the "bloom" period)

- Continue research to develop improved ant control systems or bait stations. Bait stations are needed for sugar-feeding ants (Argentine and native gray ants). There are problems associated with bait stations, i.e. economics and regulatory issues.
- There is a need to better understand endemic biological control of katydids and what materials cause disruption.
- Need to test the efficacy of non-toxic bee repellents or inhibitors of pollen germination and pollen tube growth to reduce seediness of mandarins.

III. Important Regulatory Needs (as they relate to insect management during the "bloom" period)

- There is a need for more realistic label restrictions relating to bees. See "bee language" on both the Success and Agri-mek labels.
- There is a need for registration of ant bait stations and pesticides that might be used in them.

IV. Important Educational Needs (as they relate to insect management during the "bloom" period)

- Education of registrants as to the need for ant bait stations. Need for more cost-effective bait stations

Weed pest control during this period

1. Chemical Controls

- Glyphosate: Resistance in Malva
- Trifluralin: Applied via chemigation, short residual period
- Solicam: Applied via chemigation, limited activity on broadleaf weed species, may not be used on coarse-textured soils or south of Monterey, Kings, and Tulare counties.
- Paraquat Dichloride: Short residual period, use requires closed system, inadequate grass control, post-emergence use only.
- Surflan: Excellent control over many grasses and broadleaves including nutsedge and field bindweed. Used as a pre-emergent herbicide. Long residual period; 6-12 months.
- Devrinol: Light use in young plantings, short residual activity, poor control on broadleaf weed species, documented to break down when used under drip irrigation systems.
- Visor: Controls several annual grasses and broadleaf weeds and provides suppression on several difficult weed species. Expensive.

2. Cultivation as a means of control

- Burning/torching: used infrequently but is effective. Organic growers may use.
- Disc middles; caution must be used to avoid damage to tree roots.
- Mowing.

3. Important Research Needs

- Need to develop new herbicides; there have been no new herbicides registered for some time.
- Need to find effective pre or post emergent herbicide for use on Malva.
- Bloom sprays for mandarins (thinning and fruit set sprays, PGRs).
- Need to test the efficacy of non-toxic bee repellents or inhibitors of pollen germination and pollen tube growth to reduce seediness of mandarins.

4. Important Regulatory Needs

- Need new products.

5. Important Education Needs

- New, onerous restrictions on chemigation.

Petal Fall (April thru May)

1. Activities Occurring During this Period

- Irrigate as needed
- Foliar nutrition
- Fertilization
- Monitor and control vertebrate activity
- Check for root and trunk disease
- Scouting for all pests
- Check for vertebrate damage (rats, gophers, coyotes)
- Harvest
- Pruning
- Weed control
- Pest control (including snails and ants)
- PGR applications (to delay abscission of mature fruit such as on Valencias and grapefruit)
- PGR applications to improve fruit size
- PGR applications for thinning to improve fruit size
- PGR applications to improve fruit set, specifically Clementine mandarins

Insect pest control during this period

Citrus Thrips

- Cultural: Dust suppression
- Biological: Preserve natural enemies such as predatory mites by avoiding broad-spectrum insecticides.
- Chemical: Use of "soft" pesticides including Success, Agri-mek and Veratran.
  - Agri-Mek: tends to preserve natural enemies, is used with a small amount of oil to increase translaminar movements into leaves and fruit, but its relatively high cost in contrast to effective alternatives (especially Success) have limited its use by California growers for citrus thrips control.
  - Veratran: tends to preserve natural enemies, is a stomach poison, and is less effective than Success or Agri-Mek. It is made from the ground seeds of a lily-like plant that grows in Venezuela and contains 0.2% alkaloids as the active ingredient. Efficacy is increased by lowering water pH to 4.5 prior to adding Veratran D to the spray tank. Sugar (5-10 lbs/a) or cane molasses (1-2 gal/a) are usually added to Veratran D (even though the product is 80% sugar to begin with to increase efficacy.
  - Success: tends to preserve natural enemies and is used with a small amount of oil to increase translaminar movement into leaves and fruit.
  - Broad Spectrum: Baythroid, Danitol, Dimethoate, and Carzol. Thrips have shown resistance to Baythroid, Dimethoate and Carzol in some areas of California.

Cutworm

- Cultural: None at this time
- Biological: No commercial natural enemies available at this time. Some native natural enemies exist; avoid broad-spectrum insecticides. If cutworm is present at the time of citrus thrips treatment, Baythroid, Danitol, Dimethoate, or Success will simultaneously control both species unless citrus thrips resistance is an issue.

GWSS

- There exists (in some areas) quarantine restrictions that prohibit the movement of fruit, after harvest, to non-infested areas.
- Cultural: None at this time
- Biological: None at this time.
- Chemical:
  - Generally accepted that treatment with Admire (imidacloprid) for nymphs is 85% effective but disruptive to cottony cushion scale. It also reduces other natural enemies.
  - Treatment with Assail for immature GWSS in March. This application tends to be more disruptive of natural enemies but more effective against GWSS than Admire. Assail is cheaper but only lasts one generation, whereas Admire lasts 6 months or 2 generations.
  - Foliar treatments for GWSS are often incorporated as part of a treatment for citrus thrips. For example, growers will use a full rate of the pyrethroids Danitol or Baythroid or they will mix Success w/ a low rate of OP (Lorsban or Dimethoate) or a pyrethroid (Baythroid or Danitol).

Other worms

- Fruittree leafroller in Valencias (possibly)
- Amorbia (most commonly found when grown near avocados). *Trichogramma* wasp releases are an effective control.
- Orange Tortrix: Biological: No commercial natural enemies available at this time. Some native natural enemies exist; avoid broad-spectrum insecticides. If cutworm is present at the time of citrus thrips treatment, Baythroid, Danitol, Dimethoate, or Success will simultaneously control both species unless citrus thrips resistance is an issue.
  See cutworm above. This is generally an infrequent pest.

Citrus red mite: *Can still be a problem in May*

- Cultural: Dust reduction and proper irrigation
- Biological: avoid broad spectrum insecticides to encourage natural enemies (predatory mites/beetles)
- Chemical:
  - Oils are moderately effective. Often the rate of oil in the citrus thrips treatment is increased from 0.5% to 1.4% to help control red mite. Efficacy is rate-dependent. Oils are less expensive than miticides.
  - Nexter (a small amount of this product is used). It is fairly efficacious and less selective but more disruptive. Efficacy is rate dependent.
  - Omite: can be used in warm weather. Omite is more compatible with natural enemies, however it has a long REI and is a minimal exposure pesticide (MEP).

- Vendex: can be used in warm weather. Vendex is more compatible with natural enemies than other registered miticides.
- Kelthane: can be used in warm weather. It is tough on natural enemies and there are some problems with resistance.

Two spotted spider mite: Rarely a problem this time of year. Infrequent pest.

- Cultural: Dust reduction and proper irrigation
- Biological: Avoid broad spectrum insecticides to encourage natural enemies (predatory mites/beetles)
- Chemical:
  - Oils are moderately effective. Often the rate of oil in the citrus thrips treatment is increased to help control two-spotted spider mite. Efficacy is rate-dependent. Oils are less expensive than miticides.
  - Nexter (a small amount of this product is used). It is fairly efficacious and less selective but more disruptive. Efficacy is rate dependent.
  - Omite: can be used in warm weather. Omite is more compatible with natural enemies, however it has a long REI and is a minimal exposure pesticide (MEP). There are problems with resistance to Omite.
  - Vendex: can be used in warm weather. Vendex is more compatible with natural enemies than other registered miticides. There are problems with resistance to Vendex.
  - Kelthane: can be used in warm weather. It is tough on natural enemies and there are some problems with resistance.

Red Scale

- Cultural: None
- Biological: Aphytis wasp releases are effective at a rate of 5,000/acre every two weeks until a total of 100,000/acre are released. Avoid broad-spectrum pesticide applications.
- Chemical: The period of May thru June is the first window for chemical treatments as the first generation of scale crawlers are emerging and settling down on leaves and twigs. Treatments may be Lorsban, Supracide, Sevin, Esteem or Applaud. There are problems with red scale resistance to Lorsban, Supracide, and Sevin.
  Efficacy of insecticides is influenced by resistance (Lorsban, Supracide, Sevin,), spray timing, and spray coverage. The organophosphates (Lorsban and Supracide) and carbamates (Sevin) are toxic to parasitic wasps. The insect growth regulators (Esteem and Applaud) are toxic to predatory beetles, and oil is toxic to predatory mites. GWSS treatments reduce or eliminate many of the natural enemies needed for red scale. Efficacy of OPs and carbamates are improved if they are applied at the time of crawler emergence. Efficacy of insect growth regulators are improved if they are applied when 1st instar scale are white caps, just prior to molting. Growers generally avoid using insect growth regulators during the first window of spraying because they are toxic to vedalia beetles and will disrupt cottony cushion scale control.

Cottony Cushion Scale - CCS

- Cultural: Ants protect scale insect pests from parasites and predators and so ant control can help biological control be more effective. (The only registered product for the sugar-feeding ants is Lorsban). The industry needs more selective insecticides for ant control.
- Biological: Vedalia Beetle is the most effective natural enemy of cottony cushion scale. It is critical that it be present during March –April to gain full control of cottony cushion scale.

Vedalia beetles are not commercially reared. Growers find vedalia beetles in their orchards and move them to where they are needed. Esteem/Applaud, Admire, Assail, Baythroid, Danitol, and Provado treatments are toxic to Vedalia Beetle and so should be avoided if Cottony Cushion Scale is present. Esteem is especially toxic because it affects Vedalia in neighboring orchards. CCS is emerging as a primary pest due to new insecticide registrations that disrupt Vedalia Beetle.

- Chemical:
  - Supracide: Is moderately effective against cottony cushion scale. Very toxic to most natural enemies except Vedalia Beetle.
  - Malathion: Is moderately effective against cottony cushion scale. Very toxic to most natural enemies except Vedalia Beetle.
  - Applaud: Controls CCS very slowly but could be used under some circumstances because it has IPM compatibility with natural enemies other than beetles.

Brown Garden Snail

- Cultural: Skirt pruning. Snails attack fruit that is close to the ground. Skirt pruning helps to lift up the skirts so that snails cannot reach the fruit.
- Biological: Move decollate snail (predatory snail) into orchard. Spread of decollates throughout an orchard can require 5 years to complete. Chemical treatments for slugs are incompatible with decollates.
- Chemical
  - Metaldehyde
  - Sluggo (iron phosphide)

Citrus Peelminer

- Cultural: Orchard sanitation, which includes clean harvest and sucker removal. Clean orchard floor.
- Biological: Native parasites are weakly controlling this pest in the San Joaquin Valley. A nonnative (*Cirrospilus*) is presently being released.
- Chemical: Insecticides are relatively ineffective in stopping citrus peelminer infestations.

Ants

- Cultural: Skirt pruning
- Biological: None at this time
- Chemical
  - Lorsban (sugar-feeding ants)
  - Clinch or Esteem Ant Bait for red ants.

Katydids

- Cultural: None at this time.
- Biological: None at this time.
- Chemical
  - Tank mix with citrus thrips material. For example, low rates of organophosphate (Lorsban, Dibrom, Cygon) or pyrethroid (Baythroid, Danitol) insecticides with Success for thrips. At this time of year, there is a high risk of damage because katydids prefer to feed on young fruit and at this time of the year they are larger instars and therefore harder to kill. Lorsban registration is important to maintain because it is one of the most effective and selective insecticides for katydid control. It can be used at

extremely low rates (2-6 oz/acre) and quickly and effectively kill katydids. Many of the natural enemies in the San Joaquin Valley have resistance to Lorsban.

Earwigs

- Earwigs are an emerging pest problem in some areas of the valley where organophosphates are no longer used. Earwigs cause damage to young trees by girdling them. They can attack the young fruit of mature trees. There are no controls available.

Grasshoppers

- Cultural: None at this time.
- Biological: Nosema bait.
- Chemical
  - Sevin**:** Sevin can be an effective insecticide. The difficulty in using this product is that you must have a quick response, apply a high rate, and get good coverage since grasshoppers can arrive suddenly in large numbers.

2. Important Research Needs:

- Establish economic thresholds for citrus thrips with new and/or selective materials.
- Need to determine resistance levels in thrips for new products.
- Need for new insecticides to control citrus thrips.
- Need research on control measures for earwigs and/or other sporadic pests that emerge, i.e. grasshoppers, etc.

3. Important Regulatory Needs:

- Obtain Section 18 for Micromite for grasshopper and citrus leafminer.

4. Important Education Needs:

- Educate growers as to pH requirement when using Success and Veratran. Need to keep Success above 6 pH and acidify Veratran to 4.5 pH.
- Need to avoid treating populations of flower thrips; they are easily confused with citrus thrips.
- Educate growers regarding managing pesticide resistance, in general, and withholding unnecessary treatments. Unlikely to have new insecticides registered.
- Educate growers regarding timing of use of Glyphosate.

Weed Pest Control During this Period Generally in maintenance mode during this time of the year.

- Cultural: None at this time
- Biological: None at this time
- Chemical:
  - Glyphosate: Malva is resistant, no residual activity, post emergence use only
  - Paraquat Dichloride: Short residual activity, requires use of closed system, inadequate grass control.

Summer Season (June thru September)

1. Activities occurring during this season

- Irrigate as needed
- Leaf analysis
- Prune Valencias, lemons (yearly) topping/hedging
- Scouting
- Monitor summer weeds
- Pesticide applications (including ant and snail control)
- PGR Applications of GA on Valencias and Lemons
- Fertilizing (foliar nutrition)
- Herbicide applications
- Harvest Valencias
- Cultivating/mowing
- Checking for vertebrate damage (rats, gophers, coyotes)

2. Important Research Needs

- Continued research on management tactics for citrus peelminer
- More research on selective citricola scale treatments
- Research on pesticide resistance in red scale (Esteem)

3. Important Educational Needs

- Pesticide resistance issues: New products such as Success, Admire, and Esteem are heavily relied upon for citrus thrips, GWSS, and red scale, respectively. This will eventually lead to resistance. Growers need to be taught to rotate chemistries and use nonchemical methods to reduce the rate of resistance development. In particular, Admire & Esteem/tank mixing/GWSS treatments.
- Overuse of insecticides when they are not needed because the pests are below an economic threshold.
- Reduce weeds. When preparing for the frost season, weed growth should be minimized. The application of preemergence herbicides in the fall will prevent the emergence of winter weeds; post emergence herbicide applications will eliminate established weed growth. Disking the orchard floor to eliminate weeds should be avoided in the fall because nighttime temperatures tend to be lower on disked ground compared to non-disturbed soil on a cold night.

Insect Pest Control During this Period

GWSS

- Areas of GWSS suppression are treated, as needed, primarily with foliar sprays.

Citrus red mite (still a problem thru May)

- Cultural: Dust reduction and proper irrigation.
- Biological: Most years heat and virus greatly reduces citrus red mite in citrus.

Two spotted spider mite: *Occasionally a problem this time of the year.*

- Cultural: Dust reduction and proper irrigation.
- Biological: Use of predatory mites
- Chemical: Omite, Kelthane, oil

Broad Mite: *(coastal lemons)*

- Cultural: Dust reduction and proper irrigation.
- Biological: Maintain control of ants.
- Chemical: Same as bud mite treatments, except do not include oil alone.

Silver Mite:

- Cultural: Dust reduction and proper irrigation.
- Biological: Maintain control of ants.
- Chemical:
  - Nexter

Greenhouse Thrips: *Generally a coastal problem in the spring, summer and fall. Becomes a problem where broad-spectrum OPs were not used.*

- Cultural: Harvest early.
- Biological: None commercially reared.
- Chemical:
  - Lorsban: Very effective with good coverage.
  - Malathion effective but is disruptive to beneficials.

Red Scale:

- Biological: *Aphytis melinus* wasp releases are effective at a rate of 5,000/acre every two weeks until a total of 100,000/acre are released. Avoid broad-spectrum pesticide applications.
- Cultural: None at this time.
- Chemical: The second window (June – July) for chemical treatments occurs when the 2nd generation of crawlers emerge.
  - Treatments may be Lorsban, Supracide, Sevin, Esteem or Applaud. There are problems with red scale resistance to Lorsban, Supracide, and Sevin in some red scale populations.
  - Efficacy of insecticides is influenced by resistance (Lorsban, Supracide, Sevin,), spray timing, and spray coverage. The organophosphates (Lorsban and Supracide) and carbamates (Sevin) are toxic to parasitic wasps, the insect growth regulators (Esteem and Applaud) are toxic to predatory beetles, and oil is toxic to predatory mites. GWSS treatments reduce or eliminate many of the natural enemies needed for red scale. Efficacy of OPs and carbamates are improved if they are applied at the time of crawler emergence. Efficacy of insect growth regulators are improved if they are applied when 1st instar scale are white caps, just prior to molting.

- Oil treatments may be used at this time of year as dilute applications in well-irrigated orchards when temperatures are less than 95 degrees. Oils are relatively non-toxic to natural enemies because their residual activity is brief.

Cottony Cushion Scale - CCS

- Cultural: Ants protect scale insect pests from parasites and predators and so ant control can help biological control be more effective. The only registered product for the sugar-feeding ants is Lorsban. The industry needs more selective insecticides for ant control.
- Biological: Vedalia Beetle is the most effective natural enemy of cottony cushion scale. It is critical that it be present during March –April to gain full control of cottony cushion scale. Vedalia beetles are not commercially reared. Growers find vedalia beetles in their orchards and move them to where they are needed
  - Esteem/Applaud, Admire, Assail, Baythroid, Danitol, and Provado treatments are toxic to Vedalia Beetle and so should be avoided if Cottony Cushion Scale is present. Esteem is especially toxic because it affects Vedalia in neighboring orchards.
    CCS is emerging as a primary pest due to new insecticide registrations that disrupt Vedalia Beetle.
- Chemical:
  - Supracide: Is moderately effective against cottony cushion scale. Very toxic to most natural enemies except Vedalia Beetle.
  - Malathion: Is moderately effective against cottony cushion scale. Very toxic to most natural enemies except Vedalia Beetle.
  - Applaud: Controls CCS very slowly but could be used under some circumstances because it has IPM compatibility with natural enemies other than beetles.

Citrus Peelminer

- Cultural: Orchard sanitation including clean harvest and sucker removal. Clean orchard floor.
- Biological: Introduced parasites are being researched. Avoid broad-spectrum pesticides to preserve natural enemies.
- Chemical: There is no efficacious material registered to control this pest.

Ants

- Cultural: Skirt pruning in Valencias. This minimizes foliage that is touching the ground.
- Biological: None available
- Chemical:
  - Lorsban for sugar-feeding ant control.
  - Clinch ant bait or Esteem ant bait for red ant control.

Citricola

- Cultural: None at this time
- Biological: None at this time. Avoid broad-spectrum pesticides to preserve natural enemies
- Chemical:
  - Lorsban: Is the most selective insecticide available for citricola scale control because many natural enemies have developed resistance to it. Under heavy spring population conditions, you need to treat immediately to prevent sooty mold and therefore yield reductions. However, these treatments are not very effective because the scale is large and located deep inside the tree canopy. When possible,

treatments should be delayed until later in the year (Aug-Sept) for maximum toxicity to small nymphs on the outside of the tree or even further to (October – November) to preserve natural enemies. Efficacy of treatments is influenced by weather, i.e. principally by temperature and moisture. Cool, wet springs and cool summers exacerbate the citricola scale problem. High heat in August/September reduces their numbers.

- Provado and Assail: These neonicotinoid insecticides are moderately effective against citricola scale. The disadvantage of these insecticides is that there are not international codexs established and they are fairly broad spectrum, killing most natural enemies. The advantages are that they have much shorter PHI than Lorsban, and they are more effective in the spring months.
- Admire: GWSS treatments with Admire have had the benefit of reducing (but not eliminating) citricola scale populations.

Fuller Rose Beetle: *Phytosanitary export issue for Japan*.

- Cultural: Skirt pruning
- Biological: None at this time. Avoid broad-spectrum pesticides to preserve natural enemies.
- Chemical:
  - Sevin: works well; may need two treatments as beetle emerges over a long period of time.
  - Kryocide: works well; may need two treatments as beetle emerges over a long period of time.

PRE-HARVEST THRU HARVEST SEASON
*** September thru January ***

1. Activities occurring during this season

- Irrigate as needed
- Apply growth regulator if needed (Gibberellic acid, 2,4-D)
- Frost protection (fans, reduce weeds, irrigation)
- Scouting (some)
- Protect against brown rot and leafhoppers
- Apply preemergent herbicides
- Check for vertebrate damage (rats, gophers, coyotes)
- Harvest (early navels, lemons, mandarins)
- Insecticide treatments
- *Aphytis melinus* releases

2. Important Research Needs

- Continued research on monitoring and methods to reduce levels of bean thrips in export shipments, post harvest controls.
- Efficacy of late fall, winter, early spring treatments for GWSS and impact on natural enemies.

3. Important Regulatory Needs

- REIs need to be equal to, or shorter than, PHIs.
- Need to change Japanese MRL to Codex MRL for Lorsban.

4. Important Educational Needs

- Late season applications of pesticides for red scale are not very effective because you have multiple stages and overlapping generations.

Insect Pest Control During this Period

Citrus Thrips: *(late season silvering in areas disrupted by GWSS treatments)*

- Biological: None available at this time.
- Cultural: None practiced at this time.
- Chemical: Various insecticides used depending on the region of California and the presence of other pest species at the same time (e.g. citrus cutworm).
  - Success is the major material used at this time.
  - Baythroid
  - Dimethoate
  - Carzol
  - Veratran D
  - Danitol
  - Agri-Mek

GWSS: *(At this time of year, GWSS are eliminated pre-harvest, if shipping to/through non-infested areas).*

- Quarantine restrictions exist in some areas in California that require preharvest treatments to disinfest the fruit before it is harvested.
- Cultural: None at this time.
- Biological: None at this time.
- Chemical:
  - Lannate is used because of short PHI and Codex MRLs.
  - Assail is an option for fruit exported to Japan, Korea, and Canada.
  - Baythroid is an option but has only partial Codex MRLs and has a limit of 6.4 oz. per year. So if used for citrus thrips (at full rate) control then can't be used for GWSS control.

Red Scale

- Cultural: None at this time.
- Biological: *Aphytis* releases fairly effective if applied when weather is sufficiently warm.
  Avoid broad-spectrum pesticide applications.
  GWSS treatments reduce or eliminate this natural enemy.

Cottony Cushion Scale

- Cultural: None, ant control (only have Lorsban for ant control). Need more tools/research.
- Biological: Vedalia Beetle although not commercially reared. Move as needed

Brown Garden Snail

- Cultural: None at this time.
- Biological: Move decollate snail, a predatory snail, on an "as needed" basis
- Chemical:
  - Metaldehyde
  - Iron phosphide (Sluggo)

Citrus Peelminer

- Cultural: Practice good orchard sanitation, including clean harvest and sucker removal. Keep orchard clean.
- Biological: None at this time.
- Chemical: None at this time.

Ants

- Cultural: None at this time.
- Biological: None at this time.
- Chemical: Lorsban for control of sugar-feeding ants. Sometimes use of preemergent herbicides combined with Lorsban. Efficacy depends on warm temperatures and dry conditions.

Bean Thrips: *This pest presents an export problem w/ New Zealand and Australia.*

- Cultural: Reduce weeds, such as tree tobacco, that harbor bean thrips. Do not export fruit planted next to rangeland or beans or other host crops.
- Biological: None at this time.
- Chemical: Undeveloped at present.

Citricola Scale

- Cultural: None at this time.
- Biological: None at this time, however, avoid use of broad-spectrum pesticides
- Chemical:
  - Some late-season Lorsban treatments are applied if weather is warm enough to reduce citricola but avoid disruption of natural enemies. Lorsban is not used December thru March because it can cause ridging of fruit. Japan has lower MRLs (.3 ppm) than international codex (1.0 ppm) and this prevents exported fruit from being treated w/ Lorsban this time of the year.
  - Provado or Assail may also be used to reduce citricola at this time. Short REI, PHI, and partial Codex. Not temperature dependent.

Weed Pest Control During this Period

A minority of growers plant winter/fall cover crops, which works well where frost is not a problem and erosion control is practiced. Weeds: In addition to existing weed problems, both flax weed and common groundsel are becoming more of a problem in the San Joaquin Valley.

1. Chemical Controls

- Simazine: Weak on many grasses. Product may not be used on sandy or gravelly soils where product may move into the root zone and damage roots. Groundwater problems associated with the use of this product. Found on California's Groundwater Protection "A" List.
- Diuron: Phytotoxicity when used on sand, loamy sand or gravelly soils. On California's Groundwater Protection "A" List.
- Glyphosate: No residual activity. Post emergence use only. Must avoid drift. Seeing resistance in Malva.
- Paraquat Dichloride: Short residual period, use requires closed system, inadequate grass control, post-emergence use only. Also worker safety issues concerning use of this product.
- Krovar (bromacil/diuron): On California's Groundwater Protection "A" List. Can be phytotoxic when used on soils with less than 1% organic matter.

2. Cultivation as a means of control

- Burning/torching (not frequently used but is effective/maybe organic). Possible regulatory issues with particulate and smoke.
- Disc middles (potential damage to tree roots)
- Mowing Possible regulatory issues with particulate and smoke.

3. Important Research Needs

- Weeds may serve as host for Glassy-Winged Sharpshooter (GWSS) nymphs to complete life cycle in the second generation.
- Weeds serve as hosts for beet leafhoppers who transmit "stubborn" disease
- Vegetation on the orchard floor during the frost season adds to the risk of frost damage; this vegetation may be in the form of weed species or a seeded cover crop.

Dense stands of vegetation pose a greater risk of lowering nighttime temperatures. Where cover cropping is practices, planting in late fall (November) reduces the risk because of minimal growth of the cover during the frost season.

- More research on cover crops (need to identify species and mixtures of species and consequences of their use). Study should include an economic analysis of the cost of potential additional water and nutrient needs and impacts on frost hazard.
- Research newer herbicides which are generally used at lower rates.
- Weed resistance. Which species to what chemicals?
- Cost benefit of weed control.
- New application technologies in citrus.
- Use of mulches as a weed suppressant (possible insect control as side benefit)

4. Important Regulatory Needs

- Impact of regulations surrounding ground and surface water runoff. Great need for consistency between agencies at all levels, i.e. county, state, and federal.
- Register additional (newer) herbicides.

5. Important Educational Needs

- Citrus IPM Manual needs to be updated, especially in the weed section. Add updated UC IPM Guidelines weed control to Citrus IPM Manual.
- Pictures need to be included of various stages of weed development for each species. Need to characterize the cost/benefit of weed control.
- Educate on mitigation of groundwater and other off-target effects of herbicides.
- New application technologies.
- Use of mulches as a weed suppressant (possible insect control as side benefit)

POST HARVEST

Insect Pest Control During the Season

GWSS

- Evergreen ultra low volume atomized space treatment. Kills adults. Only used in packinghouses. Only lasts 24 hours. Extra inspection.

Bean Thrips

- Heat is being used but of unknown efficacy. Extra inspection. Efficacy of Evergreen is still unproven.

Scale and Sooty Mold

- High pressure fruit washer. Works very well. Has reduced incidences of post harvest diseases and improves shine from wax. Some problems are seen with early fruit.
- Cyanide used as a disinfestation treatment. Only 1 operator currently approved to fumigate using this method.

Fruit Flies

- Cold: Dependent on fruit fly species. USDA APHIS approved treatments.
- Fumigation: MB – APHIS approved.
- Heat: Approved but extremely phytotoxic
- Irradiation: Unproven, expensive, sterilizes rather than disinfests.

1. Important Research Needs

- Evergreen and other post harvest controls for bean thrips.
- Impact of irradiation on fruit quality.
- Alternative quarantine treatments.
- Cultural or chemical management in the field to delay host susceptibility to quarantine pests.

2. Important Regulatory Needs

- Development of pest-free zones for export shipment.

De-greening and delaying fruit ripening in postharvest storage

- Plant growth is regulated by naturally occurring growth regulators that act as hormones. To change the plant's physiology, synthetically produced plant growth regulators are commonly applied to certain agricultural crops. Selected plant growth regulators may have an indirect effect on the plants susceptibility to postharvest decay caused by opportunistic pathogens. Ethylene gas applications to stored fruit are used to ripen fruit and this treatment may increase the susceptibility to decay. Conversely, any treatment that delays plant senescence will not only delay ripening but may reduce susceptibility to those pathogens that favor senescent tissues for infection. For example, postharvest treatment of lemons with gibberellic acid reduces ethylene production, delays ripening, and consequently delays the onset of sour rot caused by *Geotrichum citri-aurantii*. For control of stem decays of citrus, 2,4-D treatments delay the senescence of lemon fruit buttons and thus, delay the

development of Alternaria stem end rot. *Diplodia* and *Phomopsis* stem end rots of oranges and *Penicillium*, *Alternaria*, and *Colletotrichum* decays of mandarins have been commercially controlled with postharvest fruit treatments of 2,4-D.

Disease Control During Post Harvest Storage

1. Preharvest practices for postharvest disease management. The incidence of postharvest diseases can be reduced with integrated preharvest cultural and chemical practices that minimize injuries and protect fruit, respectively. Any handling practice that prevents wounds from occurring can help to reduce decay. Insect management can be an effective approach to reduce fruit injuries and subsequent decays of citrus. Fungicides available or planned for registration include Abound (Azoxystrobin and Topsin-M (thiophanate-methyl), respectively, for management of *Penicillium, Alternaria*, and *Colletotrichum* decays of citrus. Preharvest air-blast applications of these fungicides can help to reduce decay losses from clear rot (i.e. preharvest penicillium decays), as well as, postharvest *Penicillium* decays (e.g. , green and blue mold).

2. Truck or bin drenches. Postharvest drenches of harvested fruit in the field have been effective in reducing *Penicillium* decays of early-harvested fruit that will be de-greened. For this, both thiabendazole and Imazalil have been effective.

3. Postharvest applications of sanitizers, alkaline treatments, and fungicides. Sanitation treatments such as hypochlorous acid (sodium hypochlorite) and ozonated water (ozone) are commonly used to reduce the inoculum levels of fruit pathogens, especially *Penicillium* and *Geotrichum* species. High-pressure fruit washes work very well to reduce post harvest diseases and improve fruit appearances. Water used to wash fruit that does not contain a sanitizing agent can be contaminated with spores of these pathogens and effectively inoculate fruit with decay organisms.

   Alkaline treatments such as sodium bicarbonate that change the pH in the microenvironment of the wound, as well as, fungicidal compounds including σ-phenylphenol, thiabendazole, and Imazalil are also used to prevent infections of fresh injuries by *Penicillium* species. Alkaline treatments and σ-phenylphenol generally do not penetrate the rind tissue of the fruit to any effective degree. Thus, these treatments must be applied before fungal growth develops into the wounded tissue. Fungicides such as thiabendazole (TBZ) and Imazalil can penetrate a short distance into the rind and button of the fruit and can prevent the development of decays after an infection period and prevent sporulation of *Penicillium* species on decaying fruit. Newer fungicides planned for registration on citrus such as Pyrimethanil, Azoxystrobin, and Fludioxinil have not been completely characterized. Preliminary evaluations indicate that Pyrimethanil and Azoxystrobin are similar to Imazalil and TBZ, whereas Fludioxinil penetrates less into fruit tissue.

1. Summary of Management Practices for Major Postharvest Decays in California:
   Penicillium decays (P. digitatum, P. italicum):
   - Sanitation treatments (e.g. chlorine, ozone)
   - Alkaline treatments including sodium carbonate and sodium bicarbonate are slightly to moderately effective but may be phytotoxic.

- Registered fungicides include SOPP, TBZ, and Imazalil. Planned registrations include Fludioxinil, Pyrimethanil, and Azoxystrobin.
- Heat treatments are slightly to moderately effective but phytotoxic.
- Irradiation unproven for decay control may alter fruit surface shine.

2. Sour Rot
   - Sanitation treatments (e.g. chlorine, ozone)
   - Alkaline treatments including sodium carbonate and sodium bicarbonate are slightly to moderately effective but may be phytotoxic.
   - The fungicide SOPP is moderately effective.
   - Heat treatments are moderately effective but phytotoxic.
   - Irradiation unproven for decay control may alter fruit surface shine.

Green Mold/Blue Mold:

- Cultural: Prevent injuries
- Sanitation: Physically remove damaged/decayed fruit.
- Biological Controls:
  - Treat with Biosafe products (*Pseudomonas* strain) which acts as an aid but cannot be used as a stand alone as it is unreliable.
  - Messenger (recently registered) but not widely used yet in California. Efficacy is somewhat questionable.
- Chemical sanitation
  - Wash with chlorine products such as sodium hypochlorite. Used as a general sanitizer but not as a stand-alone.
  - Ozone.
  - Chlorine dioxide.
- Equipment sanitation
  - Quaternary Ammonium. Wash with chlorine products or other oxidizing products such as chlorine dioxide.
  - Formaldehyde also efficacious but has worker safety issues.
- Fruit protectants
  - SOPP (sodium orthophenylphenol). Should not be used as a stand-alone treatment. Serves the purpose of controlling wound site but not overall control. End up with decay if used as a stand-alone. Wash treatment used as an "in-line" process. Essential to control pH within a very narrow range to prevent fruit burn. Has a bad odor and there may be some disposal issues depending on locale.
  - Liquid lime sulfur: Registered as a general material to control penicilium and other decays. No residual control. Cannot be used as a stand-alone. Will not provide control if wound occurs after treatment.
- Wash water treatments
  - Sodium bicarbonate, a "generally recognized as safe (GRAS) material. Cannot be used as a stand-alone. Need to employ an integrated system to prevent organism from spreading in the wash water.
  - Soda Ash: Same action as sodium bicarbonate.
- Residual Fungicides:
  - TBZ: Thiabendazole: Used as an effective fungicide but documented resistance. Can only be used as a stand-alone where resistance hasn't been detected. As

season progresses, resistant populations build up and efficacy is reduced. Limited sporulation control.

- Imazalil: Similar to TBZ. Different class of chemistry and different mode of action. Effective sporulation control. Documented cross-resistance between (up to) three classes of fungicides with three different modes of action; i.e. SOPP, TBZ, and Imazalil (and combination thereof).

Sour Rot

- Cultural: Prevent injuries. Use of PGRs such as Gibberellic acid (delayed senescence).
- Sanitation: physically remove damaged or decayed fruit.
- Biological Controls: None currently available.
- Chemical sanitation:
  - Wash with chlorine products such as sodium hypochlorite. Used as a general sanitizer but not as a stand-alone.
  - Ozone
  - Chlorine dioxide
- Equipment sanitation:
  - Quaternary Ammonium Compounds
  - Wash w/ chlorine products or other oxidizing products
  - Chlorine dioxide
  - Formaldehyde (worker safety issues associated with its use).
- Chemical: SOPP (provides less than 50% control).

Minor decays - *Alternaria*

(Can be problems in some years but not a consistent problem)

- Cultural: Use of 2,4-D to maintain integrity of button, used post-harvest, maintain tree vigor.

Brown Rot

- Cultural: Some literature refers to use of hot water treatment although oftentimes results in phytotoxicity. Fruit damage is so extreme that treatment is not practical.

Stem End Rot

(*Primarily seen in desert lemons)*

- Chemical control: TBZ (very effective)

Cottony Rot, Trichoderma, Botrytis

(Fairly regional/found on coast)

- Chemical: TBZ (effective treatment) however quiescent infections may occur in the field for which TBZ may be of limited effectiveness.

2. Important Research Needs:

- Resistance management tools ranging from sanitation to residual fungicides with new modes of action.
- Support registration of Pyrimethanil (Janssen – registrant): For *Penicillium* decays.
- Support registration of Fludioxinil (Syngenta): For *Penicillium* decays.

- Support registration of Azoxystrobin (Syngenta): For penicillium decays.
- New strategies for Sour Rot control (other countries have residual fungicides available for use that are not available in US). Guazatine materials have multiple active ingredients which EPA has made difficult to register (need tox. Data for each a.i. within each product). Not cost effective for registrant to conduct studies.

3. Important Regulatory Needs:

- Need expedited registration of Pyrimethanil, Fludioxinil, and Azoxystrobin
  Guazatine materials have multiple active isomers which EPA has made difficult to register (need toxicity data for each a.i. within each product). Not cost effective for registrant to conduct studies. Places U.S. growers at a competitive disadvantage.

4. Important Educational Needs:

- Need for instructional video detailing proper post-harvest handling of fruit. Focus on prevention of injuries, temperature management, treatments, washes, etc.
- Need for educational materials (for packing house managers and crew) re: use of new materials and strategies for resistance management, overuse, rotation of chemistries, etc.
- Need for growers continued education on the value of use of PGRs on lemons to delay senescence/color in order to better respond to market supply and demand.

Priority Critical Needs

Priority Research Needs (random order)

- Overall objective to develop an economical and effective integrated program that maximizes biological control and minimizes non-selective insecticides.

- Need better understanding of the impact of the GWSS suppression program on natural enemies. Research winter/fall treatments for GWSS vs. Spring treatments (which is the least disruptive). Search for GWSS treatments that are compatible w/ IPM.

- Develop economical and practical ant control systems that work on sugar-feeding ants (Argentine and native gray ants) in order to improve biological control of various pests. (Problems associated with bait stations: economics, regulatory issues.

- Continue research efforts on biological control of newly introduced pests such as GWSS, citrus peelminer and citrus leafminer (not yet in SJ Valley that we know of but is predicted) as well as, established pests such as citricola scale.

- Continued research on monitoring and methods to reduce levels of bean thrips and other phytosanitary pests (e.g. peelminer, fuller rose, GWSS, fruit flies) in export shipments, post harvest controls.

- Pesticide Resistance issues: red scale (Esteem), GWSS (Admire), and citrus thrips (Success). New insecticides for citrus thrips and red scale will be needed.

- Develop alternative quarantine treatments.

- Continue research on pre-bloom, bloom, petal fall and/or June drop foliar applications of PGRs [2,4-dichlorophenoxyacetic acid (2,4-D), 2,4,-dichlorophenoxyproprionic acid (2,4-DP), 3,5,6-trichloro-2-pyridyloxyacetic acid (3,5,6-TPA), gibberellic acid (GA3), 6-benzoyladenine (BA), N-(2-cloro-4-pyridinyl)-N-phenylurea (CPPU), aminoethoxy-vinylglycine (AVG)] for improving fruit set and size of mandarins, maximum peel thickness foliar PGR applications for increasing fruit size [2,4-DP), 3,5,6-trichloro-2pyridyloxyacetic acid (3,5,6-TPA), gibberellic acid (GA3), 6-benzoyladenine (BA), N-2-cloro-4-pyridinyl)-N-phenylurea (CPPU)] to increase fruit size, and Preharvest foliar applications to prevent Preharvest fruit drop and improve fruit quality of late harvested fruit [gibberellic acid (GA3), 6-benzoyladenine (BA), N-(2-cloro-4-pyridinyl)-N-phenylurea (CPPU), aminoethoxyvinylglycine (AVG)].

- Need to test the efficacy of non-toxic bee repellents or inhibitors of pollen germination and pollen tube growth to reduce seediness of mandarins.

- Pre-plant fumigants for those citrus replants where pre-plant fumigation is really needed. Current products of interest include methyl iodide and sodium azide.

- Field evaluation of new post-plant nematicides.

- Post-plant nematicide rotation procedures that ensure continued performance of new products that are under study (avoid increased product degradation over time).

Priority Regulatory Needs – random order

- Codex MRLs for all markets: Assail, Esteem, Applaud, Provado, Baythroid, Danitol, Success. Expedite registration of Platinum for GWSS. Need to change Japanese MRL to Codex MRL for Lorsban.

- Quarantine issues: GWSS issues for harvest and movement.

- Need registration of ant bait stations. What is the holdup?

- Registration of alternative products for resistance management of citrus thrips, CA red scale, silver/rust mite.

- Regulations governing movement of exotic pests need to be strengthened.

Priority Educational Needs – random order

- Educate State and Federal regulatory community. Recent EPA/CDPR tour. Real need for season-long understanding of how management methods fit into IPM

- Educate local regulators with respect to proper timing of GWSS treatments.

- Understanding of impact of invasive pests

- Educate citrus industry re Citrus IPM: new insecticides/proper use & compatibility with IPM. pH education for Success and Veratran. Need to keep Success above 6 pH and acidify Veratran to 4.5 pH. Need to not treat flower thrips population, easily confused with citrus thrips. Education re: managing pesticide resistance, in general, and withholding unnecessary treatments. Unlikely to have new insecticides registered. Scarring related to pest damage. Late season applications of pesticides for red scale are not very effective because you have multiple stages and overlapping generations.

Critical Needs - other

Research Needs (random order)

- Citrus Bud Mite is the number one problem in the coast region. There is the need for a non-oil dependent control, which is compatible with biological controls.
- Need to investigate Evergreen, ozone, methyl salicylate and temperature on bean thrips survival. Evergreen and ozone to kill
- Cutworm indigenous biological control
- Continue research to establish thresholds for treatment requirements. Threshold for GWSS is zero in the eyes of the grape growers.
- Need to better understand endemic biological control of katydids and what materials cause disruption.
- Need to find effective, pre or post emergent herbicide on malva.
- Economic thresholds for citrus thrips with new and/or selective materials.
- Need for new insecticides for citrus thrips.
- Need research on control measures for earwigs and/or other sporadic pests that emerge, i.e. grasshoppers, etc.
- More research on selective citricola scale treatments. Need treatment with biological controls.
- More research into rootstocks which are truly resistant to aggressive biotypes of citrus nematodes.
- Coordinated effort to rotate citrus ground to avoid aggressive biotypes of citrus nematode.

Regulatory Needs (random order)

- Expedite the registrations of three new active ingredients for post-harvest fungicides.
- Applaud 60 day PHI is problem. Cannot be used for Valencias. Good IPM tool, need shorter PHI so it can be more effectively used.

- Impact of ground and surface water runoff. Need consistency between agencies (counties, state, Fed)

- Realistic label restrictions relating to bees (see Success/Agrimek labels).

- Obtain Section 18 for Micromite for grasshopper and citrus leafminer

- REIs need to be equal to, or shorter than, PHIs.

Educational Needs – random order

- Continue existing educational programs. Includes mobile lab, book on GWSS (update), grower seminars.

- Methyl salicylate and temperature: Need research on driving bean thrips from navel oranges.

- Need weed identification/Citrus IPM Manual needs to be updated. Pictures need to be included.

- Education of registrants as to the need for ant bait stations.

- Chemigation-examine new restrictions associated with chemigation.

- Timing of Glyphosate use.

Effects of International Issues

The MRLs in export markets are almost never the same as U.S. standards and the MRLs have not been available from a single data source, in the past.

Although many of the important export markets defer, at least partially, to the international Codex standards, the Codex system covers less than half of the U.S. pesticides and has slowed to the point where 8 years are needed for the setting of MRLs on new pesticides. Thus, harmonization of pesticide standards is a goal for exporters that is far from being accomplished.

Many pest and disease concerns and restrictions in export markets are used as trade barriers to prevent the exporting of citrus from the U.S. Some of the quarantine pests identified by export market countries require pesticide treatments that are not warranted for the production of the crop in the U.S.

Imported produce can be the source of pest and disease outbreaks that require intense pesticide use and possible quarantine protocol treatments that disrupt IPM and the marketing of fruit.

REFERENCES

1. California Department of Food and Agriculture. **California Agricultural Statistics Service, 2002**

2. United States Department of Agriculture. **National Agricultural Statistics Service, 2002**

3. California Department of Food and Agriculture. **2002 County Agriculture Commissioner's Data.** California Agricultural Statistics Service.

4. California Department of Food and Agriculture. **Export Statistics, 2002**

5. California Department of Pesticide Regulation. **California Pesticide Use Data Base**. **2002**

6. University of California Statewide Integrated Pest Management Project. **Pest Management Guidelines**. Log on to www.ipm.ucdavis.edu
.

7. California Department of Pesticide Regulation and University of California Statewide Integrated Pest Management Project. **Pest Management Survey**. 1994.

8. University of California, Statewide Integrated Pest Management Project. **Integrated Pest Management for Citrus**, Second Edition. 1991.

9. California Citrus Quality Council. Personal communications and input.

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