

Citrus Institute 2018



Photos: SWFREC Citrus grove, Plot O

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

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- **Weed control**

Preventive

Mechanical

*Chemical – **popular method***

- **Weed management programs**

Row middle – Mechanical mowing


Chemical mowing, wiping

Under tree – Utilizing herbicides



Challenges

- Managing problematic weeds
- Minimizing crop injury



Challenges

- **Managing problematic weeds**

- Minimizing crop injury

Problem weeds in citrus



Dayflower



Goat weed



Spanish needle

**Examples of
problem
weeds in citrus**



Pig weed



Parthenium



Guinea grass

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

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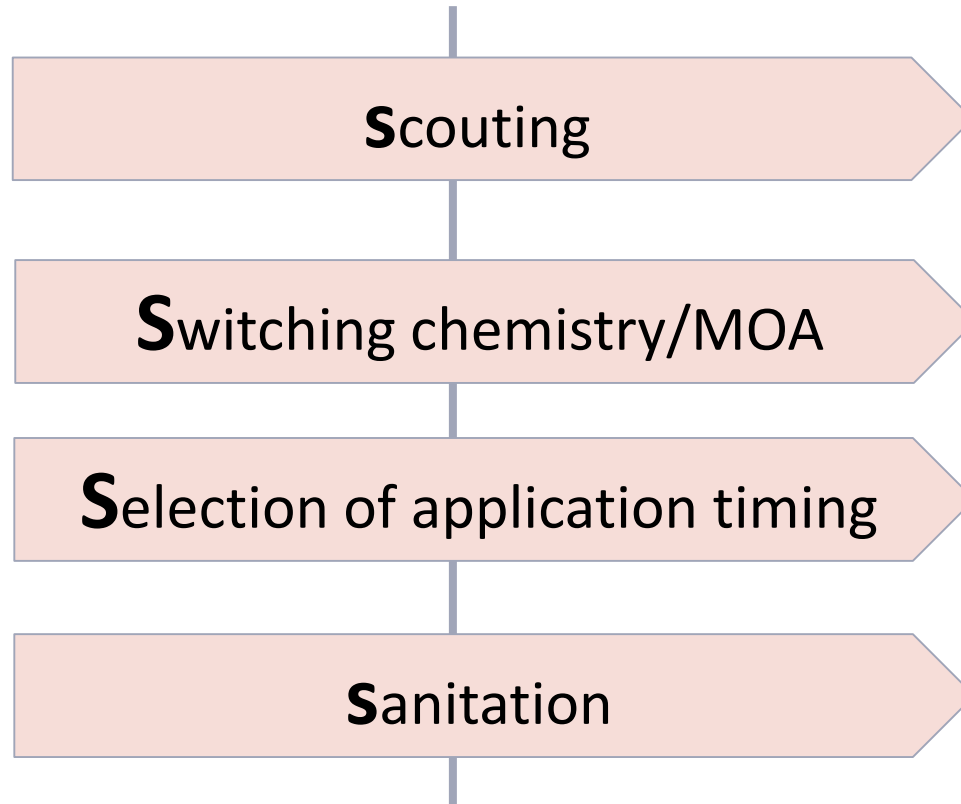
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Eg., Glyphosate

Herbicide resistance and/tolerance is the major reason

“Four S of resistance/tolerance management”



Problem weeds in citrus

- **Spanish Needle**

- Herbicide tolerance



Problem weeds in citrus

● Ragweed Parthenium

- Herbicide resistance
- Herbicide tolerance



Problem weeds in citrus

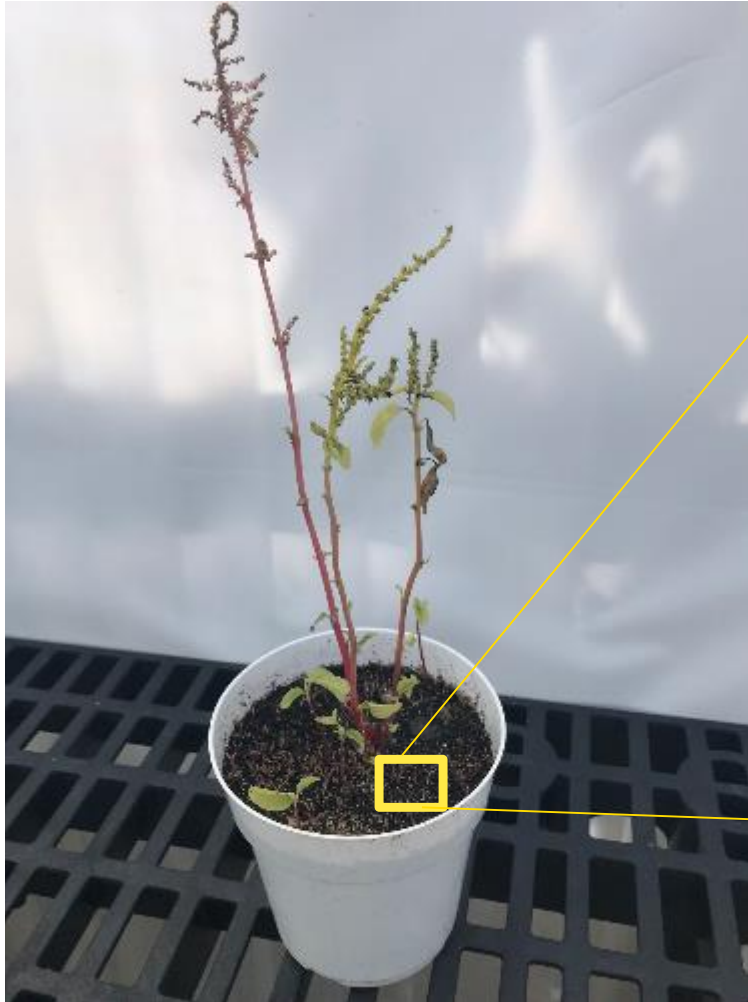
● Pigweed - Amaranth

- 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

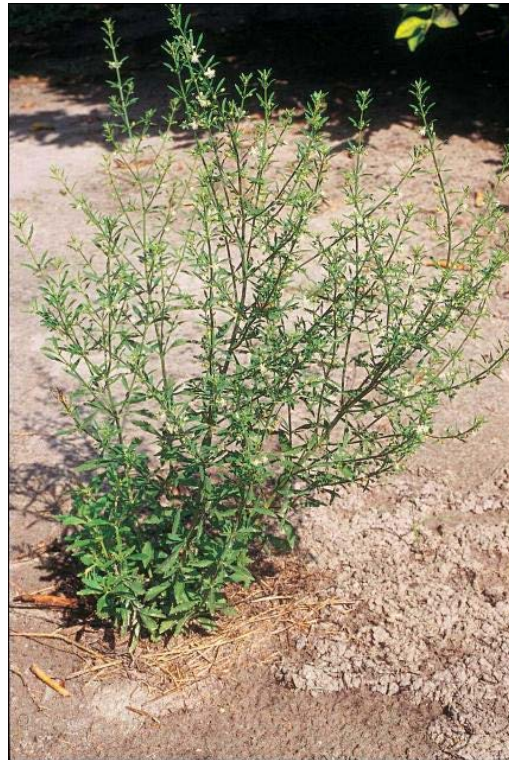


Giant Amaranth/Pig weed
Immokalee, FL

Problem weeds in citrus

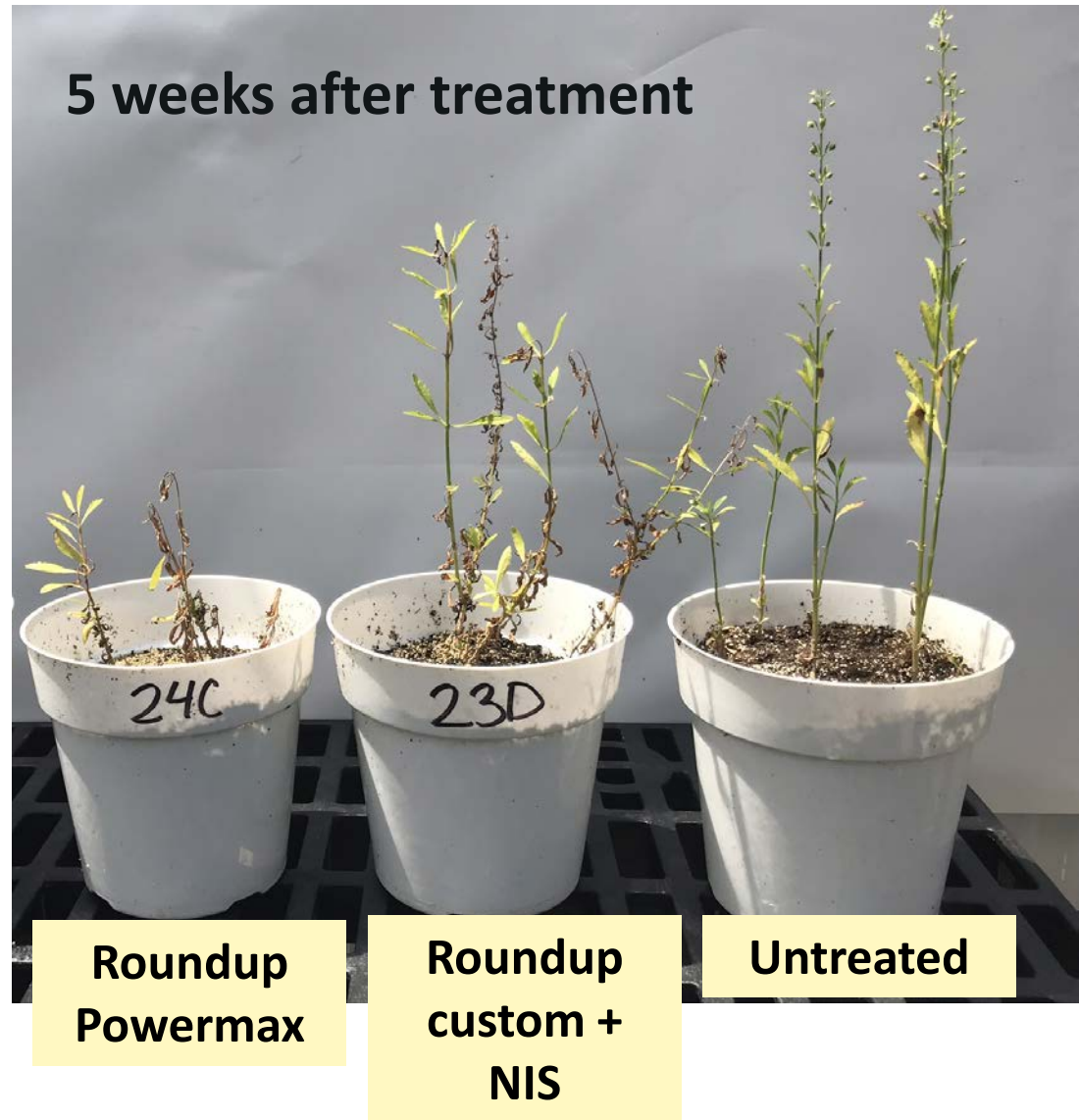
- Goat weed

- Herbicide tolerance
- Seed bank formation



● Goat weed tolerance

- Slow response to glyphosate products



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



Tropical whiteweed Flowers: Note blue or purplish hue of flowers


Potential new weed watch in citrus


● Tropical whiteweed

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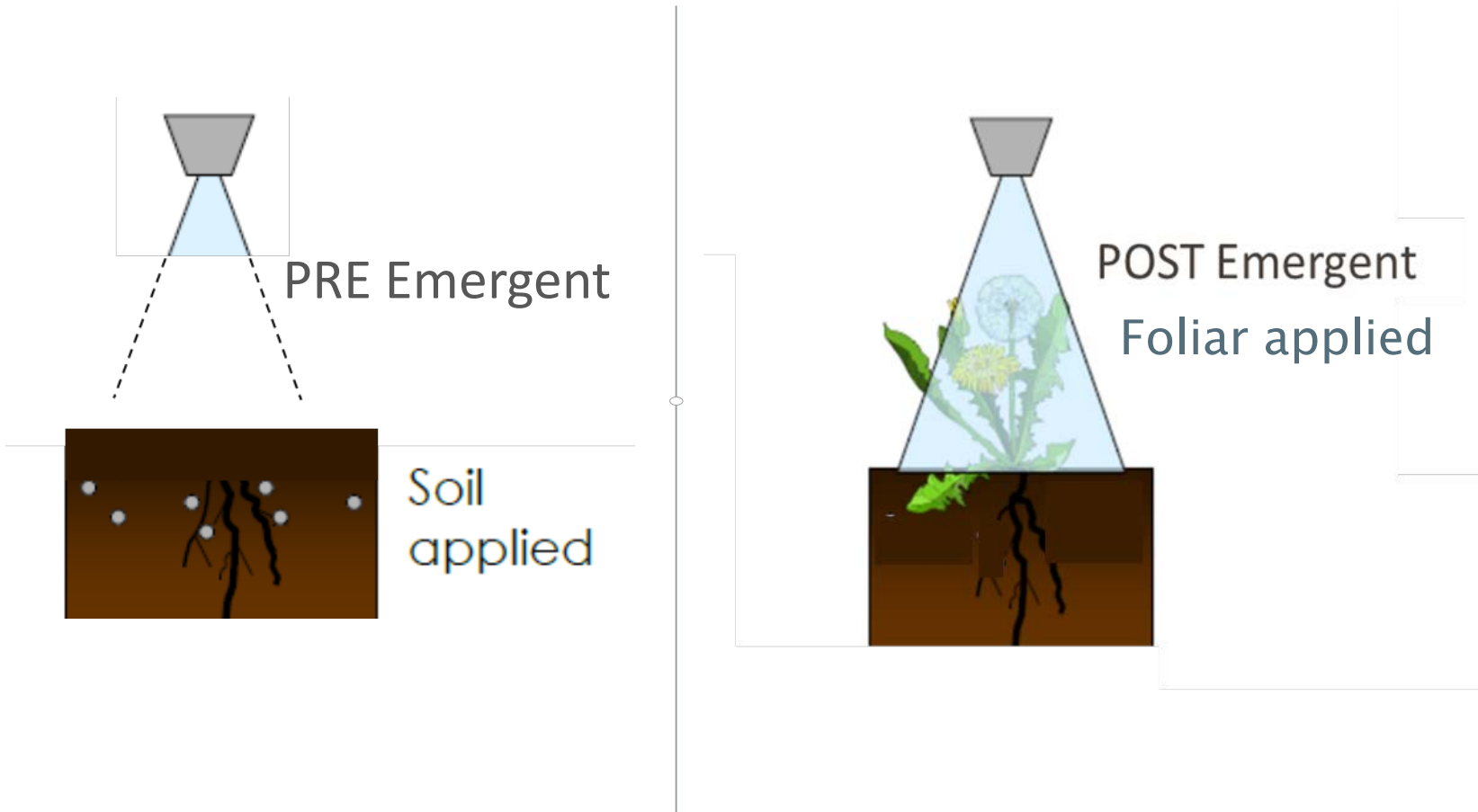


Tropical whiteweed leaves – ovate and serrated

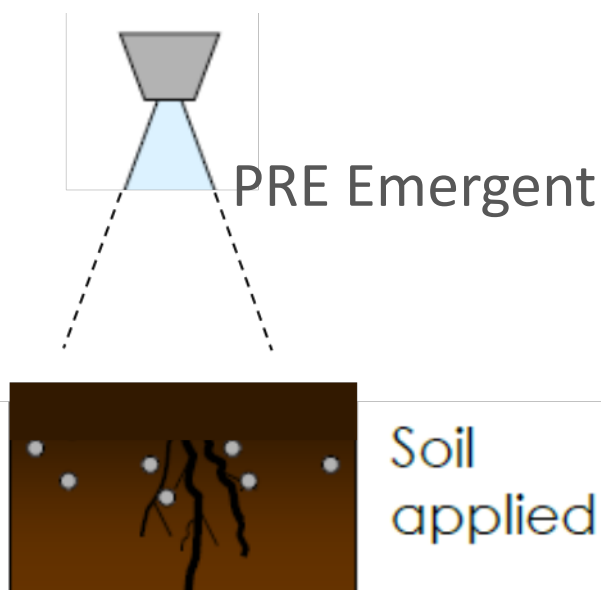
- 
- **Managing problematic weeds**
 - **Selecting the right herbicide program**
 - **Synergy b/w herbicides**
 - **Selecting proper adjuvants**

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

Herbicide classification - application timing



Herbicide classification - application timing



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

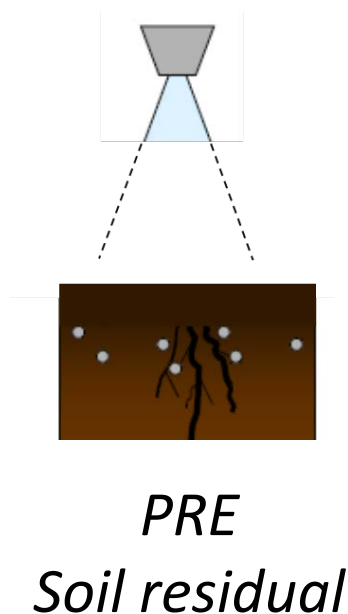
Minimum 'existent weed coverage' to ensure max soil incorporation

Rain or irrigation to activate

Major PRE-emergent herbicides used in FL citrus

- Active ingredient – Brand name(s)

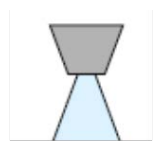
- **Bromacil – Hyvar X**
- **Simazine – Princep, Caliber 90, etc.**
- **Diuron – Direx, Karmex, etc.**
- **Norflurazon - Solicam**
- **Indaziflam - Alion**
- **Pendimethalin - Prowl**



* 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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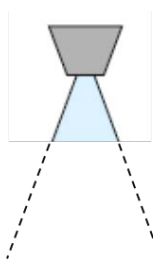


PRE
Soil residual

- Bromacil – Hyvar X
- Simazine – Princep, Caliber 90, etc.
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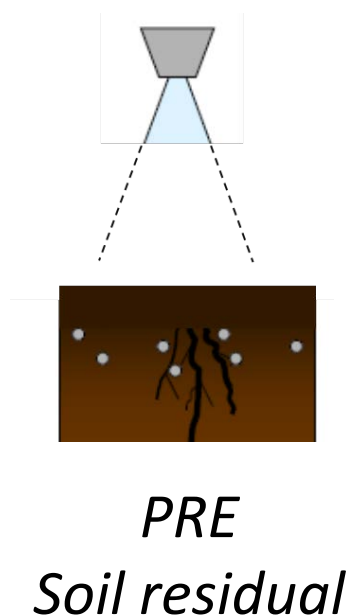
PRE
Soil residual

● 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

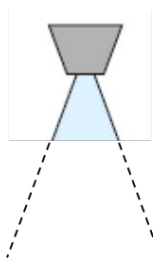
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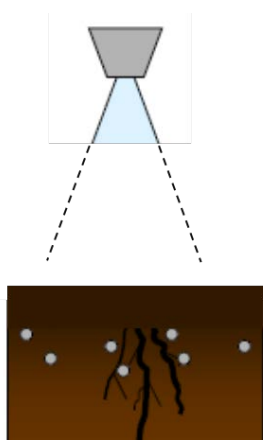


PRE
Soil residual

● 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



PRE
Soil residual

● 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
EPA Reg. No. 59639-99
(Except California and New York)

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.

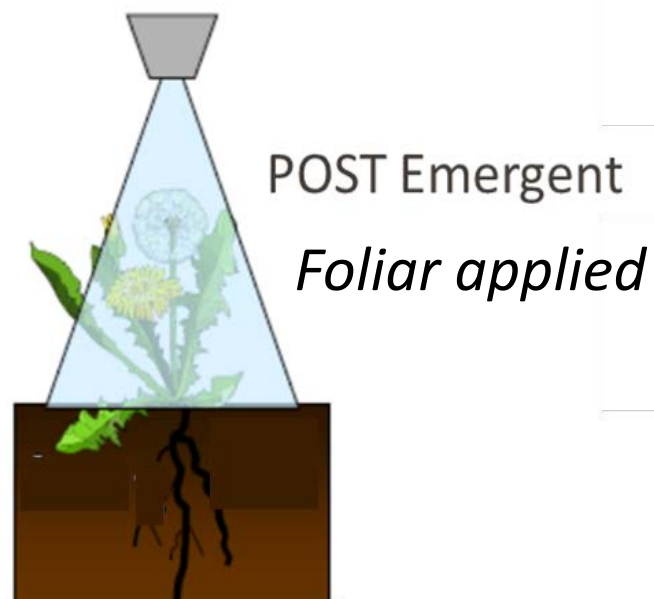
DIRECTIONS FOR USE

Herbicide classification - application timing

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

Usually no residual activity

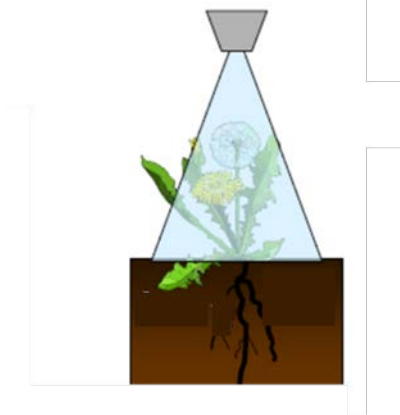
Require surfactants



Major POST-emergent herbicides used in FL citrus

- Active ingredient – Brand name(s)

*Non-selective
herbicides*



*POST
Foliar applied*

- **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*



*POST
Foliar applied*

● **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
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- **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



Carpet wiper



Panel wiper

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*



*POST
Foliar applied*

● 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*



*POST
Foliar applied*

● 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

Goat weed



Dayflower



Spanish needle

**Examples of
problem
weeds in citrus**



Pig weed



Parthenium



Guinea grass

- **Fusilade**
- **Poast, Poast plus**



Dayflower



Goat weed



Spanish needle



Pig weed



Parthenium



Guinea grass

Effective on

- **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*



*POST
Foliar applied*

● 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

Goat weed



Dayflower

**Examples of
problem
weeds in citrus**



Spanish needle



Pig weed



Parthenium



Guinea grass

● Saflufenacil - Treevix



Dayflower



Goat weed



Spanish needle



Pig weed



Parthenium



Guinea grass

Effective on

Saflufenacil – Treevix is effective on ‘Parthenium’ weed

Trial conducted at Wauchula, FL

Pest Type		W Weed	W Weed	W Weed	
Pest Name		Ragweed Parthe>	Ragweed parthe>	Ragweed parthe>	
Rating Date		6/26/2013	7/3/2013	7/16/2013	
Rating Type		% kill	% kill	% kill	
Rating Unit		%	%	%	
Number of Subsamples		1	1	1	
Days After First/Last Applic.		6 6	13 13	26 26	
Trt-Eval Interval		6 DA-A	13 DA-A	26 DA-A	
Trt No.	Treatment Name	Rate	1	2	3
		Rate Unit			
1	Roundup PowerMax LI700 Choice	64 fl oz/a 0.5 % v/v 4 pt/100 gal	3.8 d	1.5 c	10.0 c
2	Roundup PowerMax AIM Dynamic Choice	64 fl oz/a 2 fl oz/a 0.5 % v/v 4 pt/100 gal	11.3 d	6.3 c	16.3 c
3	Rounup PowerMax Treevix LI700 Choice	64 fl oz/a 1 oz wt/a 0.5 % v/v 4 pt/100 gal	93.8 a	95.0 a	92.5 a
4	Roundup PowerMax Matrix LI700 Choice	64 fl oz/a 2.0 oz wt/a 0.5 % v/v 4 pt/100 gal	57.5 b	20.0 b	77.5 ab
5	Gramoxone Inteon LI700 Choice	2 qt/a 0.5 % v/v 4 pt/100 gal	35.0 c	13.8 b	63.8 ab
6	Gramoxone Inteon Aim Dynamic Choice	2 qt/a 2 fl oz/a 1 % v/v 4 pt/100 gal	35.0 c	15.0 b	42.5 bc
7	Rely 280 LI700 Choice	3 qt/a 0.5 % v/v 4 pt/100 gal	92.5 a	88.8 a	70.0 ab
8	Rely 280 Karmex 80WP LI700 Choice	3 qt/a 3 lb/a 0.5 % v/v 4 pt/100 gal	91.3 a	88.8 a	81.3 a

*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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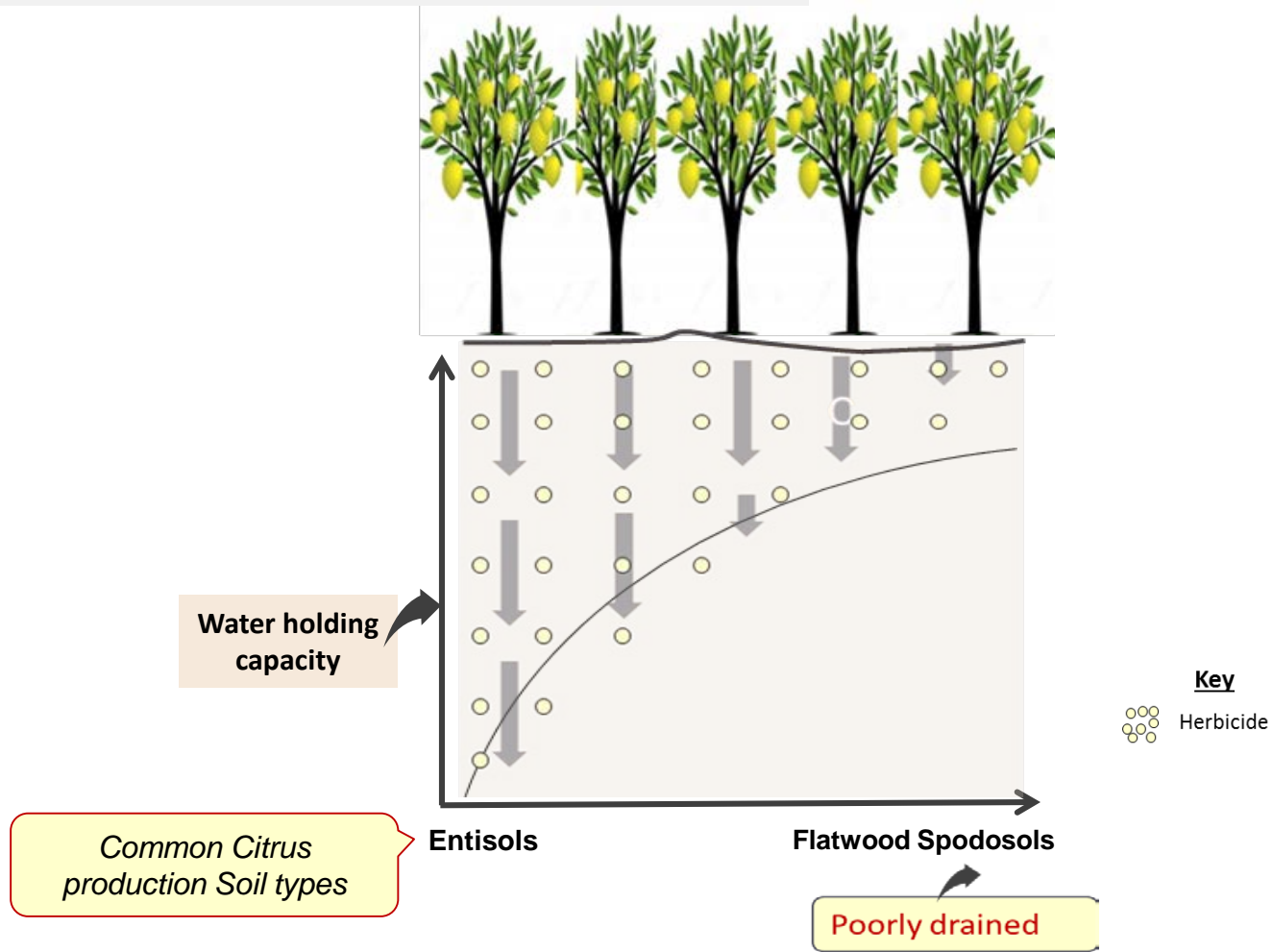
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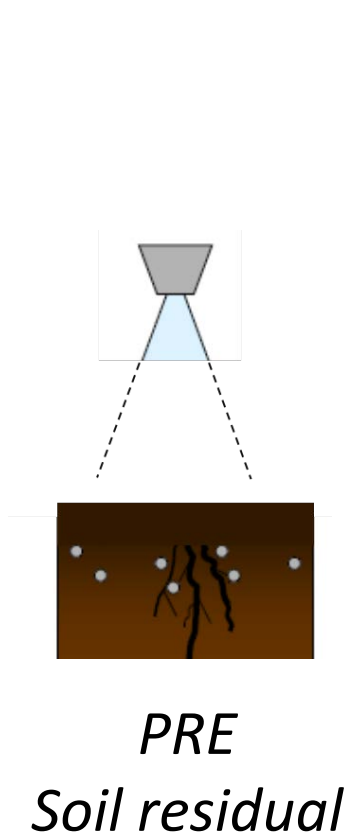
- **Soil and Weather**

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



<u>Active ingredient</u>	<u>K_{OC} mL/g</u>
Bromacil	32
Simazine	130
Diuron	480
Norflurazon	700
Indaziflam	<1000
Pendimethalin	17,200

Source 9th edition of the Herbicide Handbook (Senseman, 2007)
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

$$* 1 + 1 = 3$$

Herbicide synergy — Mixing herbicides in one application



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

Active ingredients	Herbicide products in the test mixture	Rate oz product/A	Weed control (%)	
			150 DAT	
Indaziflam	Alion	3	58 ^{*c}	
Indaziflam	Alion	5	89 ^b	
Flumioxazin	Chateau	6	18 ^d	
Flumioxazin	Chateau	8	20 ^d	
Indaziflam Flumioxazin	Alion Chateau	3 6	82 ^b	(65) +17
Indaziflam Flumioxazin	Alion Chateau	5 8	94 ^a	(91) +3
Control	n/a	n/a	5 ^e	

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.

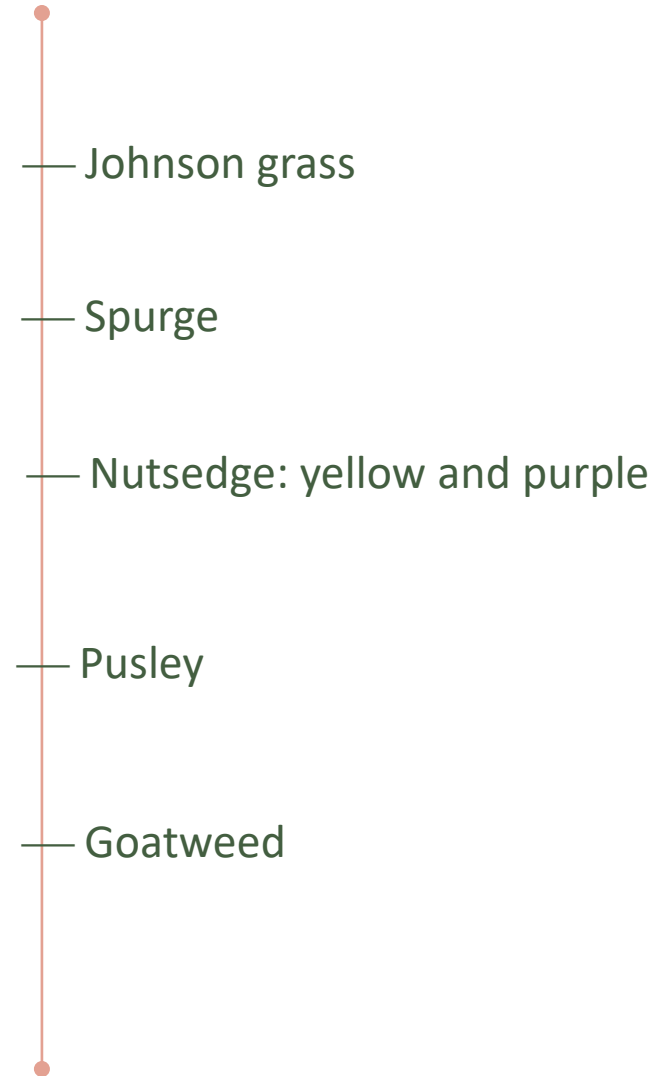
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Herbicide synergy — in citrus weed management



**Control
100 DAT**

**Indaziflam + Flumioxazin
100 DAT**



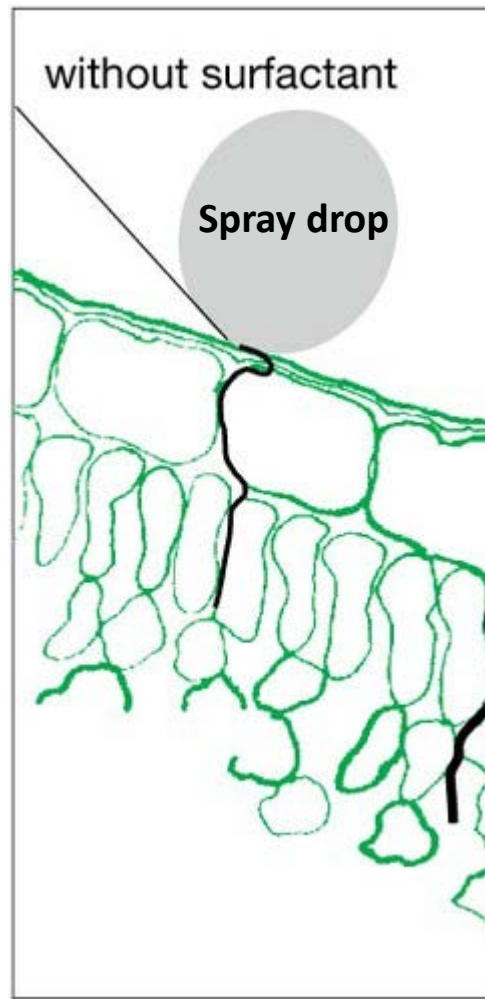
- **Managing problematic weeds**

- Selecting the right herbicide program

- Synergy of herbicides

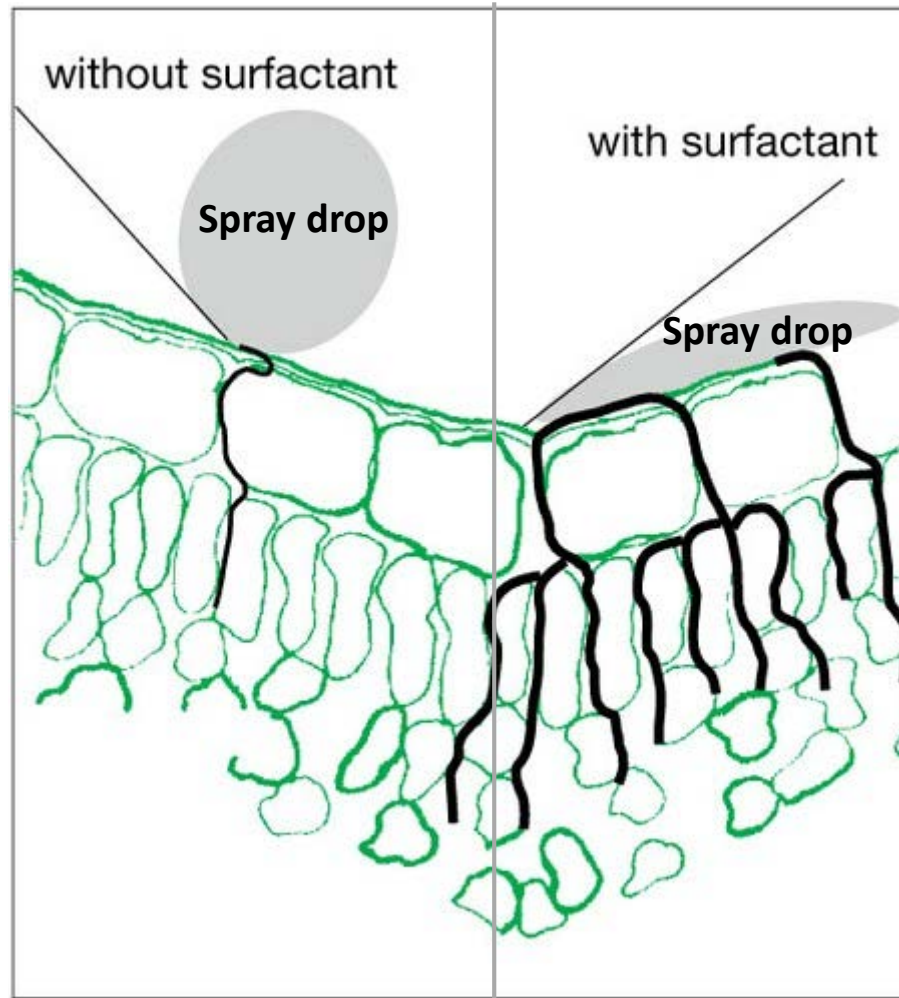
- **Selecting proper adjuvants**

Surfactants – indispensable ‘adjuvant/ingredient’ for POST emergent herbicides



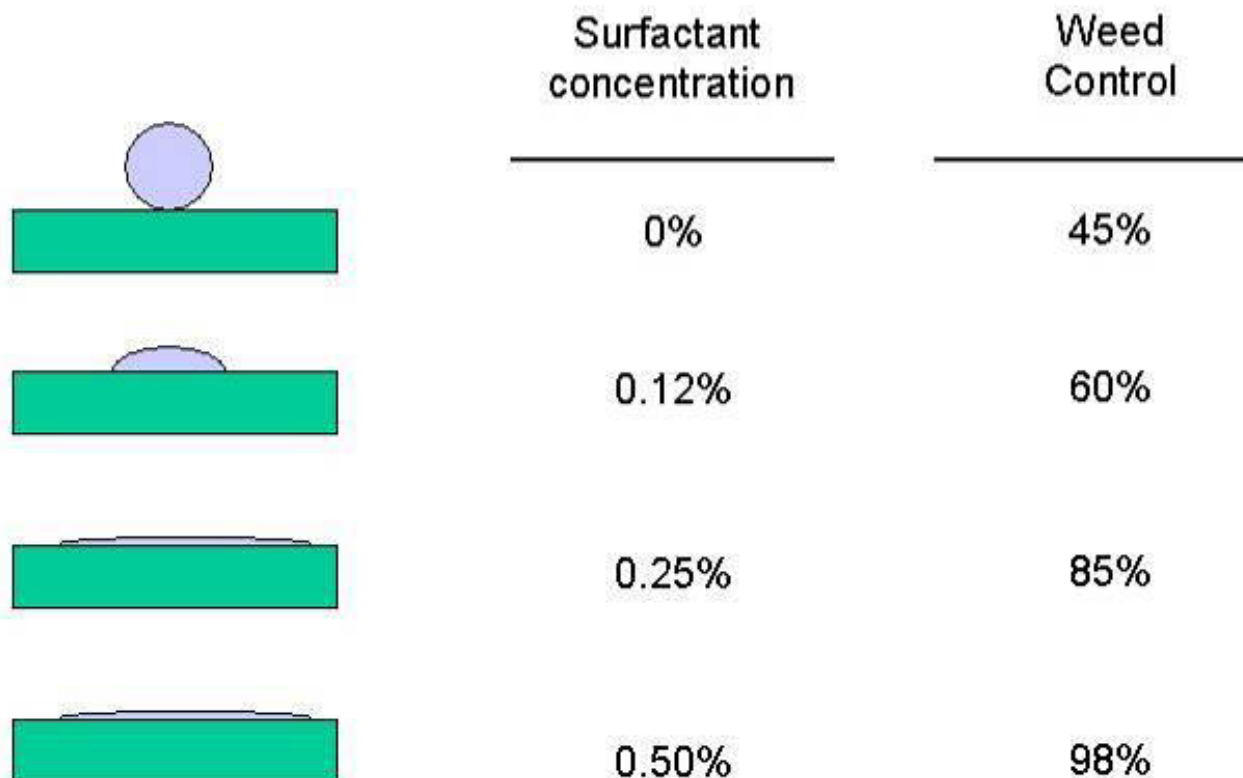
Surfactants reduce the ‘surface tension’ of spray droplets

Surfactants – indispensable ‘adjuvant/ingredient’ for POST emergent herbicides



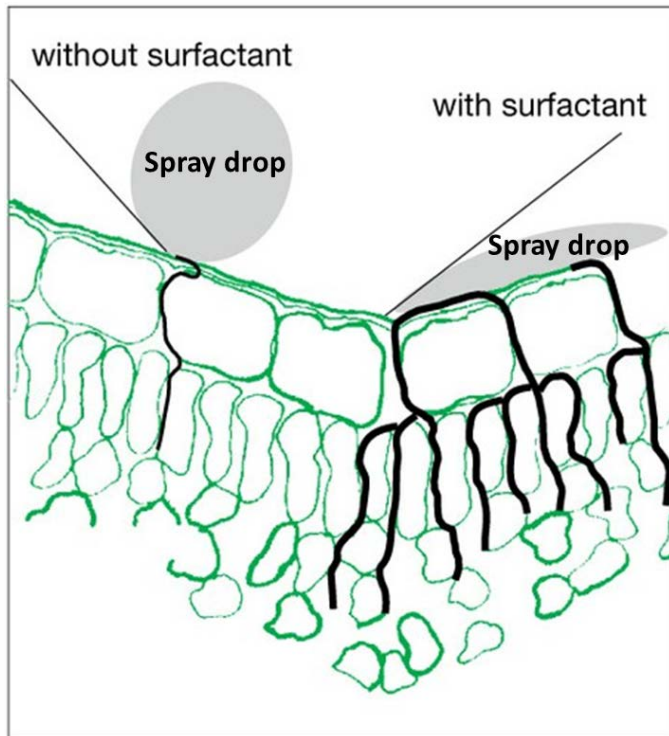
Spray Droplets with **low surface tension** are more likely to be retained and penetrated onto plant surfaces

Surfactant addition = better weed control for POST-emergent herbicides



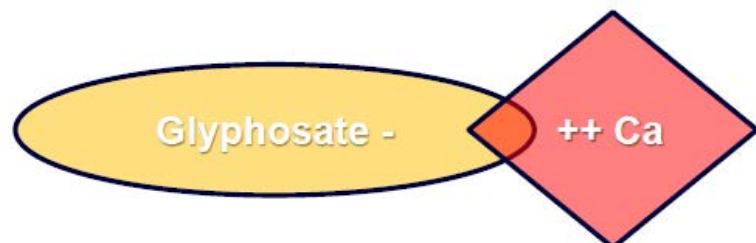
Source: Bob Hartzler, ISU Weed Science

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



Interaction b/w cations and the herbicide
reduce efficacy

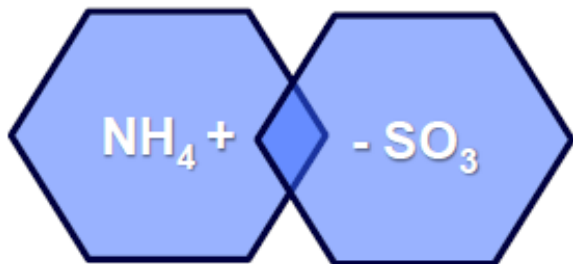
Glyphosate is **NOT absorbed** in this form

- Considered essential for herbicides like glyphosate

- Hard water: contains high concentrations of dissolved minerals

Example: Ca^{2+} , Mg^{2+} , Fe^{3+}

Water conditioner – important component of herbicide mix



- *Ammonium sulfate (AMS)*

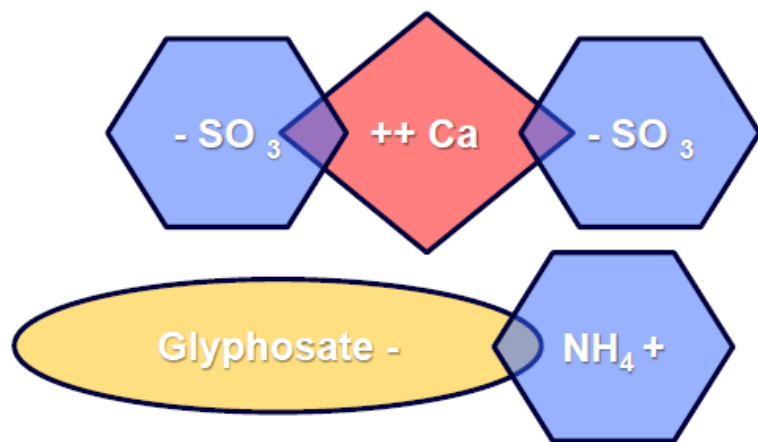
Water conditioner – important component of herbicide mix



AMS disassociates when added to water

■ ***Ammonium sulfate (AMS)***

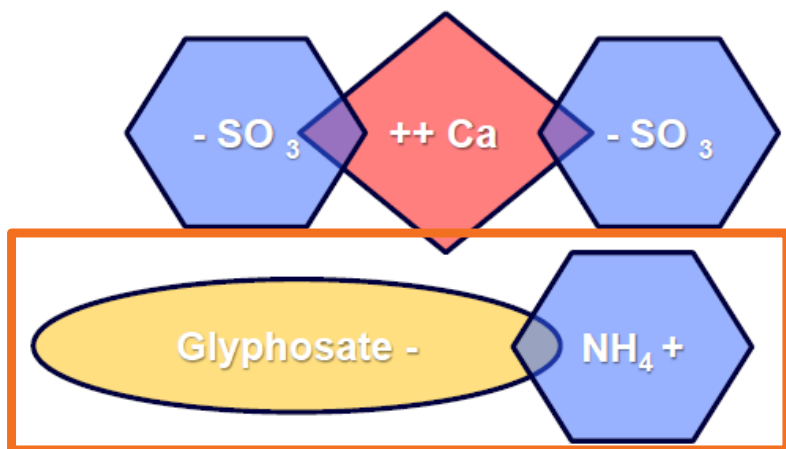
Water conditioner – important component of herbicide mix



Sulfate binds to cations
Ammonium binds to glyphosate

■ ***Ammonium sulfate (AMS)***

Water conditioner – important component of herbicide mix




Sulfate binds to cations
 Ammonium binds to glyphosate
 Glyphosate is **absorbed** in this form

- ***Ammonium sulfate (AMS)***

Application rate is 7 to 18 lb/100 gal

8 to 10 lbs/100 gal common rate

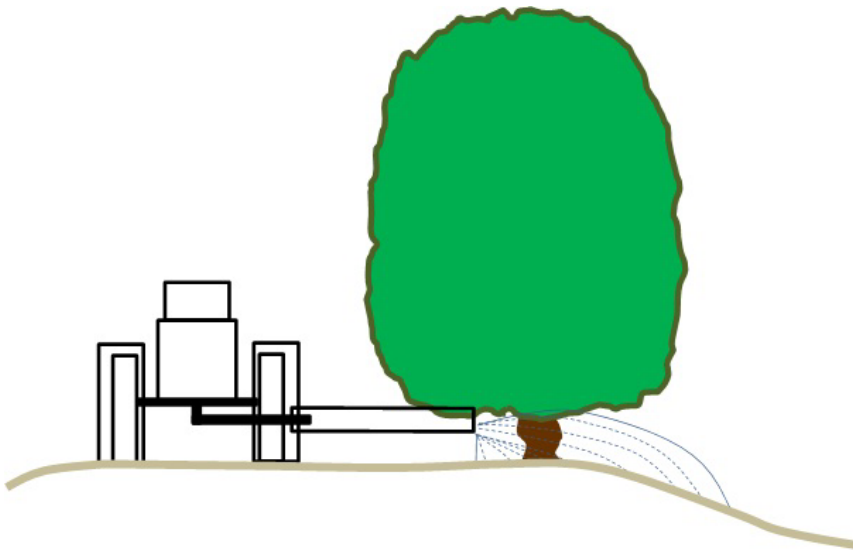
Must be added to tank before herbicide



Challenges

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

- 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



■ Herbicide phytotoxicity to citrus

- Diuron



Contact phytotoxicity

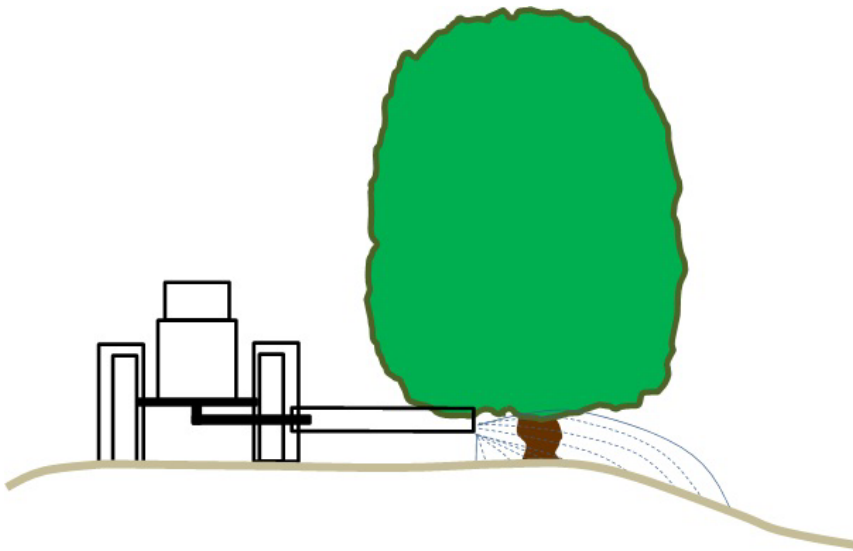
■ Herbicide phytotoxicity to citrus

- Indaziflam - Alion



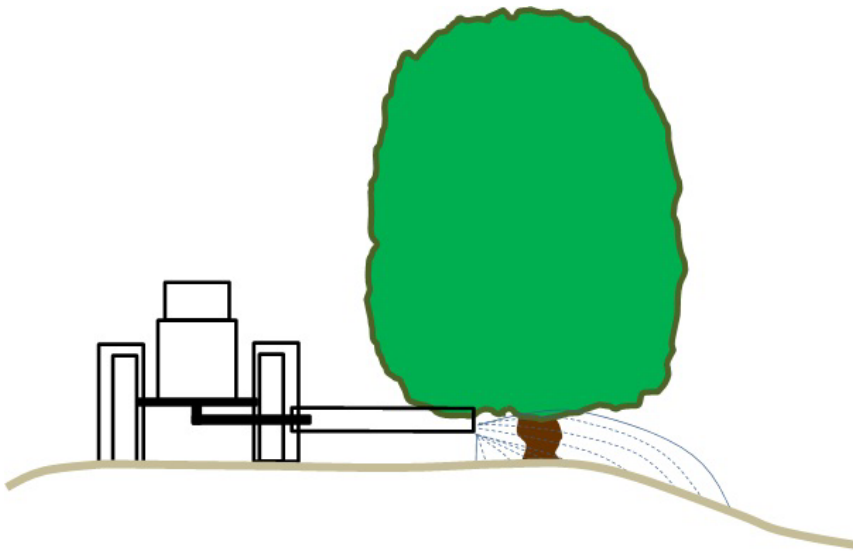
Contact phytotoxicity

■ Spray coverage



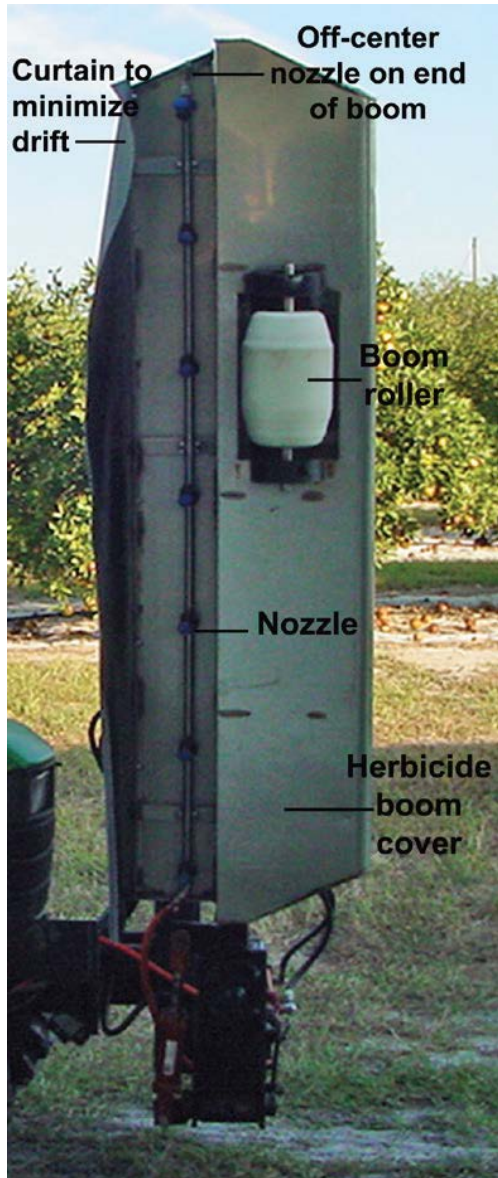
- Herbicide product
- Application speed
- Ground conditions
- Application pressure
- Boom height
- Angle of the OC nozzle

■ Spray coverage



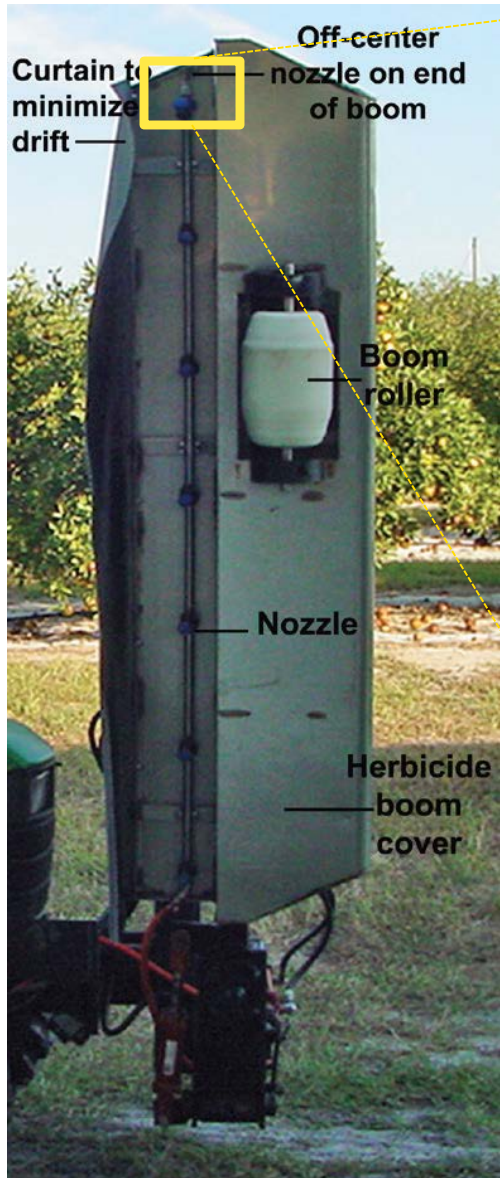
- Herbicide product
- Application speed
- Ground conditions
- Application pressure
- Boom height
- **Angle of the OC nozzle**

Herbicide boom spraying - OC nozzle angle



Information Credits: Steve Futch

Herbicide boom spraying - OC nozzle angle



Off center nozzle on the end of the boom



■ Reach of the spray is impacted by the OC nozzle angle

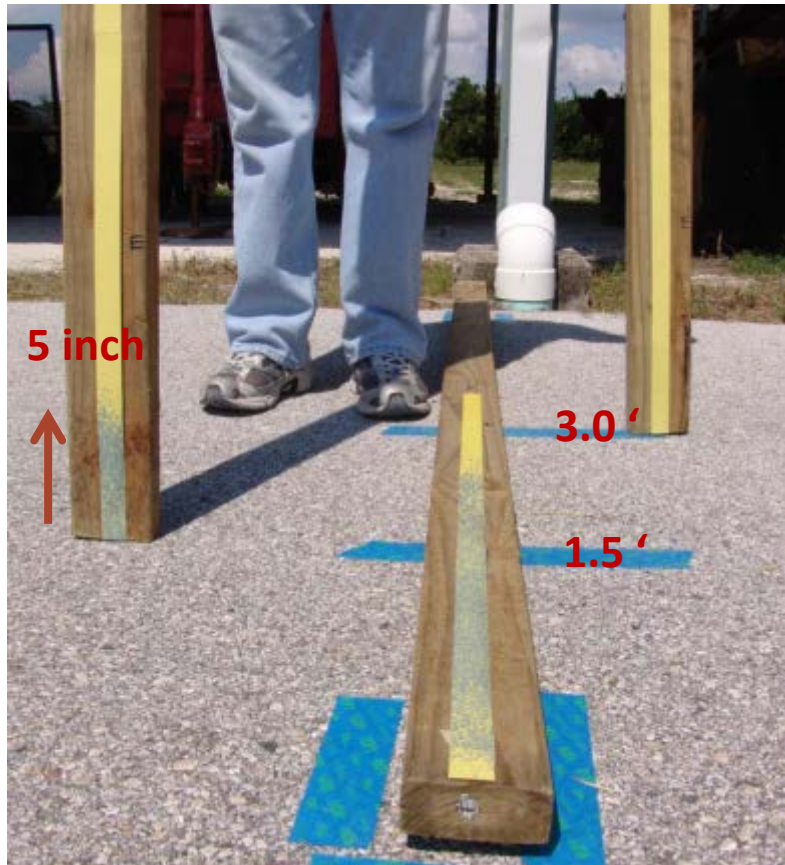
- Off Center (OC) Nozzle angle

- 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

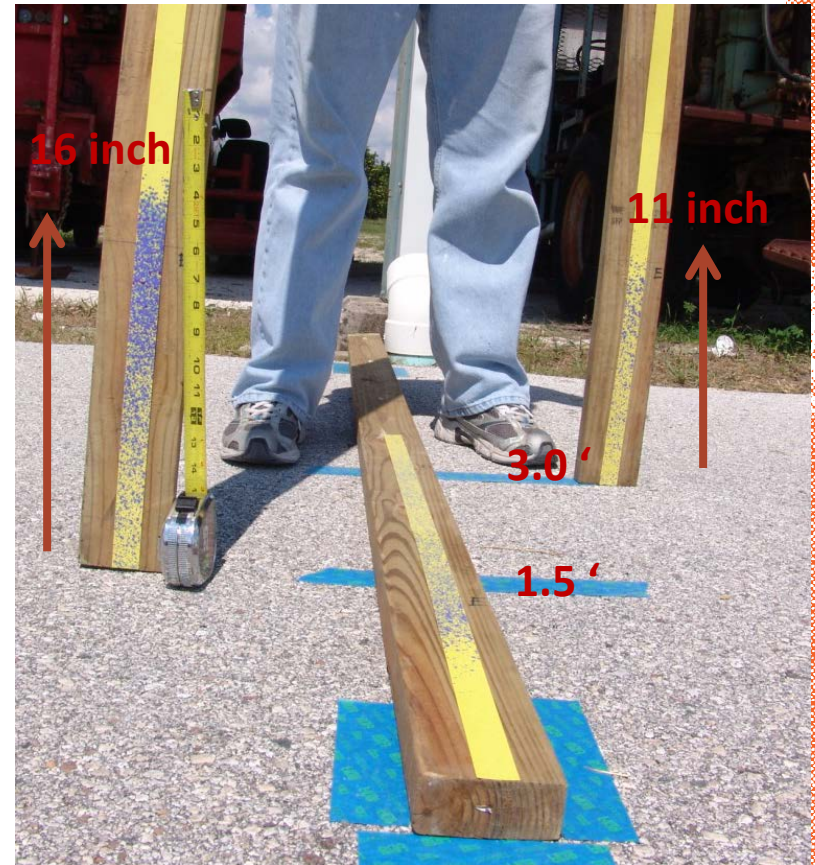
Ref: Steve Futch et al
Study conducted at the CREC, Lake Alfred

- Reach of the spray is impacted by the OC nozzle angle

OC nozzle at 10°

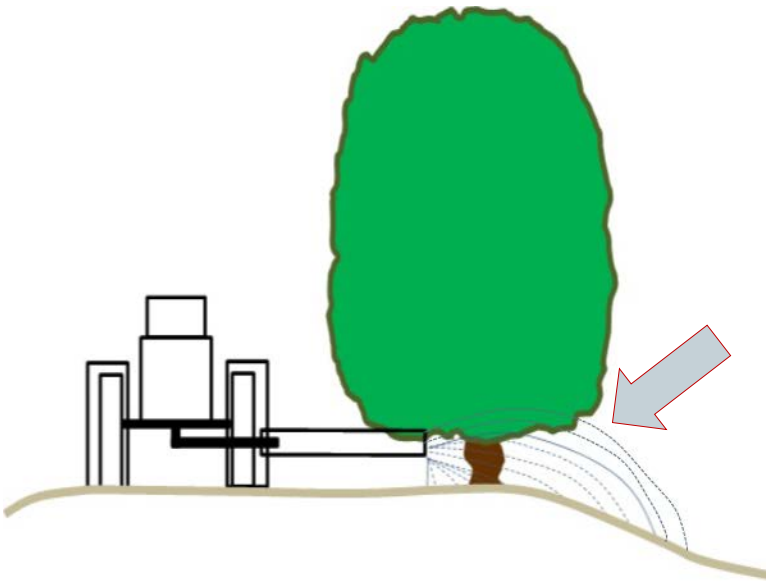


OC nozzle at 40°



Ref: Steve Futch et al
Study conducted at the CREC, Lake Alfred

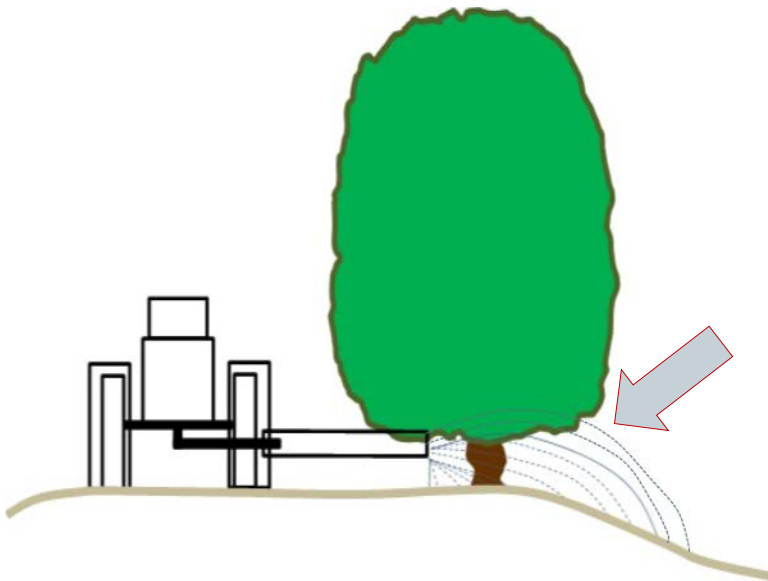
- Reach of the spray is impacted by the OC nozzle angle



Increased OC nozzle angle

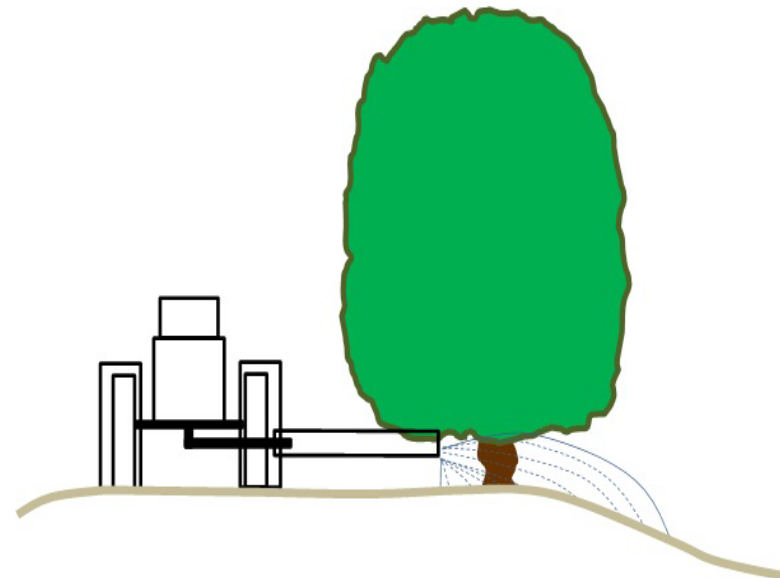
- spray droplets may drift into citrus foliage and fruits

■ Reach of the spray is impacted by the OC nozzle angle



Increased OC nozzle angle

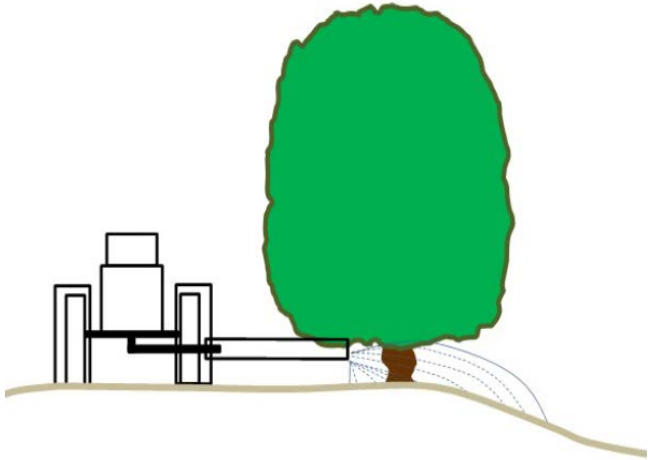
- spray droplets may drift into citrus foliage and fruits



Optimum OC nozzle angle

- adequate coverage under tree
- no herbicide injury

Apply accurately..



- **Maintain proper boom height/angle**
- **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**

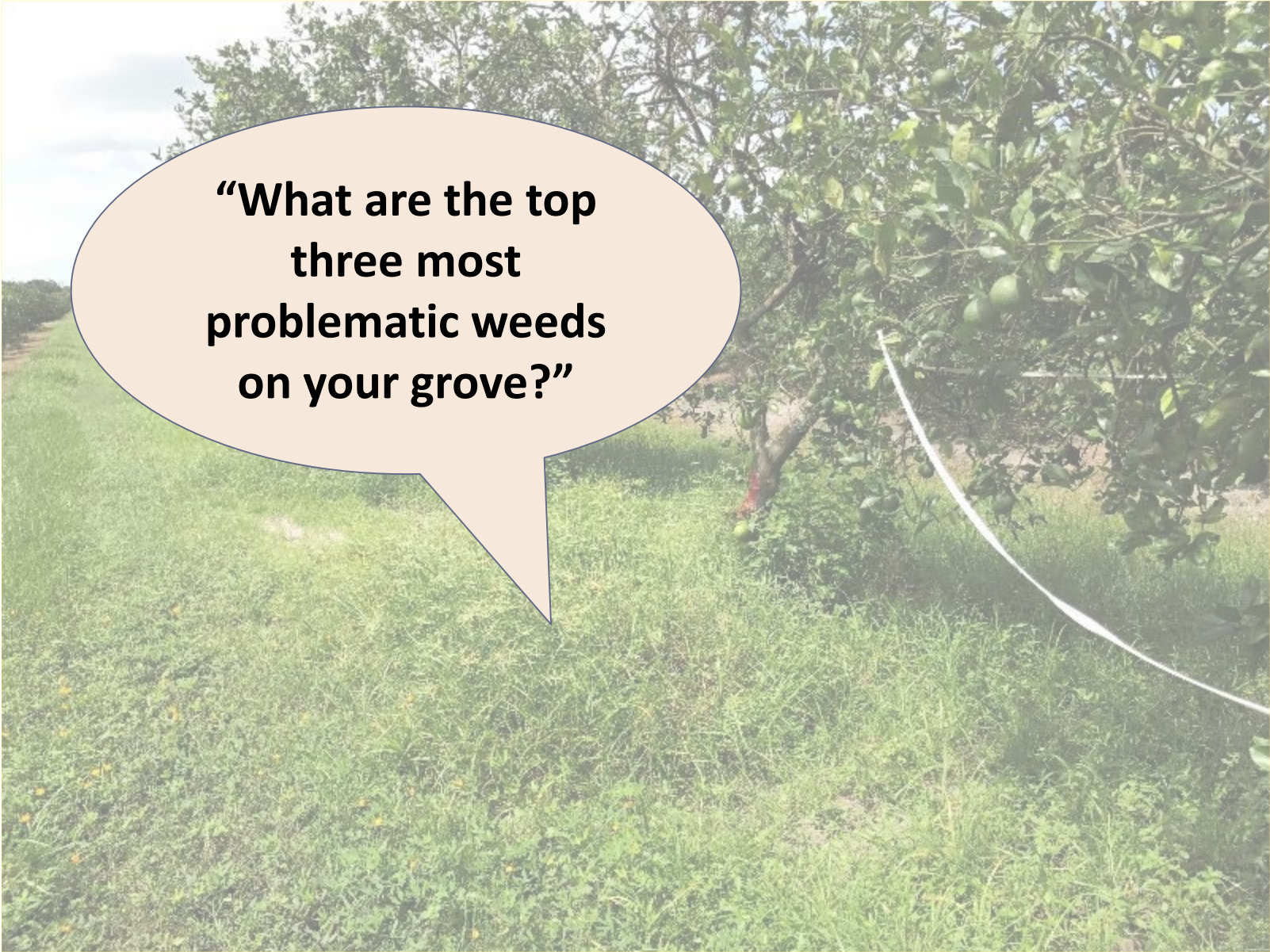
Citrus weed management: summary

Challenges


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

Opportunities

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- **Synergy b/w herbicides**
 - Mix compatibility
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 - 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?”

“Every weed on the planet”

Thank you...



SWFREC weed science team

Contact

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