Weed Control in Florida Citrus

February 6, 2019

Steve Futch
Extension Agent, Multi County, Citrus
Citrus Research & Education Center
Lake Alfred, FL
shf@ufl.edu
863-956-8644
References Used in Today’s Presentation

- 2018 Florida Citrus Pest Management Guide
- Identification of Weeds in Florida Citrus, SP-341
- Identification of Mites, Insects, Diseases, Nutritional Symptoms and Disorders on Citrus, SP-176
- Annual Citrus Cost and Returns Economic Reports
Outline

- Historical weed control
- Currently recommended herbicides for weed control
  - Preemergence
  - Postemergence
- Middles management
- Vine control
- Herbicide equipment
**Why monitor and control weeds**

- Cost of control programs
- Negative effect on the tree
- Compete for essential inputs (water, fertilizer, light, space, etc.)
- Improve harvesting efficiency
- Reduces hand labor requirement and costs
Citrus production expenses by major categories, 2017-18*:

- Weed Control
  - Middle and in-row $194.67 10.4%
- Irrigation $214.32 11.4%
- Pest Mgt (inc. greening) $684.59 36.5%
- Fertilizer $496.43 26.5%
- Tree Replacement & care $254.38 13.6%
  - (7 trees/ac)
- Pruning/Hedging/Topping $30.42 1.6%
- Total $1,874.81 100.0%*

*Cost of Production for Processed Oranges Grown in Southwest Florida, 2017-18. Ariel Singerman, UF, CREC, Lake Alfred. Above costs do not include interest on operating costs, management cost, property taxes or interest on capital investment. These costs would add an additional $459.93 for a total cost of $2,334.72.
Weed control/management program cost breakdown

- Mechanical mow middles $52.94
- Herbicide application (4) $45.31
- Herbicide materials $88.18
- Total weed control $194.67

### Estimated cost for weed control program for Valencia grove in central Florida

<table>
<thead>
<tr>
<th>Production Year</th>
<th>Weed Management Cost</th>
<th>Total Annual Production Cost</th>
<th>Weed Control as Percent of Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976-77</td>
<td>$31.25</td>
<td>$346.19</td>
<td>9.03%</td>
</tr>
<tr>
<td>1985-86</td>
<td>$91.93</td>
<td>$618.08</td>
<td>14.87%</td>
</tr>
<tr>
<td>1995-96</td>
<td>$204.75</td>
<td>$837.70</td>
<td>24.44%</td>
</tr>
<tr>
<td>1999-00</td>
<td>$208.01</td>
<td>$831.43</td>
<td>25.00%</td>
</tr>
<tr>
<td>2009-10</td>
<td>$225.11</td>
<td>$1,571.18</td>
<td>14.3%</td>
</tr>
<tr>
<td>2017-18</td>
<td>$194.67</td>
<td>$1,874.81</td>
<td>10.4%</td>
</tr>
</tbody>
</table>

Annual Cost of production – Muraro and Singerman
Weed control costs for Florida citrus industry

447,012 acres X $194.67 per acre = $87 million per year*

- Assuming all acreage received herbicides and at the Southwest Florida citrus production cost.
- Total citrus acreage total from NASS, Aug. 28, 2018; cost of production from Singerman’s annual cost of production report
Weeds compete with citrus trees for:

- nutrients
- water
- space
- light
- harbor insects and rodents
- increase fire hazard
- increase cold damage from radiation freezes (2-4°F colder)
- interfere with low volume irrigation systems
- intercept soil-applied chemicals
- affect harvesting operations
Desirable effects of weeds:

- minimizes soil erosion from wind and water
- increase soil organic matter
Historical chemical weed control in Florida citrus:

- first experiments with preemergence herbicides conducted in 1956
- grower use began in 1964
- early studies found greater tree growth when herbicides were used vs. mechanically hoed
- treatments with better weed control resulted in larger trees and subsequent greater yields
Benefits from herbicide use:

- Hand labor is minimized
- Reduced equipment operational cost vs. mechanical, tillage or mowing
- Reduced mechanical damage tree trunk or irrigation system
- Reduce soil seed bank
- Movement within grove is improved for cultural and harvesting operations
Current weed control programs:

- citrus industry relies heavily on herbicide use due to scarce labor supply and its cost
- today greater than 95% of acreage utilizes some form of chemical weed control
Weed control program(s): 

- Preventative
  - sanitation
  - spot spraying
  - hand labor

- Chemical
  - soil-applied preemergence herbicide
  - foliar-applied postemergence herbicides
    - systemic
    - selective
    - non-selective
  - contact
Weed control program(s) (cont’d.):

- Chemical mowing – sub-lethal rates to suppress the growth and/or regrowth for 45-90 days
- Biological – *Phytophthora palmivora*
- Mechanical
  - mowing
  - tillage – less common due to fibrous root damage and potential erosion in bedded citrus
- Hand labor

* Product no longer sold
Prevention:

- Most likely overlooked as an economical weed control method
- Sometimes preventing or minimizing a problem weed introduction could provide significant cost savings over time
  - Example: vines
- Includes sanitation, spot spraying, hand labor
Mechanical Tillage (Cultivation):

- Advantages
  - Economical
  - Only temporary control, must be repeated with each new weed crop
  - 5-6 +/- operations per year
  - Time between operations allows for seed production which increases weed pressure over time
  - Incorporates seed into soil where viable for years
  - Clean soil surface is warmer in winter on marginal freeze nights (2-4°F) (FSHS 97:21-24, 1984)
Mechanical Tillage (Cultivation):

- Disadvantages
  - Damages roots near soil surface
    - Non-tilled blocks twice as many roots in 0-6 inches of soil vs. tillage blocks (FSHS 93:30-33, 1980)
    - The top 1 foot of soil contains:
      - upwards of 75% of the roots in poorly drained sites
      - more than 50% of the roots in well drained sites
    - Roots near soil surface are very important in areas of soil-borne insects, esp. Diaprepes, nematodes
  - Damage to tree trunk or major roots by implements
  - Increases soil erosion potential
  - Ineffective for deep rooted perennial grasses
    - (bermuda, torpedo, bahia grasses and nutsedge)
Mechanical Tillage (Cultivation):

- **Today**
  - Nearly all groves are limited to one-way cultivation due to close in-row tree spacing and micro irrigation tubing on soil surface
  - Once your weed control program is a failure
    - control measures become limited to correction with chemical control methods
    - corrective action can be expensive
  - In-row areas need some form of chemical weed control to maintain maximum irrigation coverage area
Selection of herbicide and its rate will vary depending upon:

- weed species present
  - grasses, broadleaf, vines, sedges
- growth stage of weed species
  - seedling, vegetative, seed production, maturity
- soil type (be aware of county restrictions on label)
- cost of herbicide material(s)
- scion
- tree age
- Season
  - annuals - one-year life cycle (summer vs. winter annuals)
  - biennials – two-year life cycle
  - perennials – live move than two years
Young groves require greater attention to material selection and rate:

- tree sensitivity to higher rate
- sensitivity of young tree trunk to herbicide, especially green trunks
- greater exposure of soil to sun light allows increased weed growth
Light measurements in January vs. July for Young and Mature Trees

Mature and Young Tree Light Readings
Weed monitoring:

- before application,
  - determine stage of growth and type of weeds present
- possible combination of pre- + postemergence materials may be required
- some preemergence herbicides may control of both broadleaf and grasses
- encourage rotation of herbicides to broaden control of difficult to control weeds
Four “R’s” of any pest control program

- right material
- right amount
- right time
- right way

Without the proper selection of the four “R’s”, any pest control program is subject to failure
Pre vs. postemergence program

- Preemergence
- Postemergence
- Pre + postemergence combination
What is ‘preemergence’ herbicide?

- Herbicide applied to **soil surface** (not mechanically incorporated) before the specified crop or weed emerges.
- Preemergence herbicides require incorporation via rain or irrigation to enhance activity by moving herbicide into zone of weed seed germination.
Rates in this presentation

- In this presentation, rates are rate per treated acre and not per grove acre.
  - Be sure to understand the difference.
Major preemergence herbicides used in Florida citrus

- Bromacil - Hyvar X
- Diuron - Direx, Karmex, Diuron, etc.
- Indaziflam - Alion
- Norflurazon - Solicam
- Pendimethalin – Prowl H2O, Prowl, Pendimethalin
- Simazine - Princep, Caliber 90, Simazine, etc.

* Other herbicides are registered but less commonly used
Bromacil (Hyvar 80WP, part of Krovar I)

- introduced in 1963
- for control of annual and perennial grasses and annual broadleaf weeds
- preemergence with limited postemergence activity
- prohibited from use in vulnerable, deep, sandy ridge type soils
- potential damage to off-target species (esp. oak trees)

<table>
<thead>
<tr>
<th>Tree age</th>
<th>Rate</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 4 years</td>
<td>2-4 lbs</td>
<td>Do not exceed 6 lbs per year, use lower rates on lighter soils</td>
</tr>
<tr>
<td>1-3 years</td>
<td>2-3 lbs</td>
<td></td>
</tr>
<tr>
<td>&lt; 1 year</td>
<td>2-3 lbs</td>
<td></td>
</tr>
</tbody>
</table>
Bromacil phytotoxicity

Root uptake not contact injury
Diuron (Diuron, Direx, Karmex)

- first recommended in 1962
- control of annual broadleaf weeds and some annual grasses
- preemergence herbicide
- foliar contact may develop a bleached or bronzed appearance
- Highlands County restrictions of 4.8 lb a.i. yr.

<table>
<thead>
<tr>
<th>Tree age</th>
<th>Rates</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 year</td>
<td>2 lbs (80DF) or 2 qts (4L)</td>
<td>Lower rates on young trees</td>
</tr>
<tr>
<td>&gt; 1 year</td>
<td>2-4 lbs (80DF) or 2-4 qts (4L)</td>
<td>Max 8 lbs or 8 qts per year</td>
</tr>
</tbody>
</table>
Diruon contact phytotoxicity
**Bromacil + Diuron (Krovar I)**

- control of annual broadleaf, annual vines, annual and perennial grasses
- contact activity enhanced by surfactant
- extra diuron increases activity on broadleaf weeds
- prohibited from use on ‘ridge’ type soils (see label)

<table>
<thead>
<tr>
<th>Tree age</th>
<th>Rate</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 3 years</td>
<td>4-6 lbs, apply pre/early post</td>
<td>Do not exceed 12 lbs year</td>
</tr>
<tr>
<td>1-3 years</td>
<td>2-4 lbs</td>
<td>Do not exceed 8 lbs year</td>
</tr>
<tr>
<td>&lt; 1 year</td>
<td>2-4 lbs</td>
<td>Use lower rate on lighter soils</td>
</tr>
</tbody>
</table>
Indaziflam (Alion)

- Registered in summer of 2011
- Preemergence herbicide for the control of broadleaf and grass weeds. Emerged weeds will not be controlled unless combined with a postemergence herbicide (glyphosate or other post products).
- Understand rate/A/yr labeling requirement

<table>
<thead>
<tr>
<th>Tree Age</th>
<th>Rate</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 90 days after planting</td>
<td>5-6 oz/A</td>
<td>Avoid contact with foliage, max 10.4 oz/A/yr</td>
</tr>
</tbody>
</table>
Indaziflam contact phytoxicity
Norflurazon (Solicam 80WP)

- first recommended in 1985
- preemergence herbicide
- recommended for control of annual grasses and certain broadleaf weeds
- may be injected through low volume under tree irrigation system with proper backflow prevention devices

<table>
<thead>
<tr>
<th>Tree age</th>
<th>Rates</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>3-5 lbs</td>
<td>Max 10 lbs year</td>
</tr>
</tbody>
</table>
Norflurazon phytotoxicity
Simazine (Simazine 90DF, Caliber 90WDG, Princep 4L)

- one of the first herbicides used (1962)
- preemergence herbicide
- registered for control of broadleaf weeds, annual vines, and annual grasses, does not control perennial grasses
- apply prior to weed emergence, no contact activity

<table>
<thead>
<tr>
<th>Tree age</th>
<th>Rates</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 year</td>
<td>Use lower rates</td>
<td></td>
</tr>
<tr>
<td>&gt; 1 year</td>
<td>4.4 lbs or single application of 8.8 lbs (90)</td>
<td>Max 8.8 lbs or 2 gal per year</td>
</tr>
<tr>
<td></td>
<td>1.0 gal or single application of 2.0 gal (4L)</td>
<td></td>
</tr>
</tbody>
</table>
Simazine phytotoxicity
Pendimethalin
(Prowl H2O, Prowl, Pendimax)

- Compound has been registered for years
- Control of annual grasses, does not control sedges
- Some formulations may be nonbearing use only, Prowl H2O labeled for bearing citrus (July 2006, use varies by product)
- Spectrum of broadleaf weeds controlled is increased by tank mixing with diruon or simazine

<table>
<thead>
<tr>
<th></th>
<th>Rate</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prowl H2O</td>
<td>6.3-7.0 pt/A</td>
<td>Max 12.6 pt/A/yr</td>
</tr>
<tr>
<td>others</td>
<td>2-4 qts</td>
<td>Max 8 qts per year</td>
</tr>
</tbody>
</table>
Other preemergence herbicides labeled but not used as frequently:

- Napropamide (Devrinol)
- Oryzalin (Surflan)
- Oxyfluorfen (Goal) currently non-bearing only
- Trifluralin (Treflan)

* Others registered but not commonly used
What is a ‘postemergence’ herbicide?

- Herbicide applied **after** the specified crop or weeds emerge from the soil that you are wanting to control.
Major postemergence herbicides used in Florida citrus:

- Carfentrazone (Aim EC)
- Glyphosate (Roundup, Touchdown, etc., etc.)
- Glyphosate + 2,4-D (Landmaster)
- Fluazifop-p-butyl (Fusilade)
- Paraquat (Gramoxone Inteon)
- Saflufenacil (Treevix)
- Sethoxydim (Poast, Poast Plus)
Paraquat (Gramoxone Inteon, Graxeroxone SL 2.0)

- recommended in 1969
- used for postemergence control of grasses and broadleaf weeds
- restricted use pesticide, reporting requirements, proposed new rules requiring special training, and applicator will be required to have a RUP license
- destroys all green tissue on contact, expect rapid regrowth from perennial species

<table>
<thead>
<tr>
<th>Tree age</th>
<th>Rates</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>2.5-4 pts</td>
<td>Avoid contact with citrus foliage, stems and fruit</td>
</tr>
</tbody>
</table>
Gramoxone Injury, Fruit & Foliage
Glyphosate
(Roundup, Touchdown, Glyfos, Glyphomax, etc, etc.)

- first recommended in 1979 (Roundup), 1992 (Touchdown), 2003 (Glyphomax)
- postemergence, non-selective, systemic herbicide
- for total or partial control of most weed species, with some somewhat tolerant species noted (Florida & Brazil pusley, dayflower, Ragweed parthenium, Spanish needle) which is impacted by plant size
- avoid green bark on young trees and fruit on mature trees
- can be used for chemical mowing and wiping
- water containing Ca, Mg, Fe, Al at levels of 400 ppm may require use of ammonium sulfate for optimum activity
### Glyphosate (cont’d.)

<table>
<thead>
<tr>
<th>Location</th>
<th>Rate trt/A in A. E.</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undertree</td>
<td><strong>Annual weeds:</strong> 0.75-1.5 lb A.E.</td>
<td>Apply in 10-40 gpa. Use ammonium sulfate with some water sources. Avoid contact with fruit, foliage and green bark</td>
</tr>
<tr>
<td></td>
<td><strong>Perennial weeds:</strong> 1.75-3.75 lb A.E.</td>
<td></td>
</tr>
<tr>
<td>Middles Management</td>
<td></td>
<td>Suppression of grasses and broadleaf weeds for 45-90 days</td>
</tr>
<tr>
<td>Chemical mowing</td>
<td>Bahiagrass: .094-.188 lb A.E.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bermudagrass: .141-.37 lb A.E.</td>
<td></td>
</tr>
<tr>
<td>Wiping</td>
<td>5-10% solution - carpet wiper</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50-100% solution- panel wiper</td>
<td></td>
</tr>
<tr>
<td>Spot trt.</td>
<td>1-2% solution</td>
<td></td>
</tr>
</tbody>
</table>
### Glyphosate (cont’d)

<table>
<thead>
<tr>
<th>Herb Form</th>
<th>A.E.</th>
<th>A.I.</th>
<th>Rate per treated acre in A.E.- previous slide</th>
<th>Max rate per trt/A (qts)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.75 lb</td>
<td>1.5 lb</td>
</tr>
<tr>
<td>Equivalent amount products to equal the above pounds of A.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durango</td>
<td>3.0</td>
<td>4.0</td>
<td>1 qt</td>
<td>2 qt</td>
</tr>
<tr>
<td>Glyphomax</td>
<td>3.0</td>
<td>4.0</td>
<td>1 qt</td>
<td>2 qt</td>
</tr>
<tr>
<td>Roundup Original</td>
<td>3.0</td>
<td>4.0</td>
<td>1 qt</td>
<td>2 qt</td>
</tr>
<tr>
<td>Roundup UltraMax</td>
<td>3.7</td>
<td>5.0</td>
<td>26 oz</td>
<td>52 oz</td>
</tr>
<tr>
<td>Roundup WeatherMax</td>
<td>4.5</td>
<td>5.5</td>
<td>22 oz</td>
<td>44 oz</td>
</tr>
<tr>
<td>Touchdown</td>
<td>5.0</td>
<td>6.0</td>
<td>19.2 oz</td>
<td>38.4 oz</td>
</tr>
</tbody>
</table>
Glyphosate Injury
Foliage & Fruit
Glyphosate + 2,4-D (Landmaster II)

- Special registration in 2000
- Mixture of 2,4-D + glyphosate
- Special label requirements for record keeping, i.e. wind speed, location of use, etc.
- Distance requirement from specific crops
- Note a new formulation of 2,4-D has been submitted for labeling and expected registration by summer of 2019

<table>
<thead>
<tr>
<th>Tree age</th>
<th>Rate</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>2-8 qts + Roundup</td>
<td>See label for use and equipment requirements</td>
</tr>
</tbody>
</table>
2,4-D Injury
Fluazifop-p-butyl (Fusilade)

- recommended in 1987
- for control of annual and perennial grasses (does not control broadleaf weeds)

<table>
<thead>
<tr>
<th>Tree age</th>
<th>Rate</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-bearing</td>
<td>1.0-1.5 pts</td>
<td>Do not apply to grasses under stress conditions</td>
</tr>
</tbody>
</table>
**Sethoxydim (Poast, Poast Plus)**

- marketed as Poast in 1993, changed to Torpedo in 1994 and now as Poast Plus and/or Poast
- for postemergence control of annual and perennial grasses (does not control broadleaf weeds)

<table>
<thead>
<tr>
<th>Tree age</th>
<th>Rate</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>2.25-3.75 pts</td>
<td>Do not exceed 15 pts per year, do not apply to grasses under stress conditions.</td>
</tr>
</tbody>
</table>
Carfentrazone (Aim)

- Aim applied at 1-2 oz/A with glyphosate to enhance control of many broadleaf weeds.
- Fast-acting
- Do not apply more than 2 fl oz per application and 7.9 fl oz per acre per season
Safulfenaacil (Treevix)

- Treevix applied at 1 oz/A and not more than 3 oz/A/yr.
- Must be applied with methylated seed oil or crop oil concentrate plus AMS
- Very effective in enhancing control of broadleaf weeds:
  - Ragweed parthenium, Spanish needle, etc.
- Provides little grass control
Other herbicides labeled but not in Pest Management Guide
Flumioxazin (Chateau)

- Supplemental label expires 12-31-2019
- Application rate 6 to 12 oz
- Controls susceptible broadleaf and grass weeds
- Do not apply more than 12 oz in a single application or 24 oz in a 12 month period
- Do not apply to trees established less than one-year, unless protected from spray contact by non-porous wraps
- Residual weed control is reduced if vegetation prevents herbicide from reaching the soil surface
Glufosinate (Rely 280)

- Do not apply more than 246 fl oz per year or 82 fl oz in a single application
- Weed necrosis will occur within 2-4 days
- Avoid contact with green bark, stems, foliage or fruit
- Must have thorough coverage of weed to provide adequate control, not systemic
- Avoid application during windy conditions
Mesotrione (Broadworks)

- Can provide both pre and post emergence weed control of selected broadleaf and grass weeds
- Do not exceed 12 fl oz per year or 6 oz per season
- Do not apply more than 3 applications per year
Rimsulfuron (Solida)

- Provides both preemergence and postemergence control of susceptible weed species
- Controls susceptible annual grasses, broadleaf weeds and sedges
- Do not apply more than 4 oz per acre per season
Sulfentrazone (Spartan)

- Soil applied
- Controls selective grass, broadleaf and sedge species.
- Do not apply more than 12 fl oz per acre per year
- Use only on lemons and oranges that have been established for at least three growing seasons.
Weed Control Programs

- Improve application to:
  - Minimize application of herbicide products where shade suppresses weed growth.
  - Reduce residual herbicide cost by reducing material application location.
  - Reduce environmental impact of residual herbicides.
Herbicide application

- Residual herbicides are generally applied 2-3 times per year
  - Preemergence herbicide applied prior to weed seed germination or in combination with postemergence
  - Mixed with water or suspension fertilizers
  - Some materials may be direct injected into a well-designed irrigation systems (chemigation/herbigation)

- Postemergence herbicides applied 4-6 times per year
  - Possible development of weed tolerance
    - Brazil/Florida pusley
    - Dayflower
    - Ragweed parthenium
Herbicide application:

- Improved technology for the selective delivery of multiple herbicide products to specific sites (under tree, variable rate, and row middles)
- Improved design (covered boom, back curtain) to reduce tree foliage and fruit contact, spray drift and application in various weed heights
- Application volume
  - 20-50 GPA for under tree
  - 10-25 GPA for chemical mowing
Adjusting band width to effect cost

Percentage of grove acreage treated with herbicides

- 8'/25' = 32%
- 10'/25' = 40%
- 14'/25' = 56%
- 16'/25' = 64%
### Impact of Band Width on Material Cost

<table>
<thead>
<tr>
<th>Band width</th>
<th>Percent grove acre treated</th>
<th>Material Cost $240 per trt/A, ($120 per grove/A)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>8’ x 25’</td>
<td>32%</td>
<td>$76.80</td>
</tr>
<tr>
<td>10’ x 25’</td>
<td>40%</td>
<td>$96.00</td>
</tr>
<tr>
<td>14’ x 25’</td>
<td>56%</td>
<td>$134.40</td>
</tr>
<tr>
<td>16’ x 25’</td>
<td>64%</td>
<td>$153.60</td>
</tr>
</tbody>
</table>

*Assumed 50% of the acre is treated, material cost/A is $118.60 from Singerman’s annual report
## Weed Control by Various Products or Methods

<table>
<thead>
<tr>
<th></th>
<th>50% Grove Acreage</th>
<th>50% Grove Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Under tree – broadleaf</td>
<td>Under tree - grasses</td>
</tr>
<tr>
<td><strong>Chemical</strong></td>
<td>PRE</td>
<td>POST</td>
</tr>
<tr>
<td>Bromacil *</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Norflurazon</td>
<td>Limited</td>
<td></td>
</tr>
<tr>
<td>Thiazopyr</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Oxyfluorfen **</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Simazine</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Diuron</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Oryzalin</td>
<td>Limited</td>
<td></td>
</tr>
<tr>
<td>Pendimethalin</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Paraquat</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Sethoxydim</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Fluazifop-p-butyl **</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Biological</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Phytophthora palmivora</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mechanical</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discing/mowing</td>
<td>Limited control of grasses and broadleaf due to inability to get under tree</td>
<td></td>
</tr>
</tbody>
</table>

X = control (rate and weed species dependent)  * location restrictions,  ** non-bearing only
<table>
<thead>
<tr>
<th>Herbicide ***</th>
<th>Ridge Rate (lb product)</th>
<th>Control % *</th>
<th>Flatwoods Rate (lb product)</th>
<th>Control % *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyvar 80DF ****</td>
<td>2.0</td>
<td>91 a</td>
<td>2.6</td>
<td>81 b</td>
</tr>
<tr>
<td>Direx 80DF</td>
<td>2.0</td>
<td>74 bcd</td>
<td>2.6</td>
<td>59 cde</td>
</tr>
<tr>
<td>Hyvar 80DF + Direx 80DF ****</td>
<td>2.0 + 2.0</td>
<td>92 a</td>
<td>2.6 +2.6</td>
<td>91 a</td>
</tr>
<tr>
<td>Direx 80DF + Surflan 80DF</td>
<td>2.0 +2.0</td>
<td>79 bc</td>
<td>2.6 + 2.6</td>
<td>63 cd</td>
</tr>
<tr>
<td>Direx 80DF + Mandate 2E</td>
<td>2.0 + 1 pt</td>
<td>74 b-e</td>
<td>2.6 + 1.33 pt</td>
<td>60 cd</td>
</tr>
<tr>
<td>Direx 80DF + Mandate 2E</td>
<td>2.0</td>
<td>76 bcd</td>
<td>2.6 + 2.0 pt</td>
<td>66 c</td>
</tr>
<tr>
<td>Solicam 80DF</td>
<td>2.0</td>
<td>70 b-e</td>
<td>3.0</td>
<td>81 b</td>
</tr>
<tr>
<td>Solicam 80DF + Direx 80DF</td>
<td>2.0 + 2.0</td>
<td>81 b</td>
<td>3.0 + 2.6</td>
<td>92 a</td>
</tr>
<tr>
<td>Solicam 80DF + Simazine 90</td>
<td>2.0 + 2.0</td>
<td>73 b-e</td>
<td>3.0 + 2.9</td>
<td>89 ab</td>
</tr>
<tr>
<td>Solicam + Goal 1.6E **</td>
<td>2.0 + 2 qts</td>
<td>81 b</td>
<td>3.0 + 3 qts</td>
<td>88 ab</td>
</tr>
<tr>
<td>Surflan 80DF</td>
<td>2.0</td>
<td>64 def</td>
<td>2.5</td>
<td>37 hi</td>
</tr>
<tr>
<td>Control</td>
<td>39 g</td>
<td></td>
<td>29 i</td>
<td></td>
</tr>
</tbody>
</table>

Means followed by same letter within a column do not significantly differ (P = 0.05 Waller-Duncan). Percent control data were transformed using arcsin square root percent and are reported in de-transformed units. *Annual weed control based upon the average of 3 treatments per year with ratings at 120 days after treatment. ** non-bearing. ***All treatments including control included glyphosate at 2-3 qts. **** Prohibited from use in specific ridge counties, see label.
<table>
<thead>
<tr>
<th>Herbicide ***</th>
<th>Ridge</th>
<th>Flatwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surflan 80DF</td>
<td>2.0</td>
<td>64 def 2.5</td>
</tr>
<tr>
<td>Goal 1.6E **</td>
<td>2.0 qt</td>
<td>69 cde 3.0 qt</td>
</tr>
<tr>
<td>Goal 1.6E **+ Mandate 2E</td>
<td>2.0 qt + 1 pt</td>
<td>76 bcd 3.0 qt + 1.5 pt</td>
</tr>
<tr>
<td>Goal 1.6E **+ Mandate 2E</td>
<td>2.0 qt + 1.3 pt</td>
<td>78 bc 3.0 qt + 2.0 pt</td>
</tr>
<tr>
<td>Simazine</td>
<td>2.0</td>
<td>53 f 3.0</td>
</tr>
<tr>
<td>Simazine + Surflan 80DF</td>
<td>2.0 + 2.0</td>
<td>75 bcd 3.0 + 2.5</td>
</tr>
<tr>
<td>Simazine + Mandate 2E</td>
<td>2.0 + 1 pt</td>
<td>69 cde 3.0 + 1.5 pt</td>
</tr>
<tr>
<td>Simazine + Mandate 2E</td>
<td>2.0 + 1.3 pt</td>
<td>72 b-e 3.0 + 2.0 pt</td>
</tr>
<tr>
<td>Mandate 2E</td>
<td>1.0 pt</td>
<td>62 ef 1.5 pt</td>
</tr>
<tr>
<td>Mandate 2E</td>
<td>1.3 pt</td>
<td>68 cde 2.0 pt</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>39 g</td>
</tr>
</tbody>
</table>

Means followed by same letter within a column do not significantly differ (P = 0.05 Waller-Duncan). Percent control data were transformed using arcsin square root percent and are reported in de-transformed units. *Annual weed control based upon the average of 3 treatments per year with ratings at 120 days after treatment. ** non-bearing. ***All treatments including control included glyphosate at 2-3 qts.
Residual Activity

- Crops affected by residual herbicide activity
  - Rotational crop injury may be:
    - Erratic
    - Non-uniform
    - Varies with changes in soil type
  - In areas farmed with citrus:
    - Banding effects may be observed where tree rows were and had multiple herbicide applications over many years.
## Crop Rotation Period

<table>
<thead>
<tr>
<th>Herbicide Brand Name</th>
<th>Common Name</th>
<th>Major Weeds Controlled</th>
<th>Rotational Interval</th>
<th>$K_{oc}$ mL/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direx, Karmex, Diuron</td>
<td>diuron</td>
<td>broadleaf</td>
<td>12-24 months</td>
<td>480</td>
</tr>
<tr>
<td>Hyvar</td>
<td>bromacil</td>
<td>grass</td>
<td>12 months</td>
<td>32</td>
</tr>
<tr>
<td>Krovar I</td>
<td>bromacil + diuron</td>
<td>broadleaf &amp; grass</td>
<td>24 months</td>
<td>32/480</td>
</tr>
<tr>
<td>Alion</td>
<td>Indaziflam</td>
<td>Broadleaf &amp; grass</td>
<td>24-36 months</td>
<td></td>
</tr>
<tr>
<td>Princep, Simazine</td>
<td>simazine</td>
<td>broadleaf</td>
<td>12 months</td>
<td>130</td>
</tr>
<tr>
<td>Solicam</td>
<td>norflurazon</td>
<td>grass</td>
<td>12-24 months</td>
<td>700</td>
</tr>
<tr>
<td>Surflan</td>
<td>oryzalin</td>
<td>grass</td>
<td>12 months</td>
<td>600</td>
</tr>
</tbody>
</table>
6 Months After Tree Removal
Conclusion –

**in row weed control**

- Combination of herbicides which provide control of both grasses and broadleaf weeds increases percent weed control.
- Weed intensities vary among different locations within the state and with season.
- Herbicide rates must be adjusted and selected to control weeds present at a given site.
- Adequate weed control should be obtained at a given site before rates are reduced. Once control is not achieved with a given program, it is difficult to obtain control in the next application of herbicides.
Conclusion – in row (cont’d)

- Herbicide products and/or rates that work at one location may not provide effective control at other locations.
- Apply preemergence herbicides to relatively clean ground to obtain maximum benefit.
Middle Management in Florida Citrus Groves

- Middle management involves various methods to establish and/or control vegetation in the row middle.
Middle vegetation species

- Vegetation species vary greatly by:
  - Season
  - Location
  - Environmental factors (rain, temp., day length, etc.)
  - Soil type
    - Heavier soils have greater water & nutrient holding capacity
  - Species type
    - Grasses – sod forming more competitive than broadleaf
    - Mowed middles more competitive than unmowed
Optimum row middle vegetation

- Minimizes soil erosion from wind and rain
- Be low growing
- Non-invasive into herbicide treated area
- Easy to control (mechanically or chemically)
- Non competitive with the citrus tree for
  - Water
  - Nutrients
  - Space/light
Methods for middle vegetation control

- Mechanical
  - Mow
  - Tillage
  - Hand hoe

- Chemical

- Chemical mow/wiping
Middle management in Florida

- 44 – 68% under middle management, see slide 56
- Approximate annual cost $45 - $65 per acre per year
- Singerman’s report identified cost at $64.33 per acre per year for chemical and mechanical mowing
Middles management influences

- Vegetation species
- Soil moisture
- Nutrient status
- Soil erosion from wind and rain
- Climatic conditions
- Various biological factors
Grove establishment programs

- Newly established groves
  - Soil stabilization programs to minimize erosion
    - Annual rye or millet
    - Grasses (bahiagrass)
Mechanical tillage

- Discs
- Choppers
- Mechanical hoes
- Hand hoes
Mechanical tillage

- Advantages
  - Economical
  - Only temporary control, must be repeated with each new weed crop
  - 5-6 operations per year
  - Incorporates seed into soil where they are viable for years
  - Warmer on freeze events (2-3°F)
Mechanical tillage (cont.)

- Disadvantages
  - Damages roots – upward of 75% of roots in top 30 cm of soil (bedded systems)
    - Non tilled blocks twice as many roots in 0-15 cm soil vs. tillage
  - Damage to tree trunk and large roots
  - Soil erosion
  - Ineffective for deep-rooted perennials
    - (bermudagrass, torpedogras, bahiagrass, nutsedge)
**Mechanical mowing**

- **Advantage**
  - Minimizes soil erosion
  - Pleasing appearance
  - Reduce tall growing species

- **Disadvantages**
  - High energy and equipment demand
  - High moisture requirement
  - Cooler temperatures on minimal freeze nights
Chemical mowing

- Utilizes low rate of glyphosate to suppress vegetative regrowth of grasses and broadleaf weeds
  - Advantages
    - Low energy and equipment demand
    - Suppresses regrowth for up to 90 days
  - Disadvantages
    - Can not apply in drought conditions
    - Needs rain free period of up to several hours
    - Needs good boom design to minimize off target site damage
Chemical wiping

- **Advantage**
  - Kills tall-growing weed species
  - Easy to adjust height

- **Disadvantage**
  - Requires filtration on recirculated material
  - Maintain even flow on wiper
Carpet / panel wiping

- Carpet advantage
  - Applied in 5-33% solution
  - Application volume varies with weed density

- Panel
  - Applied in 50-80% solution
  - Application volume varies with weed density
Vine Control in Florida Citrus
Vines in citrus groves

- Vine control has become an increasingly difficult task as:
  - Vine spectrum has increased
  - Product application rate has decreased
  - Limited number of products exist that provide broadleaf weed control
  - Inability to apply herbicide to vine foliage once it reaches into the tree canopy
Problem vine species

- Balsam-apple (*Momordica charantia*)
- Milkweed or strangler vine (*Morrenia odorata*)
- Virginia creeper (*Parthenocissus quimquefolia*)
- Peppervine (*Ampelopsis arborea*)
- Catsclaw (*Bignonia unguis-cati*)
- Morningglory (*Ipomoea spp*)
- Possum grape (*Cissus verticulata*)
Vine like species

- Puncture vine
- Phaseybean
Milkweed vine
Catsclaw vine
Vine control programs

- Prevention
- Preemergence
  - Chemical control
- Postemergence
  - Chemical control
  - Mechanical
  - Hand labor
Prevention vine control

- Attempts should be made to control vines while isolated to small area or few trees
- Preventative programs can minimize seed dispersal
- Can prove very economical
Preemergence vine control

- Materials:
  - Simazine
  - Diuron
  - Indaziflam (some pre control)
Preemergence vine control

- **Simazine**
  - Must be mixed with postemergence material to control emerged vines/weeds, control enhanced by addition of surfactant
  - **Grasses or broadleaf control**
    - up to 4 lb ai/A/application
  - **Vine control**
    - Princep 4L
      - 2.0 gal/A/product in spring, do not exceed 2.0 gal/A/yr
    - Caliber 90 DF
      - 8.8 lb product, one application yr
      - 7.92 lb ai/A/single application, one application yr
    - Simazine 4L
      - 6.4-9.6 qts/A/yr (6.4-9.6 lb/ai/single application)
Preemergence vine control

- Direx
  - Must be mixed with postemergence material to control emerged vines/weeds
  - Control enhanced by addition of surfactant
  - Grasses or broadleaf control
    - 1.6-3.2 lb ai/A/application
      - Karmex 80DX, Direx 80DF: 2-4 lb
      - Direx 4L: 1.6-3.2 qts
  - Vine control
    - 3.2 lb ai/A/application
Postemergence vine control

- Applications should be made while vine is still in seedling stage
- Once established into tree canopy, insufficient surface contact by the herbicide is provided to obtain sufficient postemergence control
- Exception:
  - DeVine (*Phytophthora palmivora* MWV) for milkweed vine control – no longer available in market
Postemergence vine control

- Chemical
  - Simazine with POST product
  - Diuron with POST product
  - Glyphosate
  - Paraquat dichloride
  - Landmaster II (glyphosate + 2,4-D)

- Biological
  - *Phytophthora palmivora* (no longer in market)
Postemergence vine control

- Glyphosate
  - 1.5 to 2.25 lb A.E. per treated acre (equivalent 2 to 3 qts. of Roundup Ultra)
  - Roundup, Touchdown, Glyphomax, etc should be adjusted to provide equal amounts of A.E. per treated acre
- Gramoxone
  - Provides only burndown control without killing root system
- Landmaster II
  - Annual weeds: 1-8 qts.
  - Perennial weeds: 4-8 qts.
  - Application with glyphosate will improve effectiveness
Mechanical vine control

- Hand labor is utilized where vines are well established in tree canopy
- Labor cost is:
  - Expensive
  - Control is temporary
  - Not complete as some are missed
Conclusion of weed control

- Florida citrus growers utilize
  - Preventative,
  - Chemical,
  - Mechanical control

providing vine control in Florida citrus
Difficult Weed Control Situations
Difficult Weed Control Situations
Herbicide Placement

Area contacted by herbicide
Coverage Issue

Coverage impacts control
Coverage Issue

How do you get coverage in laid-over grass
Difficult Application Situations
To Obtain Adequate Coverage
Impact of Angle of the OC Nozzle on the Distribution Pattern
TeeJet Off-Center Flat Spray Tips

Source: TeeJet publication
# TeeJet Off-Center Flat Spray Tips

Boom height at 18”

<table>
<thead>
<tr>
<th>Nozzle</th>
<th>PSI</th>
<th>“W” in inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>OC 02</td>
<td>30</td>
<td>68 (5.66 ft.)</td>
</tr>
<tr>
<td>OC 02</td>
<td>40</td>
<td>70 (5.83 ft.)</td>
</tr>
<tr>
<td>OC 04</td>
<td>30</td>
<td>91 (7.58 ft.)</td>
</tr>
<tr>
<td>OC 04</td>
<td>40</td>
<td>93 (7.75 ft.)</td>
</tr>
<tr>
<td>OC 06</td>
<td>30</td>
<td>99 (8.25 ft.)</td>
</tr>
<tr>
<td>OC 06</td>
<td>40</td>
<td>101 (8.42 ft.)</td>
</tr>
</tbody>
</table>

Source: TeeJet Publication
Application Study

Utilizing Water Sensitive Paper

- All application tests were conducted at or with:
  - OC 04 nozzle
    - At 0°, 10°, 20°, 30° and 40° angle as measured from nozzle housing
  - 22 psi spray pressure
  - 3.1 mph
  - boom level with ground surface
  - OC nozzle at 14” above ground
Spray Distance from OC04 at 0°, 10°, 20°, 30° and 40° angle

20” = 1.66’; 40” = 3.33’; 60” = 5’; 78” = 6.5’
Boom Angle and Impact on Lower Canopy Foliage
Think About How Tree Architecture Will Impact Fruit Drop After Herbicide Application

Skirting tree will improve: 1) herbicide application; 2) minimize damage to boom and/or lower fruit/limbs; 3) improve irrigation distribution pattern; and, 4) make it easier to check irrigation jets for clogging.
Pesticide Label

- Remember the label is the law
- Be aware of REI and PHI for all applied products
- Comply with WPS training and supply required PPE
For more information contact:

Steve Futch
phone: 863-956-8644
e-mail: shf@ufl.edu