WEED MANAGEMENT IN CITRUS – CHALLENGES AND OPPORTUNITIES

Presenter: Ramdas Kanissery – Weed Scientist, Southwest Florida REC
Contribution from: Steve Futch – Extension Agent IV, Multicounty, Citrus REC Lake Alfred
Weed management in FL citrus – Big picture

Impacts of weeds

Yield loss – from competition
Serves as alternate host for pest and diseases

Weed control
Preventive
Mechanical
Chemical – popular method

Weed management programs
Row middle – Mechanical mowing
Chemical mowing
Under tree – Utilizing herbicides
Weed management in FL citrus – Big picture

- **Impacts of weeds**
  - *Yield loss – from competition*
  - *Serves as alternate host for pest and diseases*

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  - Preventive
  - Mechanical
  - Chemical – *popular method*

Weed management programs
- Row middle – Mechanical mowing
- Chemical mowing
- Under tree – Utilizing herbicides

Info credits: Steve Futch, 2017
Weed management in FL citrus – Big picture

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  - Mechanical
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- Weed management programs
  - Row middle – Mechanical mowing
    - Chemical mowing, wiping
  - Under tree – Utilizing herbicides

Info credits: Steve Futch, 2017
Managing problematic weeds

Minimizing crop injury

Challenges
Managing problematic weeds

Challenges

Minimizing crop injury
Problem weeds in citrus

- Goat weed
- Dayflower
- Pig weed
- Parthenium
- Spanish needle
- Guinea grass

Examples of problem weeds in citrus
Herbicide resistance and/tolerance is the major reason

Herbicide Resistance

- **Inherited ability** of a weed to survive & reproduce following exposure to a dose of herbicide normally lethal to the weed
- Naturally occurring OR Induced

Herbicide Tolerance

- Inherent ability of weeds to withstand a certain dose of herbicide
- Repeated use of same product or mode of action
- Age or growth stage of weed

*Eg., Glyphosate*
Herbicide resistance and/tolerance is the major reason

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_Eg., Glyphosate_
Herbicide resistance and/tolerance is the major reason

“Four S of resistance/tolerance management”

- Scouting
- Switching chemistry/MOA
- Selection of application timing
- Sanitation
Problem weeds in citrus

- Spanish Needle
  - Herbicide tolerance
Problem weeds in citrus

• Ragweed
  Parthenium

- Herbicide resistance
- Herbicide tolerance
Problem weeds in citrus

• Pigweed - Amaranth
  - Herbicide resistance/tolerance
  - Seed bank formation in soil
Problem weeds in citrus

- Pigweed - 200,000 seeds per plant*

*Data collected by researchers across the globe WSSA
Problem weeds in citrus

• Pigweed

- Seed bank formation in soil
- Compete for nutrients and moisture
Problem weeds in citrus

• Goat weed

• Herbicide tolerance

• Seed bank formation
• Goat weed tolerance

- Slow response to glyphosate products

5 weeks after treatment

Rate: 2 lbs. A.E per acre
• Dayflower

- Monocot
- Slow response to glyphosate

Dayflower growing in the drip line under the citrus tree
Potential new weed watch in citrus

• Tropical whiteweed
  - *Ageratum conyzoides*
  - Also known as Billygoat weed
Potential new weed watch in citrus

**Tropical whiteweed**

- *Ageratum conyzoides*
- Also known as Billygoat weed

Tropical whiteweed leaves – ovate and serrated
Managing problematic weeds

- Selecting the right herbicide program
- Synergy b/w herbicides
- Selecting proper adjuvants
Managing problematic weeds

- Selecting the right herbicide program
- Synergy b/w herbicides
- Selecting proper adjuvants
Herbicide classification - application timing

PRE Emergent

Soil applied

POST Emergent
Foliar applied
Herbicide classification - application timing

**Residual or PRE-emergent**: applied to soil - persist in soil and kill the emerging weed seeds and seedlings.

- Minimum ‘existent weed coverage’ to ensure max soil incorporation
- *Rain or irrigation* to activate
Major PRE-emergent herbicides used in FL citrus

- **Active ingredient** – Brand name(s)
  - **Bromacil** – Hyvar X
  - **Simazine** – Princep, Caliber 90, etc.
  - **Diuron** – Direx, Karmex, etc.
  - **Norflurazon** – Solicam
  - **Indaziflam** – Alion
  - **Pendimethalin** – Prowl

* Please refer to *Florida Citrus Production Guide 2017-18* for a complete list
Major PRE-emergent herbicides used in FL citrus

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Major PRE-emergent herbicides used in FL citrus

**Norflurazon – Solicam 80WP**

- Inhibit carotenoid biosynthesis
- Chlorophyll destruction: no photosynthesis

- Control of annual grass weeds and certain broadleaf weeds
- May be injected through low volume drip irrigation
- Use rate of 2.5 to 5 lbs/A
- Maximum 10 lbs/A/yr
Major PRE-emergent herbicides used in FL citrus

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* Please refer to [Florida Citrus Production Guide 2017-18](#) for a complete list
Major PRE-emergent herbicides used in FL citrus

- **Indaziflam - Alion**
  - Inhibit cellulose biosynthesis
  - Interfere with cell wall formation and cell division
  - Control of broadleaf and grass weeds
  - Often mixed with POST product
  - Use rate of 5 to 6 oz/A
  - Maximum 10.3 oz/A/yr
New PRE-emergent herbicide on the horizon

**Flumioxazin – Chateau**
- Inhibit PPO enzyme
- Accumulation of toxins in the plant
  - Control of grass weeds and broadleaf weeds
  - Use rate of 6 to 12 oz/A
  - Maximum 24 oz/A/yr

**Supplemental Label**

**CHATEAU® HERBICIDE SW USE IN CANEBERRY AND CITRUS FRUIT**

This supplemental label expires on December 31, 2019 and must not be used or distributed after this date.
Herbicide classification - application timing

**POST-emergent**: applied to **foliage** after weed emergence

Usually no residual activity

Require surfactants
Major POST-emergent herbicides used in FL citrus

- **Active ingredient** – Brand name(s)

  - Carfentrazone – Aim EC
  - Paraquat - Gramoxone
  - Glyphosate – Roundup, Touchdown
  - Glyphosate + 2,4-D - Landmaster

* Please refer to Florida Citrus Production Guide 2017-18 for a complete list
Major POST-emergent herbicides used in FL citrus

Non-selective herbicides

Glyphosate – Roundup, Glyfos etc.

**Mode of action**
Blocks the formation of essential amino acids
Inhibit protein synthesis

**Effect**
Starvation’ and death of susceptible plants

- POST, non-selective, systemic
- For total or partial control of most weed species
- Rate 0.75-1.5 lb A.E. – Annual weeds
- Rate 1.75-3.75 lb A.E. – Perennial weeds
Major POST-emergent herbicides used in FL citrus

- **Non-selective herbicides**
  
  **POST Foliar applied**

  **Glyphosate – Roundup, Glyflos etc.**

  **Mode of action**
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  - POST, non-selective, systemic
  - For total or partial control of most weed species
  - Rate 0.75-1.5 lb A.E. – Annual weeds
  - Rate 1.75-3.75 lb A.E. – Perennial weeds
  - Can be used for chemical mowing – 0.125-0.37 lb A.E
Major POST-emergent herbicides used in FL citrus

Glyphosate - used for chemical wiping row middles

Glyphosate wiping:
- 5–10% solution - carpet wiper
- 50–80% solution – panel wiper
Major POST-emergent herbicides used in FL citrus

Selective herbicides

POST
Foliar applied

• **Active ingredient** – Brand name(s)

  - Fluazifop – Fusilade
  - Sethoxydim – Poast plus
  - Saflufenacil – Treevix
Major POST-emergent herbicides used in FL citrus

**Selective herbicides**

- **Fluazifop-p-butyl (Fusilade)**
  - For POST emergent control of annual and perennial grass
  - No effect on broadleaf weeds
  - Rate 1.0-1.5 pts/acre
  - Tree age: ‘Non-bearing’
  - Do not apply to grasses under stress conditions
Major POST-emergent herbicides used in FL citrus

Selective herbicides

- **Sethoxydim – Poast, Poast plus**
  - For POST emergent control of annual and perennial grass
  - No effect on broadleaf weeds
  - Rate 2.25-3.75 pts/acre
  - Tree age - All
  - Do not apply to grasses under stress conditions
Examples of problem weeds in citrus

- Goat weed
- Spanish needle
- Guinea grass
- Parthenium
- Dayflower
- Pig weed
Fusilade
Poast, Poast plus

Effective on

Dayflower

Goat weed

Spanish needle

Pig weed

Parthenium

Guinea grass
• **Sethoxydim - Poast, Poast plus**

**Spot treatment**
- 1.5 – 2.25% v/v solution
- Surfactant 1% COC
- Read label for directions

Guinea grass growing close to citrus
**Selective herbicides**

- **Saflufenacil (Treevix)**
  - For POST emergent control of broadleaf weeds
  - No effect on grasses

- Rate 1 oz/acre
- Not more than 3 oz/A/yr
- Must be applied with a surfactant
Examples of problem weeds in citrus:

- Parthenium
- Guinea grass
- Spanish needle
- Goat weed
- Dayflower
- Pig weed
Saflufenacil - Treevix

Effective on

Dayflower

Goat weed

Spanish needle

Pig weed

Parthenium

Guinea grass
Saflufenacil – Treevix is effective on ‘Parthenium’ weed

Trial conducted at Wauchula, FL

<table>
<thead>
<tr>
<th>Trt Treatment No. Name</th>
<th>Rate Unit</th>
<th>W Weed Ragweed Paerthe</th>
<th>W Weed Ragweed Paerthe</th>
<th>W Weed Ragweed Paerthe</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 DA-A</td>
<td></td>
<td>6/26/2013 % kill</td>
<td>7/3/2013 % kill</td>
<td>7/16/2013 % kill</td>
</tr>
<tr>
<td>1 Roundup PowerMax</td>
<td></td>
<td>3.8 d</td>
<td>1.5 c</td>
<td>10.0 c</td>
</tr>
<tr>
<td>LI700</td>
<td>0.5 % v/v</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choice</td>
<td>4 pt/100 gal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Roundup PowerMax</td>
<td></td>
<td>11.3 d</td>
<td>6.3 c</td>
<td>16.3 c</td>
</tr>
<tr>
<td>AIM</td>
<td>64 fl oz/a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dynamic</td>
<td>2 fl oz/a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choice</td>
<td>4 pt/100 gal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Roundup PowerMax</td>
<td></td>
<td>93.8 a</td>
<td>95.0 a</td>
<td>92.5 a</td>
</tr>
<tr>
<td>Treevix</td>
<td>64 fl oz/a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LI700</td>
<td>1 oz wt/a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choice</td>
<td>0.5 % v/v</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Roundup PowerMax</td>
<td></td>
<td>57.5 b</td>
<td>20.0 b</td>
<td>77.5 ab</td>
</tr>
<tr>
<td>Matrix</td>
<td>64 fl oz/a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LI700</td>
<td>2.0 oz wt/a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choice</td>
<td>0.5 % v/v</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Gramoxone Inteon</td>
<td></td>
<td>35.0 c</td>
<td>13.8 b</td>
<td>63.8 ab</td>
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<tr>
<td>LI700</td>
<td>2 qt/a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choice</td>
<td>0.5 % v/v</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Gramoxone Inteon</td>
<td></td>
<td>35.0 c</td>
<td>15.0 b</td>
<td>42.5 bc</td>
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<td>2 qt/a</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choice</td>
<td>1 % v/v</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>7 Rely 280</td>
<td></td>
<td>92.5 a</td>
<td>88.8 a</td>
<td>70.0 ab</td>
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<tr>
<td>LI700</td>
<td>3 qt/a</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Choice</td>
<td>0.5 % v/v</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>8 Rely 280</td>
<td></td>
<td>91.3 a</td>
<td>88.8 a</td>
<td>81.3 a</td>
</tr>
<tr>
<td>Karmex 80WP</td>
<td>3 qt/a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LI700</td>
<td>3 lb/a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>0.5 % v/v</td>
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Information credit: Steve Futch
Considerations for selecting herbicide programs

Choosing the right herbicide program:

- Weed profile in the grove
  - Type of weed: grass, broadleaf, sedges
  - Growth stage: seedling, mature, seed production

- Citrus tree age
  - Young groves require greater attention
  - Higher sensitivity of young tree trunks

- Soil and Weather
Considerations for selecting herbicide programs

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- Citrus tree age
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- Soil and Weather

Choosing the right herbicide program:
Herbicide movement in Florida citrus production

Some regions within the state are prone to leaching due to high amount of rainfall and inherent soil type.
Adsorption coefficients of PRE-emergent herbicides used in FL citrus

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>$K_{OC}$ mL/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromacil</td>
<td>32</td>
</tr>
<tr>
<td>Simazine</td>
<td>130</td>
</tr>
<tr>
<td>Diuron</td>
<td>480</td>
</tr>
<tr>
<td>Norflurazon</td>
<td>700</td>
</tr>
<tr>
<td>Indaziflam</td>
<td>&lt;1000</td>
</tr>
<tr>
<td>Pendimethalin</td>
<td>17,200</td>
</tr>
</tbody>
</table>

The data of Indaziflam were taken from USEPA (2011)
Managing problematic weeds

- Selecting the right herbicide program
- Synergy of herbicides
- Selecting proper adjuvants
Herbicide synergy – Mixing herbicides

**Synergy effect:**
The total effect of mixing herbicides is greater or more prolonged than the sum of the effects of the two taken independently.

**synergy**

\[ 1 + 1 = 3 \]
Synergy effect:
The total effect of mixing herbicide is greater or more prolonged than the sum of the effects of the two taken independently.

- **additive**
  \[1 + 1 = 2\]

- **synergy**
  \[1 + 1 = 3\]

- **antagonistic**
  \[1 + 1 = 1 \text{ or less}\]
Herbicide synergy – Mixing herbicides in one application

Advantages

• Reduce application number & cost
• Broad-spectrum & prolonged weed control

However,

Need to ensure

• Mixing compatibility
• Proper adjuvant selection
• Absence of any antagonistic effects
Herbicide synergy – Mixing herbicides

Advantages

• Reduce application number & cost
• Broad-spectrum & prolonged weed control

However,

Need to ensure

• Mixing compatibility – Label, Jar test
• Proper adjuvant selection
• Absence of any antagonistic effects
## Herbicide synergy – in citrus weed management

**Trial conducted in Immokalee, FL**

<table>
<thead>
<tr>
<th>Active ingredients</th>
<th>Herbicide products in the test mixture</th>
<th>Rate oz product/A</th>
<th>Weed control (%) 150 DAT</th>
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</thead>
<tbody>
<tr>
<td>Indaziflam</td>
<td>Alion</td>
<td>3</td>
<td>58&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Indaziflam</td>
<td>Alion</td>
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<td>89&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
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<td>Chateau</td>
<td>6</td>
<td>18&lt;sup&gt;d&lt;/sup&gt;</td>
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<td>3 6</td>
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<td>n/a</td>
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DAT: Days After Treatment
*Means with the same letter superscripts within a column do not significantly differ (Tukey’s HSD, P< 0.05)
All treatments including control received glyphosate (Roundup Power Max) at 88 oz product per acre.

*Expected responses for the mixtures are shown in the parenthesis following the observed response. The difference between observed and expected values are shown by a + sign to indicate synergism.*
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Herbicide synergy — in citrus weed management
Managing problematic weeds

- Selecting the right herbicide program
- Synergy of herbicides
- Selecting proper adjuvants
Surfactants – indispensable ‘adjuvant/ingredient’ for POST emergent herbicides

Surfactants reduce the ‘surface tension’ of spray droplets
Surfactants – indispensable ‘adjuvant/ingredient’ for POST emergent herbicides

Spray Droplets with low surface tension are more likely to be retained and penetrated onto plant surfaces

Info credit: PSU extension
Surfactant addition = better weed control for POST-emergent herbicides

<table>
<thead>
<tr>
<th>Surfactant concentration</th>
<th>Weed Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>45%</td>
</tr>
<tr>
<td>0.12%</td>
<td>60%</td>
</tr>
<tr>
<td>0.25%</td>
<td>85%</td>
</tr>
<tr>
<td>0.50%</td>
<td>98%</td>
</tr>
</tbody>
</table>

Source: Bob Hartzler, ISU Weed Science
POST herbicides benefit most - from the use of appropriate surfactants

- Glyphosate + Non-ionic surfactant
- Paraquat + Crop Oil Concentrate
- Treevix + Methylated Seed Oil
**Water conditioner** – important component of herbicide mix

- Considered essential for herbicides like glyphosate
- Hard water: contains high concentrations of dissolved minerals
  Example: Ca$^{2+}$, Mg$^{2+}$, Fe$^{3+}$

Interaction b/w cations and the herbicide reduce efficacy

Glyphosate is **NOT absorbed** in this form

Information Credits: Sarah Lancaster, UF IFAS
Water conditioner – important component of herbicide mix

- Ammonium sulfate (AMS)

Information Credits: Sarah Lancaster, UF IFAS
Water conditioner – important component of herbicide mix

- AMS disassociates when added to water

\[ \text{Ammonium sulfate (AMS)} \]

\[ \text{NH}_4^+ \quad \text{and} \quad \text{SO}_3^- \]

Information Credits: Sarah Lancaster, UF IFAS
Water conditioner – important component of herbicide mix

- Sulfate binds to cations
  - Ammonium binds to glyphosate
  - Ammonium sulfate (AMS)

Information Credits: Sarah Lancaster, UF IFAS
Sulfate binds to cations
Ammonium binds to glyphosate
Glyphosate is absorbed in this form

**Water conditioner** — important component of herbicide mix

- **Ammonium sulfate (AMS)**
  - Application rate is 7 to 18 lb/100 gal
  - 8 to 10 lbs/100 gal common rate
  - Must be added to tank **before** herbicide

Information Credits: Sarah Lancaster, UF IFAS
Managing problematic weeds

Minimizing crop injury

Challenges
- Improper herbicide application
- Inadequate weed control
- Potential for herbicide phytotoxicity to citrus trees
Herbicide phytotoxicity to citrus

- Glyphosate
  - ‘Contact’ injury on foliage
Herbicide phytotoxicity to citrus

- Glyphosate
  - ‘Contact’ injury on fruits

Photo Credits: Steve Futch
Herbicide phytotoxicity to citrus

Paraquat

- ‘Contact’ injury on foliage & fruits

Photo Credits: Steve Futch
Herbicide phytotoxicity to citrus

- Diuron

Contact phytotoxicity

Photo Credits: Steve Futch
Herbicide phytotoxicity to citrus

- Indaziflam - Alion

Contact phytotoxicity
- Herbicide product
- Application speed
- Ground conditions
- Application pressure
- Boom height
- Angle of the OC nozzle
- Herbicide product
- Application speed
- Ground conditions
- Application pressure
- Boom height
- Angle of the OC nozzle

- Spray coverage
Herbicide boom spraying - OC nozzle angle
Herbicide boom spraying - OC nozzle angle

Off-center nozzle on the end of the boom

0°

40°

Information Credits: Steve Futch
Reach of the spray is impacted by the OC nozzle angle

- Off Center (OC) Nozzle angle
  - Greater OC nozzle angle
  - Higher and further beyond the end of the boom spray is directed
  - Increases the chances for foliage and fruit phytotoxicity in citrus

Ref: Steve Futch et al
Study conducted at the CREC, Lake Alfred
- Reach of the spray is impacted by the OC nozzle angle.

  Increased OC nozzle angle

  - spray droplets may drift into citrus foliage and fruits
- Reach of the spray is impacted by the OC nozzle angle

**Increased OC nozzle angle**
- spray droplets may drift into citrus foliage and fruits

**Optimum OC nozzle angle**
- adequate coverage under tree
- no herbicide injury
Apply accurately..

- Maintain proper boom height
- Deliver the herbicide to the target
- Avoid tree foliage, and fruit contact
- Application volume
  - 20-50 GPA for under tree
  - 10-25 GPA for chemical mowing
- Operate equipment safely
Citrus weed management: summary

Challenges

- Managing problematic weeds
- Minimizing crop injury

Opportunities

- Selecting the right herbicide program
  - POST & PRE
  - Selective herbicides
- Synergy b/w herbicides
  - Mix compatibility
- Selecting proper adjuvants
  - Surfactants
  - Water conditioners
- Avoid foliar and fruit contact
  - Proper OC nozzle angle
Citrus weed management: summary

**Challenges**
- Managing problematic weeds
- Minimizing crop injury

**Opportunities**
- Selecting the right herbicide program
  - POST & PRE
  - Selective herbicides
- Synergy b/w herbicides
  - Mix compatibility
- Selecting proper adjuvants
  - Surfactants - POST
  - Water conditioners
- Avoid foliar and fruit contact
  - Proper OC nozzle angle
“What are the top three most problematic weeds on your grove?”
“What are the top three most problematic weeds on your grove?”

“What are the top three most problematic weeds on your grove?”

“Every weed on the planet”
Thank you...

Contact

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