Arthropod Pests of Citrus and Their Management

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The Goal of Citrus Growers

1. Is to increase yield of commercially valuable size fruit per acre to increase income

2. Minimizing the impact of pests and disease vectors by keeping their populations below economic thresholds
Why the big deal about arthropod pests?

- Citrus is an **evergreen** that can host pests year round
- Citrus grows in areas where climate is favorable for pest development
- Economic impact of pests vary by region, **cultivars** and production goals
  - In TX, lack of citrus rust mite control in grapefruit leads to negative returns
Major Citrus Pests

- Psyllids, CLM, Aphids, bugs, whiteflies, blackflies
- Thrips, Worms, Moths
- CLM, Peel miner, Aphids, WF, CBF, Mites, Scales, Katydid
- Scales, Ants, Planthoppers
- Mites, Thrips, Mealybugs, Scales, bugs, Katydid
- Mites, Mealybugs, Scales, bugs, Thrips, Moths
- Nematodes, Root weevils
Major pests for each phenological stage

Winter               Spring                  Summer                        Fall

Winter

Vegetative

Flowering & Fruit Set

Bud Break

Fruit Development

Maturation

Winter
Arthropod pests affecting citrus can be grouped into two major categories:

1. **Indirect pests or disease vectors**
   Important because of their vectoring of plant pathogens that cause serious diseases

2. **Direct pests**
   that cause significant reductions of production (yields, reduction of fruit size or fruit drop) or cosmetic damage (important because cause blemish that reduces the quality of fruit: fresh fruit market)
Arthropod pests affecting citrus

- **Vectors/Facilitators**
  - Thrips
  - Mites
  - Leaf hoppers
  - Plant hoppers
  - Tree hoppers
  - Whiteflies
  - Mealybugs
  - Psyllids
  - Flies
  - Beetles
  - Ants

- **Pathogens**
  - **Viruses**
    - Leprosis
    - Tristeza
  - **Fungi**
    - Phytophthora (root weevils)
  - **Phytoplasmas**
  - **Spiroplasmas**
  - **Bacteria**
    - CVC, Stubborn
    - HLB
    - Canker
Major arthropod-borne citrus diseases

- About a dozen of arthropod-borne diseases affect citrus worldwide (Timmer et al. 2000)
- Risks of these diseases depend on the presence of vectors (facilitators) and/or pathogens
- In Texas, 4 major ones (CTV, HLB, CVC, Leprosis) present a menace/risk to citrus industry
  - either pathogen already present but vector absent (CTV)
  - or vector present and pathogen absent (Sharpshooters)
  - or both vector and pathogen present (HLB)
## Vectored diseases affecting Texas citrus

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<thead>
<tr>
<th>Disease</th>
<th>Pathogen</th>
<th>Vector</th>
<th>Disease Status</th>
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<tbody>
<tr>
<td><strong>Citrus Tristeza</strong></td>
<td>CTV</td>
<td>Aphids BCA*</td>
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<td>1% (LRGV)</td>
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<td>18% (E-TX)</td>
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<td><strong>Greening-HLB</strong></td>
<td><em>Candidatus Liberibacter</em></td>
<td>ACP</td>
<td>++</td>
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<tr>
<td><strong>Leprosis (Moving northward &amp; confirmed in Mexico)</strong></td>
<td>CLV</td>
<td>FSM Brevipalpus spp.</td>
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<tr>
<td><strong>CVC</strong></td>
<td><em>Xylella fastidiosa</em></td>
<td>Sharp-shooters</td>
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Major diseases facilitated by arthropods

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<thead>
<tr>
<th>Disease</th>
<th>Pathogen</th>
<th>Facilitator</th>
<th>Disease Status</th>
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<tr>
<td>Canker</td>
<td><em>Xanthomonas citri</em></td>
<td>CLM</td>
<td>±</td>
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<tr>
<td>Phytophthora</td>
<td><em>Phytophthora</em></td>
<td>Root weevil complex</td>
<td>+</td>
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</table>

- **Pathogen** column includes the name of the pathogen associated with each disease.
- **Facilitator** column lists the arthropod species that facilitate the disease.
- **Disease Status** column indicates the status (+ or ±) for each disease. The + sign indicates facilitation, and the ± sign indicates a less direct or variable facilitation.
Arthropod pests affecting citrus

Direct Pests

- Mites (CRM, Spider mites)
- Scales (soft and armored)
- Mealybugs
- Psyllids
- Thrips
- Root weevils
- Whiteflies
- Fruit flies

Chewing (removal of tissues), Sucking (plant sap and production of honeydew that promotes sooty mold)
Citrus rust mite: “the mighty mite”

- *Phyllocoptruta oleivora*
- Wedge shaped and elongated
- Bright lemon yellow
- 2 pairs of anterior legs and posterior false feet or lobes
- Piercing sucking mouthparts
- Toxin causes fruit silvering and russetting
Citrus rust mite: “the mighty mite”

- Smallest arthropod pest of citrus in Texas, yet the most damaging
- High reproductive potential (40+ eggs/female)
- Development favored by rainfall & >70% RH and Temp > 80°F.
- Infestations highest on interior tree canopy & NW quadrant
- One generation completed in 7-10 days
Citrus rust mite: “the mighty mite”

Two types of Damage

Quantitative

Early infestation

Reduced fruit size

Qualitative

Early

Sharkskin/buckskin

Mid-Late

Russeted/Bronzed

In TX, qualitative losses are the most important!
Citrus rust mite: “the mighty mite”

- CRM exhibits strong cultivar preference
- Cause damage on all cultivars except limes, but preferentially feeds on pomelo, grapefruit and lemon
- Major pest in industry that produces citrus species destined for fresh fruit markets
- Has been the most important pest of Texas citrus industry since its inception (Fruit produced for fresh fruit market)
- Pest control represents 50% of citrus production costs in TX. 1/3 to ½ for CRM control
Citrus rust mite: Monitoring and control

- Monitoring of CRM populations every two weeks is required during active growing season (fruit set to harvest)
- Sampling of 25 trees per grove, 4 fruit (1 from each quadrant) and 2 lens field readings per fruit
- Threshold is a combination of number of mites per lens field and percent fruit infested
  - < 3 mites/cm² and <10% of fruit infested no action
  - 1-3 mites/cm² and 10-20% of fruit infested action needed within a week
  - >5 mites/cm² and 20% or more of infested fruit, immediate action
Citrus rust mite: Monitoring and control

- No effective biocontrol agent in Texas
  - Epiphytotic fungus, *Hirsutella thompsonii*
  - Several predatory mites (e.g., *Euseuis* sp., *Amblyseuis* sp.)
  - Predaceous Whirligig Mites - *Anystis* sp
  - Predaceous Dipterous Larvae

- Control is done through miticides (abamectin, spirodiclofen, spirotetramat, fenbutatin oxide, fenpyroximate, diflubenzuron, oxamyl, tofenpyrad, **oils**, **sulfur**, **Compost Tea**, Orocit)
Proactive citrus rust mite control

- CRM continues to develop on leaves in absence/presence of fruit; leaves serve as reservoir or source of infestation for fruit

- The best time to target any pest is when pop is at lowest levels. For CRM, this period is between November to early March in south TX

- Chemicals also have longer residuals from November-March

- Combined effects of low CRM pop and longer residual control of chemicals lead to higher reductions in CRM populations
Proactive citrus rust mite control

Fig 5.1 Schematic of typical citrus rust mite population dynamics in citrus orchard in Texas

Date
January 3
January 14
January 28
February 11
February 25
March 10
March 24
April 8
April 21
May 5
May 20
June 2
June 17
June 30
July 14
July 31
August 18
September 1
September 17
September 28
October 12

log-scale of Citrus rust mite densities

0.0
0.5
1.0
1.5
2.0
2.5
3.0

Leaves
Fruit

Traditional CRM control
Proactive citrus rust mite control

- CRM is better control when targeted during the winter before bloom

**Figure 4.3.1:** Fluctuations of CRM population on citrus leaves following different treatments

- CRM Population
- January 3
- January 14
- January 28
- February 11
- February 25
- March 10
- March 24
- April 8
- April 21
- May 5
- May 20
- June 2
- June 17
- June 30
- July 14
- July 31
- August 18
- September 1
- September 17
- September 28

- **Figure 4.3.5:** Percentage of fruit infested with citrus rust mite in different treatments

- Treatment
  - Control
  - January
  - February
  - March
  - April

- Percentage of fruit infested with CRM
  - 0
  - 20
  - 40
  - 60
  - 80
  - 100

- CRM infestation level at harvest
Texas citrus mites

_Eutetranychus banksi_

- Feed on citrus foliage and fruit surface leading to blemish
- Cause severe defoliation that can lead to fruit drop
- Favors by drought and water stress
- Threshold is 10 mites per leaf
- Some predatory mites, but miticide applications most common method

Ensure that trees are well irrigated to reduce incidence of TCM
Citrus red mites

*Panonychus citri*

- Adult female are oval and globular; the male is smaller and has a tapered abdomen.
- Each female lays 20 to 50 eggs (2-3/d) on both sides of leaves.
- The life cycle from egg to egg may be as short as 12 days.
- Feeding mostly on upper surface of leaves cause stippling and mesophyll collapse leading to defoliation or silvering of fruit.
- Citrus red mite is more of a problem when trees are water stressed and conditions are hot and dry, & heavy pop lead to tree death or **firing**
Citrus red mites: Monitoring and control

- Several effective miticides are available for controlling citrus red mite
  - **Organic:** Oils, Insecticidal soaps such as potassium salt of fatty acids (Des-X, M-Pede), Orocit
  - **Conventional:** Miticides including: fenbutatin oxide (Vendex), hexythiazox (Onager), propargite (Omite), pyridaben (Nexter), spirodiclofen (Envidor), and fenpyroximate (Fujimite), abamectin (AgriMek) can be used for red mite control
False spider mites

*Brevipalpus* spp. (*B. californicus*, *B. phoenicis*, *B. obovatus*)

- Adult mites are 0.2 to 0.3 mm long, flattened and slow moving
- Pop increases usually occur on leaves and fruit toward the inside of the tree before mites are noticed on outside leaves and fruit
- Pop build-up starts in June and thru summer
- Cause necrotic spot on fruit (‘false leprosis’)
- Known vectors of leprosis virus
False spider mites

- Attacked by the entomopathogen *Hirsutella*, but TX citrus and red mites are not attached by this fungus

- Phytoseiid predators feed on FSM and rust mites, but not effective at keeping populations below economic thresholds

- Effective control requires the use of miticides

- All miticides effective on CRM also provide good control of FSM. Thus growers do not perform targeted control of FMS except in special cases
Citrus bud mites

_Eriophyes sheldoni_

- Very small, elongated & tapered at the posterior end, and has four legs at the front end near the mouth.
- Females lay up to 50 eggs mostly in the bud scales of recent growth
- **Populations increases during spring and fall flushes. Major problem in lemon**
- **Mites feed inside the buds, killing them or causing a rosette-like growth of foliage, flower and fruit**
- Rarely a problem, but infestations of 20% or more should lead to control with oil or a miticide
Occurrence of mites in Texas citrus

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<td>Citrus rust mite</td>
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<td>Citrus red mite</td>
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<td>False spider mite</td>
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The table shows the occurrence of various mites in Texas citrus, with arrows indicating their seasonal activity pattern.
Scale insect pests of citrus

Armored (hard) Scales
- CA red scales
- FL red scales
- Purple scales
- Glover scales

Soft Scales
- Barnacle scales & FL wax scales
- Black scales
- Brown soft scales
- Citricola scales
- Cottonly cushion scales
Armored Scales

Aonidiella aurantii
CA red scale

Chrysomphalus aonidum
FL red scale

Pinnaspisas pidistrae
Fern scale

Unaspis citri
Citrus snow scale

Lepidosaphes gloveri

Lepidosaphes beckii

Chaff scales
Armored Scales – Damage

- Cause severe spotting on fruit that affect their grade - A major problem in sweet oranges and grapefruit
- High armored scale infestations are generally result of poor choice of insecticidies (broad spectrum) or method of application (low volumes)
Armored Scales - Management

- Effectively controlled by parasitoids of the *Aphytis* and *Encarsia* genera and predators (*Cholicorus*)
  - *Parasitoids can purchased*

- Monitoring of males with pheromones for CA red scales (March to October), mass trapping

- Effective insecticide control as directly by trap catches (*Chlorpyrifos, carbaryl, Flupyradifurone, oils*)

- Chemical control should be implemented in case of heavy infestations – Effective control achieved when crawlers (immatures are present)
Soft Scales

*Ceroplastes cirripediformis* - Barnacle Scale

*Ceroplastes floridensis* - FL wax scales

*Coccus pseudomagnoliarum* - Citricola scale
Soft Scales

*Coccus hesperidum*
Brown soft scale

*Saissetia oleae*
Citrus black scale

*Icerya purchasi*
Cottonly cushion scale
Soft Scales - Damage

- Soft scales reduce tree vigor by removing plant sap
- Produce profuse honeydew while feeding that supports sooty mold growth. Sooty mold affects fruit grade (quality and size) and also reduces photosynthesis leading to reduced bloom
- Honeydew can also attracts fruit flies as well as ants that make biocontrol sometimes difficult (food for protection against natural enemies)
Soft Scales - Management

- Soft scales are better controlled by natural enemies, so it is important to preserve them (reduced use of broad spectrum insecticides such as pyrethroids or aerial applications)
- Sanitation such as pruning (dense canopy favors soft scale development)
- Several ladybeetles: *Cryptolaemous montouzieri, Lindorus spp., Chilocorus spp., Rodolia cardinalis* (or Videlia beetle)
- Effective parasitoids: *Metaphycus* spp.
- Control of cottony cushion scale is one the major successes of biological control
Soft Scales - Management

- Effective insecticides comprise:
  - Chlorpyrifos (E.g. Lorsban)
  - Buprofezin (Centaur)
  - Neonicotinoids (imidacloprid, thiamethoxam, clothianidin)
  - Flupyradifurone (Sivanto)
  - Pyriproxyfen (Esteem)
  - Spirotetramat (Movento)
  - Tolfenpyrad (Apta)
  - Oils

- In case of heavy populations, two active ingredients are recommended as a tank mix or back to back spray within 30 days
Citrus mealybug: *Planococcus citri*

- Mealybugs remove abundant plant sap that weakens citrus trees
- Honeydew produced serves as growth media for sooty mold which considerably downgrade fruit
- Reduced fruit size and quality are linked to heavy mealybug infestations
- Management through natural enemies (*Cryptolaemus montrouzieri* [500 adults/acre], lacewings, Syrphid larvae)
- Effective insecticides (spirotetramat, chlorpyrifos, flupyradifurone, buprofezin, oils)
Other pests
Other pests: Root weevils

- Adults feed on tender leaves
- Eggs laid on young leaves
- Larvae fall on ground and feed on roots causing extensive tunneling used by Phytophthora
Other pests: Root weevils
Other pests: Root weevils

- Because the most damaging larval stage developed under ground, root weevils control are very difficult
- Insecticides can target adults while parasitoid can affect eggs
- Most effective control of Diaprepes root weevil is exclusion with plastic mesh such as ground cover
  - Mesh prevent larvae from penetrating in the soil
  - Adults cannot emerge from the soil
  - Life cycle is affecting in two directions
Psyllid control

- Psyllid control achieved as an area-wide management program (most growers coordinate their sprays)
- 85-90% participation rate to date followed by significant reduction of psyllid populations in groves
- Flush cycles are the key for effective psyllid control
Interrelationships between young flush shoots and the dynamics of CLas and its psyllid vector

Vector

- Higher colonization by adults
- Oviposition and immature development
- Increase in vector population

CLas

- Enhanced bacterial multiplication in more nutritious phloem Sap

ACP/CLas

- Higher transmission rates
- Higher acquisition rates (adults & nymphs)
- Higher proportion of CLas-positive ACP

Increased risks of HLB spread
ACP control in conventional groves

Coordinated whole grove sprays

Border sprays sandwiched

Season long psyllid control strategy in Texas

As determined by scouting
Effective ACP control in organic groves

Coordinated whole grove sprays

Border sprays sandwiched

Dormant Spray - Coordinated

Whole Spray
Whole Spray
Whole Spray
Whole Spray

2-wk apart

Season long psyllid control strategy in Texas (organic groves)
Due to continuous growth of new flush shoots on young trees, young plantings tend to harbor more psyllids than mature groves. This makes young groves more at risk for HLB infection.

A more aggressive psyllid control **MUST** be implemented in young groves.
Attract and kill devices

- **AK device:**
  - Plasticized PVC infused with beta-cyfluthrin
  - Deploy in tree canopy to lure adult psyllid that die with 2 to 5 sec contact with the AK device

Residential trees

Border trees in groves
Attract and kill devices for *Anastrepha ludens*

- **AK device baited with MX fruit fly lures**
  - Device protected in a plastic bottle
  - Deploy a total of 6 devices per acre or in residential trees
Sustainable citrus production in the presence of ACP/HLB

- Environment/Grove care practices
- Biology-Ecology
- Inoculum Reduction Elimination
- ACP/HLB Management
- Clean Nursery Stock

- HLB & Plant health interactions
- ACP management MUST be integrated into ongoing IPM in groves

- Management of other diseases
- Balanced tree nutrition
- Avoid toxicities
Integrated Multipest and Pollinator Management

- **Goal:** to ensure citrus tree health and productivity while protecting pollinators
- **Approach:** A multipest strategy using systems approach to minimize the impact of pests (not necessarily elimination) by protecting citrus during the most vulnerable periods, while promoting natural enemies and protecting pollinators: Ecologically-based approach

- All methods of pest control must be integrated as there is no single approach that is effective on all pests
Integrated Multipest and Pollinator Management

- Tree phenology
- Pest population dynamics

Species/Variety

- Production Goal
- Type & intensity of Management

Availability of pesticides
- Policy

Regulations

Integrating Multipest and Pollinator Management

Environment

Production system
Proactive Multi-Pest Control Approach

- Because of the diversity of arthropod pests, a multi-pest control approach should be adopted in groves.
- Pest profile constantly changing in groves (invasive spp.).
- Good timing of spray to achieve better results (tree phenology is critical, most citrus pests tend to increase with new flush shoots).
- Tank mixes made to target all pests.
- Choice of chemicals that are ‘compatible’ with other management approaches.
Proactive & Multipest Integrated Approach

- IPPM cannot remain static, it must adapt to the changing pest profiles in groves
- Surveys for early detection of invasive species
- Citrus pest management must be done year-round in a proactive manner in contrast to the reactive approach generally implemented
- Understand pest population fluctuations in relation to citrus tree phenology
- Exploit ecological weakness of pests
  - E.g. Psyllid control during dormant season, at the onset of flush cycles and include border sprays
  - Attract and kill for CLM, ACP and MXFF
  - Proactive control for rust mites
  - Exclusion for root weevils
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<th>Jan</th>
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<tbody>
<tr>
<td><strong>Citrus Pest Phenology &amp; Suggested Control in Texas</strong></td>
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<tr>
<td><strong>Citrus Rust Mite</strong></td>
<td><strong>Spider mites</strong> (TCM, RdM)</td>
<td><strong>Thrips</strong></td>
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<td><strong>Barnacle, soft scales</strong></td>
<td><strong>Neonicotinoids, Abamectin, Micromite, AgriFlex, Delegate, Intrepid, Spintor, Assail, Exirel, Voliam Flexi</strong></td>
<td><strong>Mealybugs</strong></td>
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<td><strong>CA, FL red scales</strong></td>
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<td><strong>Black- &amp; White-flies, Aphids</strong></td>
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<td><strong>Pyrethroids, OPs, Portal, Sivanto Prime</strong></td>
<td><strong>Citrus Rust Mite</strong></td>
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*PLEASE READ AND FOLLOW DIRECTIONS OF PESTICIDE LABELS*

Sétamou, TAMUKCC
Example of multi-pest control program

Coordinated whole grove sprays

- Dormant Spray-Coordinated
  - Eg. Portal+ Vendex + Movento + Fungicide

As determined by scouting

Border sprays sandwiched

- Whole Spray-Coordinated
  - Apta + Exirel + Fungicide

- Whole Spray-Coordinated
  - Micromite + Agrimek + Centaur + Fungicide

- Whole Spray-Coordinated
  - Envidor + Esteem + Sivanto (or Neonicotinoid)

- Whole Spray-Coordinated
  - Abamectin + Micromite + Sivanto + Fungicide

- Whole Spray
  - BC = releases N.E.

- Whole Grove Sprays
  - Whole grove sprays are generally multi-pest

- OPs
- Pyrethroids
- Neonicotinoids
- Portal, etc...

- OCPs
- Pyrethroids
- Neonicotinoids
- Portal, etc...
## CITRUS PHENOLOGY AND MULTIPEST CONTROL PROGRAM IN TEXAS

<table>
<thead>
<tr>
<th>Month</th>
<th>PhenoLOGY/Control Period</th>
<th>Pest and Disease Management</th>
<th>Fertilization</th>
<th>Sunburn Protection</th>
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</thead>
<tbody>
<tr>
<td>Jan</td>
<td>Vegetative Flush</td>
<td>Proactive mite spray, psyllid, soft scale and thrips control, Phytophthora control</td>
<td>Soil-applied fertilizers (N32, NPK, Urea, Ammonium sulfate)</td>
<td>Avoid tree water stress, Avoid excessive pruning, Spray Clay, Kaolin or Calcium carbonate</td>
</tr>
<tr>
<td>Feb</td>
<td>Harvest &amp; Fruit Set</td>
<td>Mite spray; scale, psyllid and thrips control, Fungicidal and scale, mealybug &amp; psyllid control</td>
<td>Foliar nutritional spray (Ca, Fe, Mg, Mn, Zn)</td>
<td>Spray Clay, Kaolin, Calcium carbonate or Wax emulsions</td>
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<tr>
<td>Mar</td>
<td>Flowering</td>
<td>Mite spray; scale, mealybug &amp; psyllid control, Fungicidal spray for scab, greasy spots &amp; melanose</td>
<td>Soil-applied fertilizer in early May (Urea, N32, Ammonium sulfate, Calcium nitrate)</td>
<td>Avoid tree water stress, Spray Clay, Kaolin, Calcium carbonate or Wax emulsions</td>
</tr>
<tr>
<td>Apr</td>
<td>Fruit Development &amp; Expansion</td>
<td>Mite, scale, mealybug, psyllid &amp; root weevil control, Fungicidal spray for scab, greasy spots &amp; melanose</td>
<td>Foliar nutritional spray (Ca, Fe, Mg, Mn, Zn)</td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>Maturation</td>
<td>Mite spray; scale, psyllid &amp; leafminer control, Fungicidal spray for greasy spots &amp; melanose, Phytophthora control</td>
<td>Soil-applied fertilizer</td>
<td></td>
</tr>
<tr>
<td>Jun</td>
<td>Harvest &amp; Fruit Set</td>
<td>Mite spray, psyllid, leafminer and scale control, Fungicidal spray for scab, greasy spots &amp; melanose</td>
<td>Foliar nutritional spray (Avoid excessive N)</td>
<td></td>
</tr>
</tbody>
</table>
THANK YOU!