Stop Weeds Before They Start

— *Pointers for Enhancing Pre-emergence Herbicide Performance in Citrus*

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Horticultural Sciences

Talk Contents…

PRE-emergence weed control in citrus

- Brief overview

Strategies for improving performance

- Enhancing efficacy
- Improving tree safety

- Summary

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PRE-emergence weed control in citrus

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Brief Overview - Weed management in citrus groves

- ‘Weed free’ rows or under trees

Weed managed citrus rows

Brief Overview - Weed management in citrus groves

- Major challenge is ‘longer-term’ suppression of weeds

Weeds come up quickly in the citrus rows

Brief Overview - Weed management in citrus groves

*Citrus grove soils are persistent '**seed banks**' for weeds*

Spanish needle

Brief Overview - Weed management in citrus groves

*Citrus grove soils are persistent '**seed banks**' for weeds*

Cutleaf evening-primrose

Brief Overview - Weed management in citrus groves

*Citrus grove soils are persistent '**seed banks**' for weeds*

Suppression of weed seed bank is important to prevent future weed problems!

Pennsylvania cudweed

Important strategy to prevent weed outbreak in your grove

Suppressing weed germination – *prevention is better than cure*

- *Preventing the weed germination from soil seed bank*
- *Key strategy for long-term citrus weed control*
- *Achieved by PRE-emergent herbicide programs*

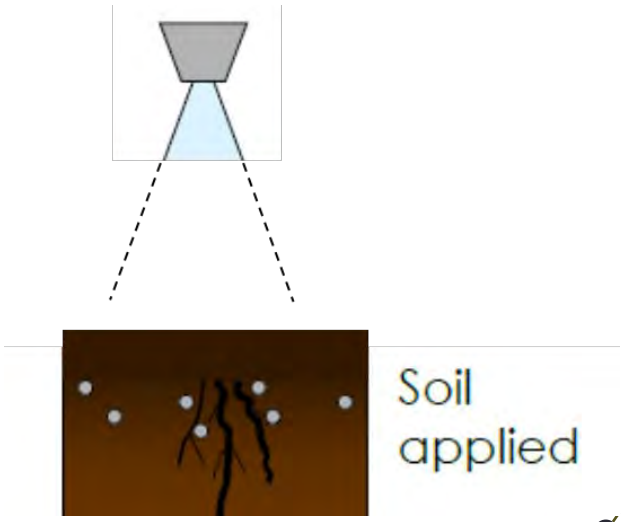
PRE-emergence herbicide programs

–for successful weed suppression in citrus

Major PRE-emergence herbicides used in FL citrus

- **Active ingredient** – E.g., Brand name(s)

PRE-emergent herbicides



- **Simazine –** Princep, Caliber 90, etc.
- **Diuron –** Direx, Karmex, etc.
- **Norflurazon -** Solicam
- **Pendimethalin -** Prowl
- **Indaziflam -** Alion
- **Flumioxazin -** Chateau

Consult **Florida Citrus Production Guide: Weed Chapter** for a complete listing of herbicides used in citrus and their rate suggestions

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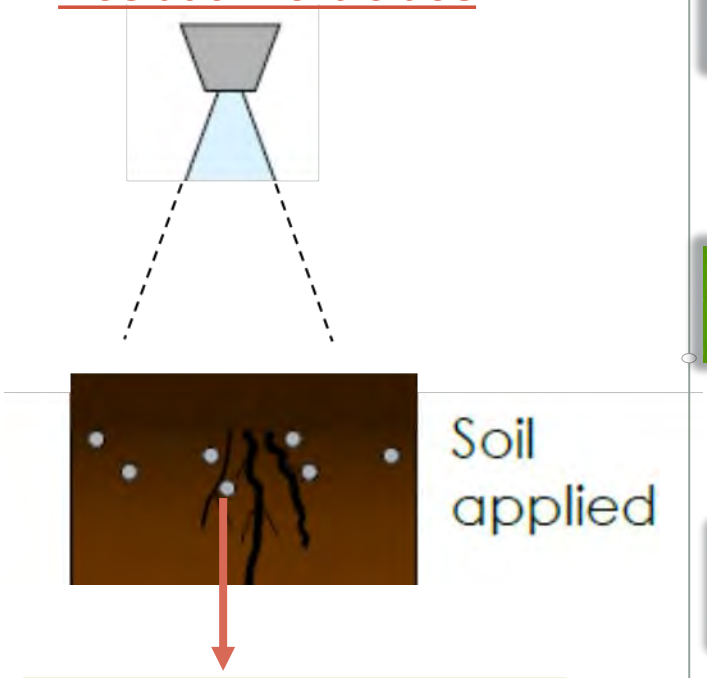
Getting the best out of PRE-emergents

–tips for improving efficacy

PRE-emergent OR Residual herbicides



Suppress weed seeds in soil

Apply residual herbicides to bare soil to ensure maximum soil incorporation

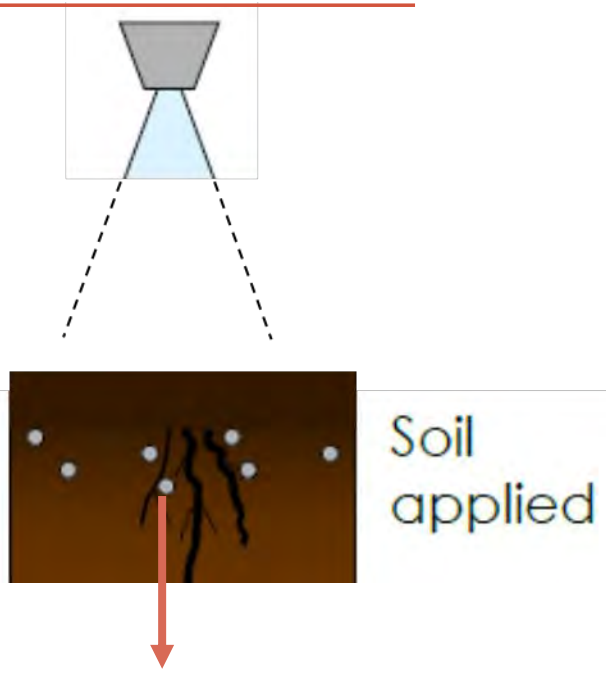
Turn-on irrigation to activate the residual herbicides in soil

Include a compatible POST-emergent tank-mix partner if there is minimal weed growth

Getting the best out of PRE-emergents

–tips for improving efficacy

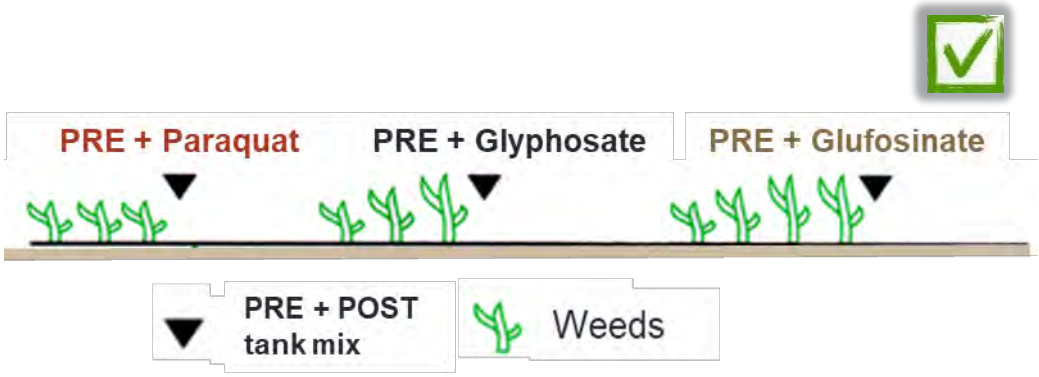
PRE-emergent OR Residual herbicides



Suppress weed seeds in soil

- **Apply** residual herbicides to bare soil to ensure maximum soil incorporation
- **Turn-on** irrigation to activate the residual herbicides in soil
- **Include** a compatible POST-emergent tank-mix partner if there is minimal weed growth

Rotate POST tank-mixing partners for **PRE-emergent** herbicides



Scouting and understanding the weed pressure
helps for PRE-emergent herbicide selection

Spanish needle

Goatweed

Ragweed
Parthenium

PRE/ POST	Active ingredient	MOA	E.g., Products	Estimated effectiveness rating
PRE	Indaziflam	29	Alion	Good
PRE	Flumioxazin	14	Chateau	Good
PRE	Diuron	5	Karmex	Fair-Good
PRE	Simazine	5	Princep	Fair-Good

- *Not a complete listing.*
- *For crop specific herbicide rates and complete herbicide listing consult UF IFAS citrus production handbook . Read the product label carefully before application.*
- *Estimated effectiveness was developed from research data, herbicide labels, and the observation from research and extension faculty*

<u>Scouting</u> and understanding the weed pressure
helps for PRE-emergent herbicide selection

Bermuda grass

Guinea grass

PRE/ POST	Active ingredient	MOA	E.g., Products	Estimated effectiveness rating
PRE	Indaziflam	29	Alion	Good
PRE	Flumioxazin	14	Chateau	Fair-Good
PRE	Pendimethalin	3	Prowl	Good

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<u>Scouting</u> and understanding the weed pressure helps for PRE-emergent herbicide selection

Dayflower

- Succulent annual
- Reproduce via seeds/stem

PRE/ POST	Active ingredient(s)	MOA	E.g., Products	Estimated effectiveness rating
PRE	Norflurazon	29	Solicam	Good
PRE	Diuron	5	Karmex	Good

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Consider using strategies to get the best out of PRE-emergent herbicides

Tank mixing PRE-emergent herbicides with different modes of action

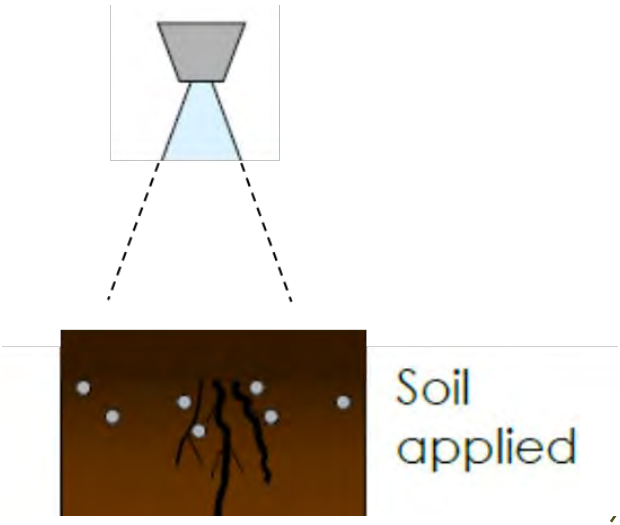
- Increase the spectrum of weed control
- Reduce tolerance/resistance issues

- **Need to ensure:**
  - Mixing compatibility
  - Absence of any antagonistic effects

Herbicide synergy – ‘**Tank Mixing**’ pre-emergent herbicides

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

Pre-emergent herbicides



Simazine – Princep, Caliber 90, etc.

Diuron – Direx, Karmex, etc.

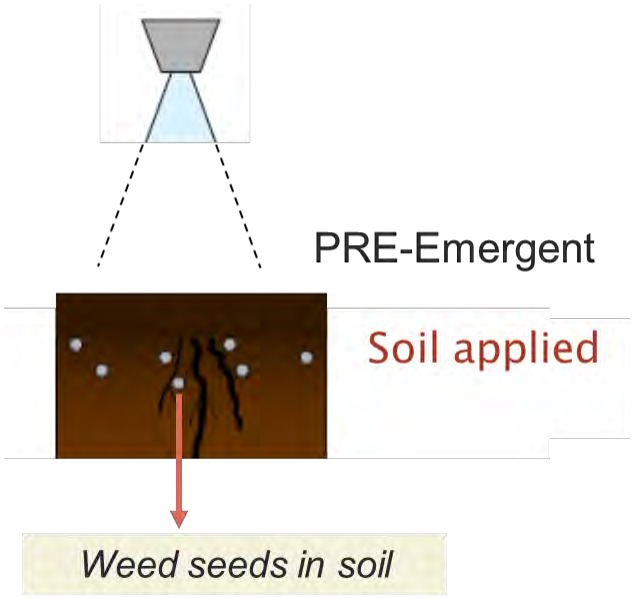
Norflurazon - Solicam

Pendimethalin - Prowl

Indaziflam - Alion

Flumioxazin - Chateau

Tank mixing PRE-emergent herbicides with different modes of action



Mode of action group (WSSA)	*Active Ingredient(s)*	*Products*
14	Flumioxazin	Chateau
29	Indaziflam	Alion

Tank mixing PRE-emergent herbicides - Treatments

Active Ingredient(s)	*Products*	*Product Rate (per acre)*
Flumioxazin	**Chateau**	**6 oz.**
Flumioxazin	**Chateau**	**8 oz.**
Indaziflam	**Alion**	**3 oz.**
Indaziflam	**Alion**	**5 oz.**
Flumioxazin + Indaziflam	**Chateau + Alion**	**6 oz. + 3 oz.**
Flumioxazin + Indaziflam	**Chateau + Alion**	**8 oz. + 5 oz.**
Control	**--**	**--**

- RCBD (4 reps)
- *All treatments included glyphosate (Roundup Custom) at 88oz product per acre & adjuvants, Quest (0.25%v/v) and Induce (0.5% v/v) in the tank mix*

Trial location: Immokalee, FL
2-year study

- **Data from Year 1 is presented**
- **Trend was similar in Year 2**

Tank mixing PRE-emergent herbicides - Results

5+ Months

Active Ingredient(s)	*Products*	*Product Rate (per acre)*
Flumioxazin	**Chateau**	**6 oz.**
Flumioxazin	**Chateau**	**8 oz.**
Indaziflam	**Alion**	**3 oz.**
Indaziflam	**Alion**	**5 oz.**
Flumioxazin + Indaziflam	**Chateau + Alion**	**6 oz. + 3 oz.**
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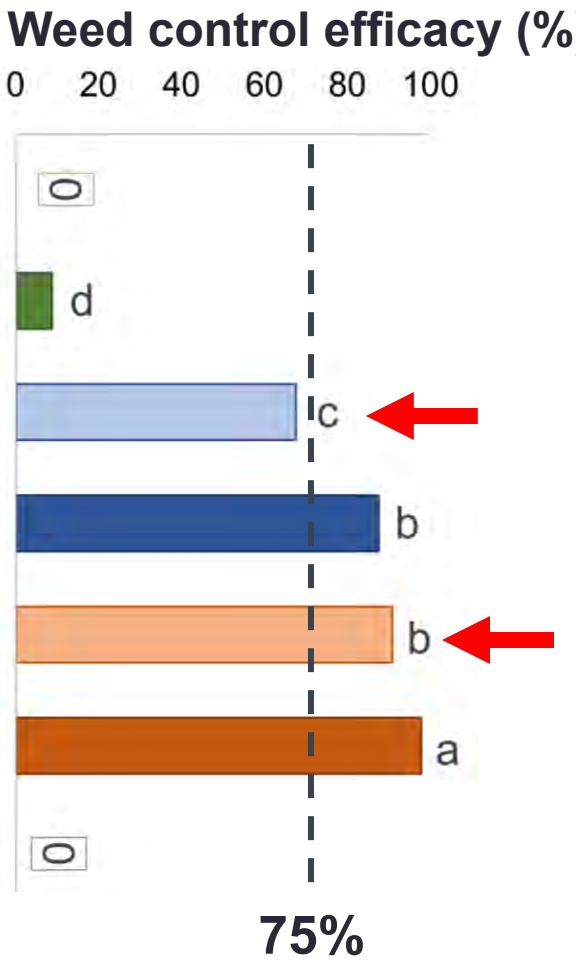
Control	**--**	**--**



- Replication (n) = 4
- Mean comparison: Fisher's LSD (α = 0.05)
- $p \leq 0.0001$

Tank mixing PRE-emergent herbicides – Presence of synergy?

5+ Months

Active Ingredient(s)	*Products*	*Product Rate (per acre)*	
Flumioxazin	**Chateau**	**6 oz.**	
Flumioxazin	**Chateau**	**8 oz.**	
Indaziflam	**Alion**	**3 oz.**	
Indaziflam	**Alion**	**5 oz.**	
Flumioxazin + Indaziflam	**Chateau + Alion**	**6 oz. + 3 oz.**	**24 (+)**
Flumioxazin + Indaziflam	**Chateau + Alion**	**8 oz. + 5 oz.**	**9 (+)**
Control	**--**	**--**	

Synergistic response calculation

Colby's method

Expected response, E = X + Y – (XY/100)

X – % weed control by herbicide Indaziflam alone

Y – % weed control by herbicide Flumioxain alone

If observed response > E the combination is synergetic (+)

- Replication (n) = 4
- Mean comparison: Fisher's LSD (α = 0.05)
- $p \leq 0.0001$

Colby, S. R. Calculating Synergistic and Antagonistic Responses of Herbicide Combinations. Weeds 15, 20–22 (1967).

Tank mixing PRE-emergent herbicides with different modes of action

Control

2 Months

Indaziflam + Flumioxazin

2 Months

Tank mixing PRE-emergent herbicides with different modes of action

Indaziflam + Flumioxazin

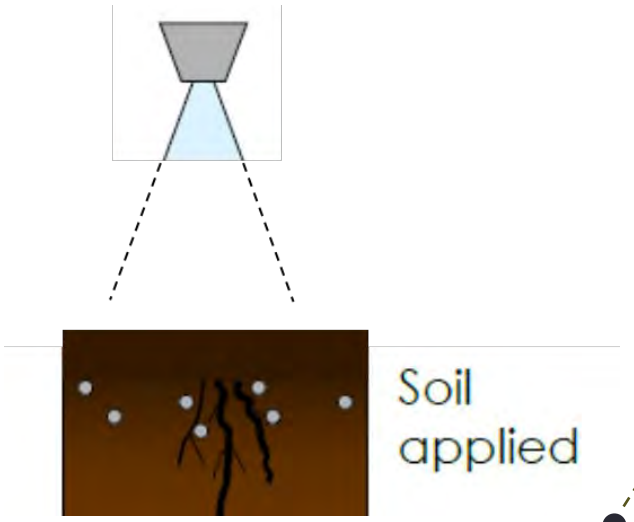
5 months after application

Study location: Immokalee

Major PRE-emergence herbicides used in FL citrus

- **Active ingredient** – E.g., Brand name(s)

PRE-emergent herbicides



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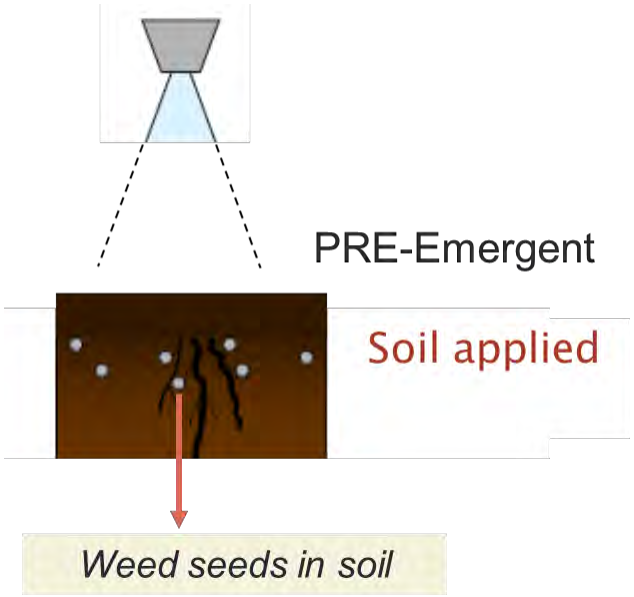
Consult **Florida Citrus Production Guide: Weed Chapter** for a complete listing of herbicides used in citrus and their rate suggestions

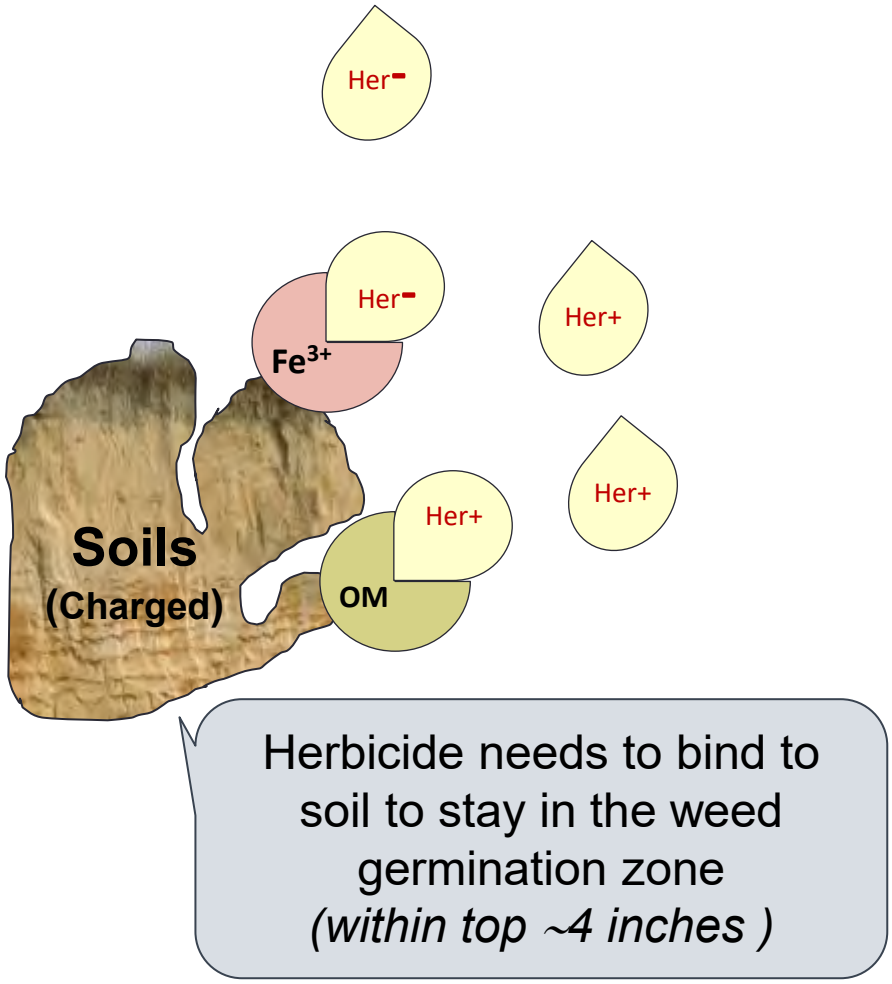
Tank mixing PRE-emergent herbicides with different modes of action



Mode of action group (WSSA)	*Active Ingredient(s)*	*Products*
2	Rimsulfuron	Pruvin
29	Indaziflam	Alion

Active Ingredient(s)	*Products*	*Product Rate (per acre)*
Rimsulfuron + Indaziflam	Pruvin + Alion	2 oz. + 3.5 oz.
Rimsulfuron + Indaziflam	Pruvin + Alion	4 oz. + 3.5 oz.

PRE-emergent herbicide retention in soil – important for weed suppression



PRE-Herbicide

Challenges with Florida soils

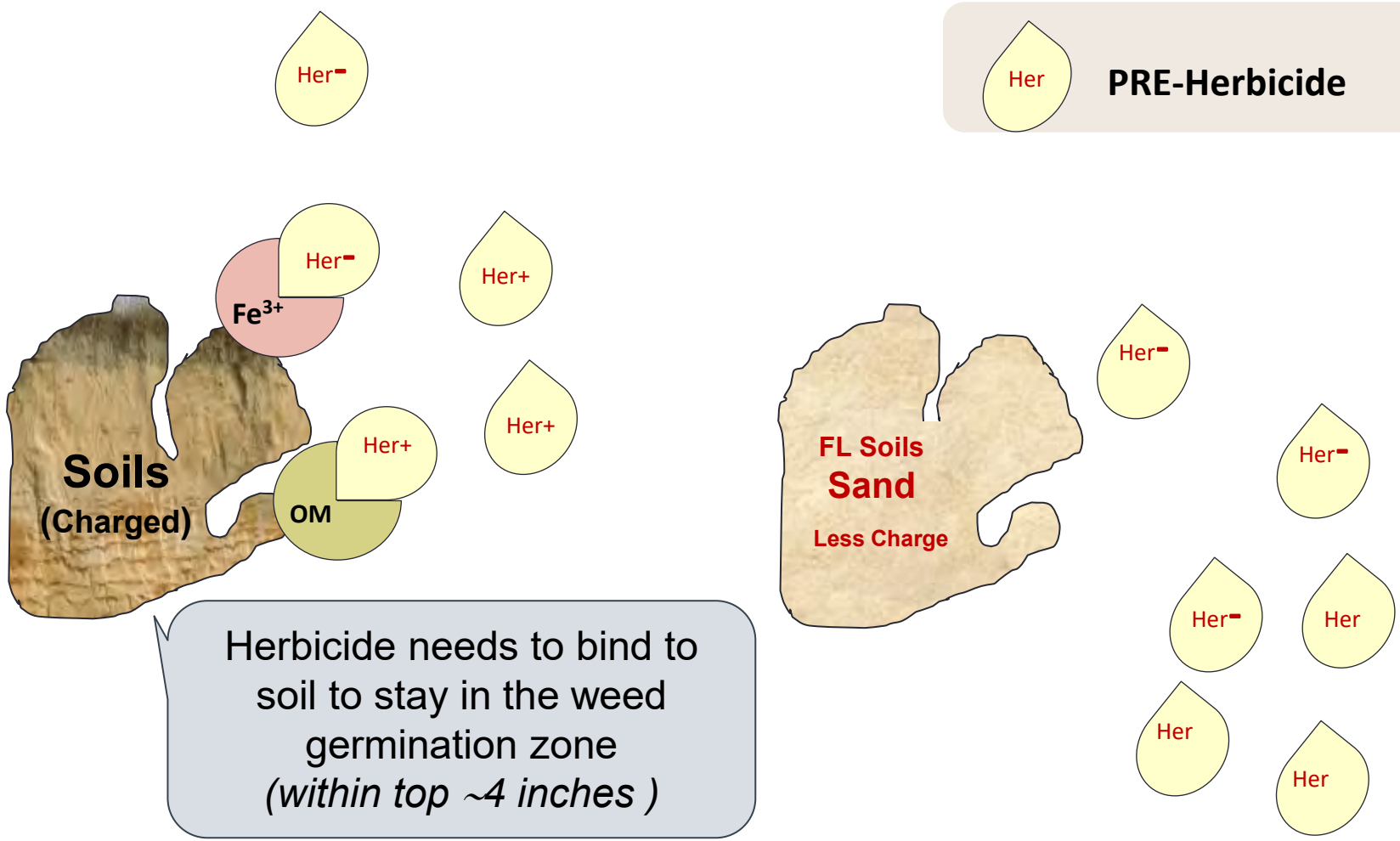
Typical Crop production soils

SW Florida
Crop production soils

Sand **>95%**
Clay **<1%**
Organic matter **<1%**

Basically, beach sand !

PRE-emergent herbicide retention in soil – important for weed suppression



Consider using strategies to get the best out of PRE-emergent herbicides

Utilizing adjuvants for improving the efficacy of **PRE-emergent** herbicides

- Herbicide sticker or Deposition agent
- E.g., Polyvinyl polymers
- E.g trade name - Hydrovant *f*A
- Tank-mixed with PRE-emergent herbicide **Flumioxazin** (Trade name: Chateau)

Trial location: Immokalee, FL

Utilizing adjuvants for improving the efficacy of **PRE-emergent** herbicides

- Herbicide sticker or Deposition agent
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- E.g trade name,. Hydrovant *f*A
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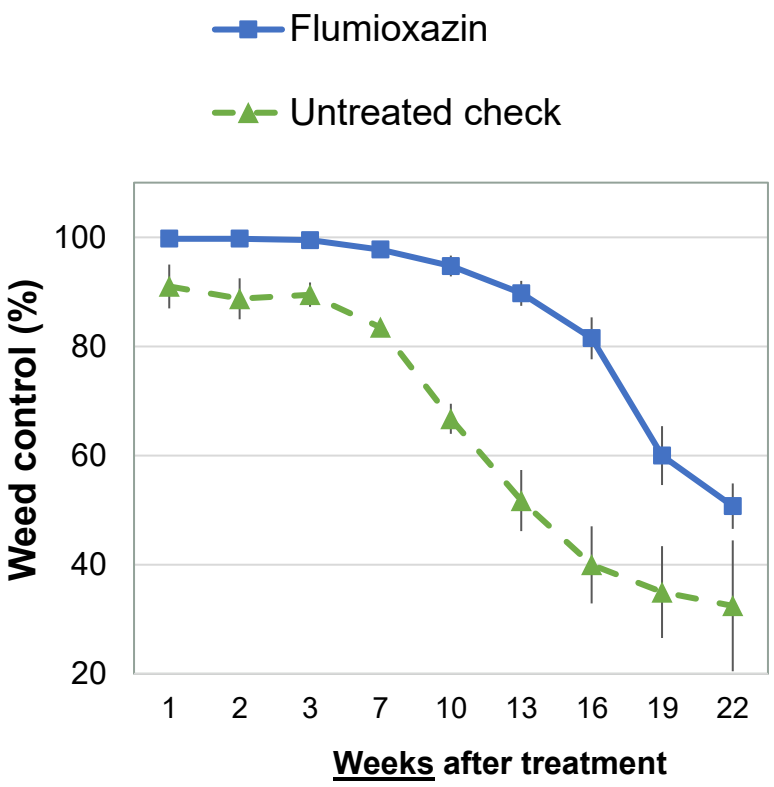

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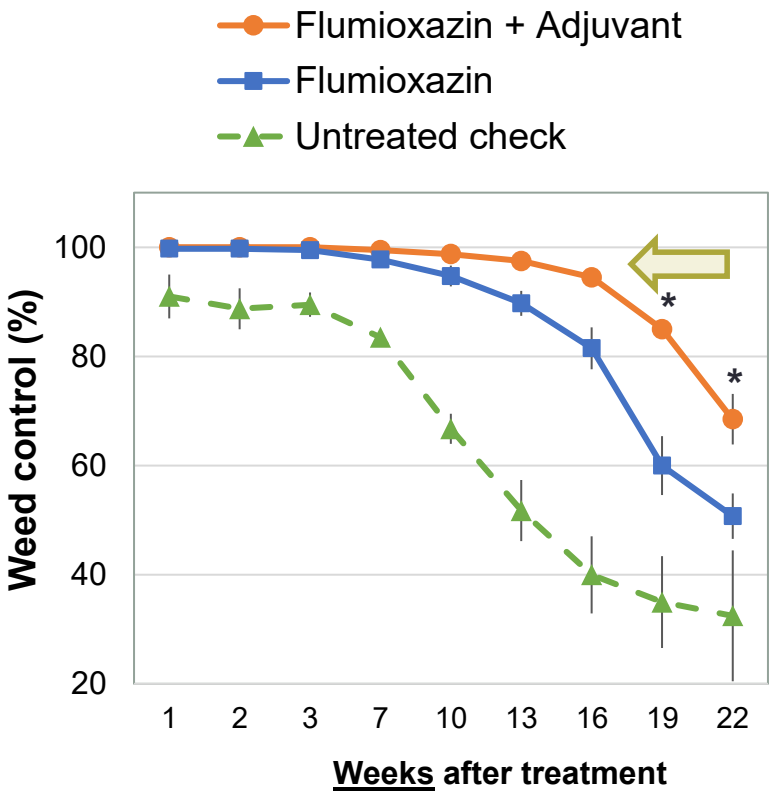
- * Significant difference ($p \leq 0.05$)

Utilizing adjuvants for improving the efficacy of **PRE-emergent** herbicides

- Herbicide sticker or Deposition agent
- Polyvinyl polymer
- E.g trade name,. Hydrovant *f*A
- Tank-mixed with PRE-emergent herbicide **Flumioxazin** (Trade name: Chateau)



Chateau 8 oz/acre + Hydrovant *f*A 0.1% v/v

- Replication (n) = 4
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Utilizing adjuvants for improving the efficacy of **PRE-emergent** herbicides

Flumioxazin + adjuvant
~3 months

Untreated control
~3 months

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Chemical weed control – *tree-safety matters*

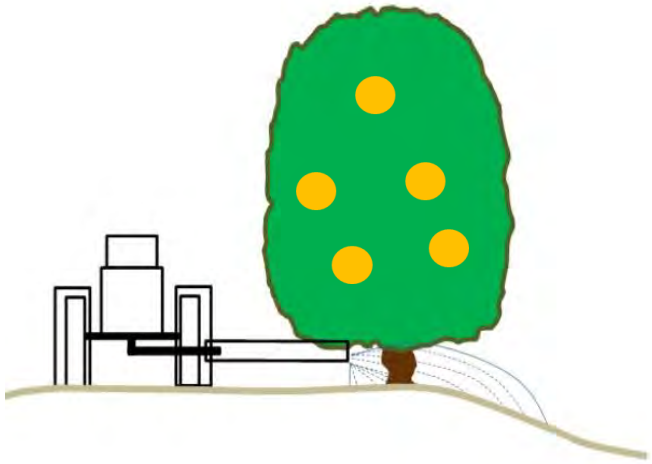
- Avoid spray contact with tree foliage

Diuron (Karmex)

Chemical weed control – *tree-safety matters*

- Avoid spray contact with tree foliage

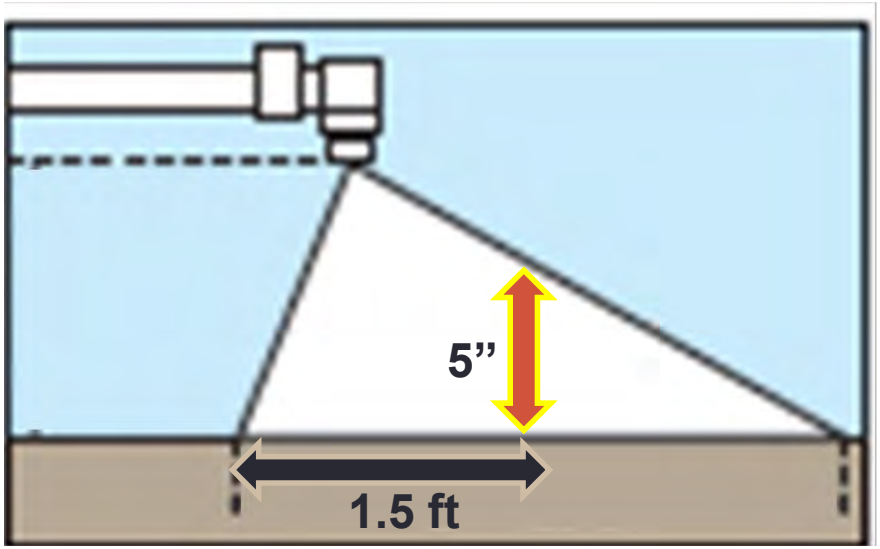
Chemical weed control – *considerations*



- **Avoid spray contact with fruits and tree foliage**

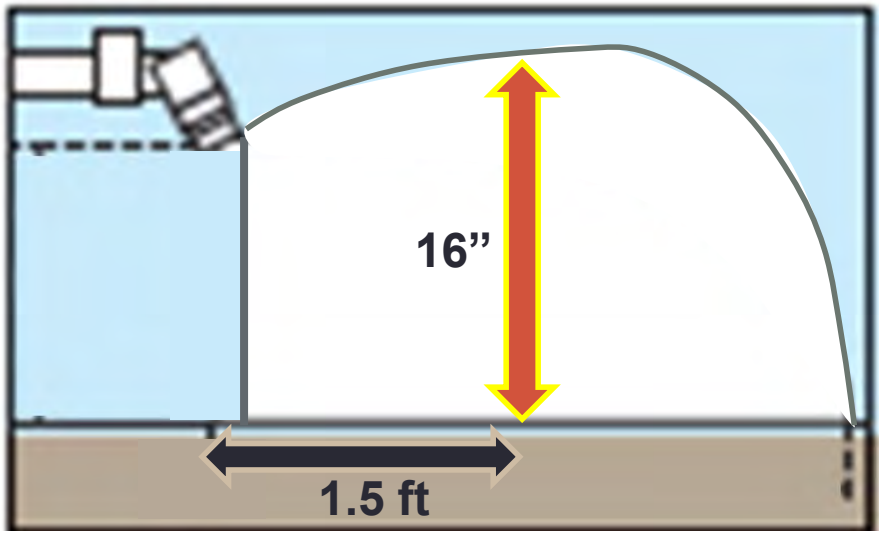
  - Deliver the herbicide to target
  - Right spray-boom height
  - **Optimal OC nozzle angle**

0-10 ^{0}



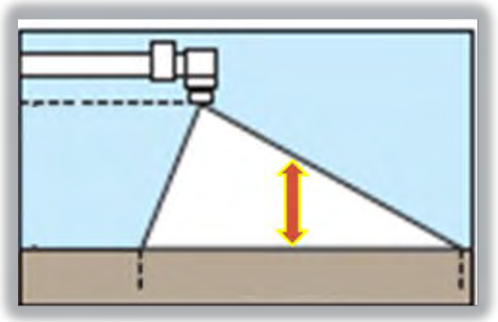
Nozzle body angle as measured from the nozzle housing

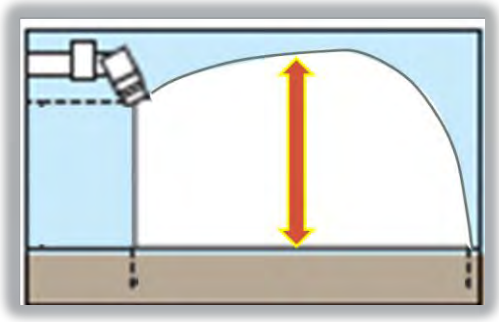
40 ^{0}



Source: Steve Futch et al. 2012

Reach of the spray is impacted by the OC nozzle angle





- Off Center (OC) Nozzle angle

- Higher the spray, and farther the spray beyond the boom

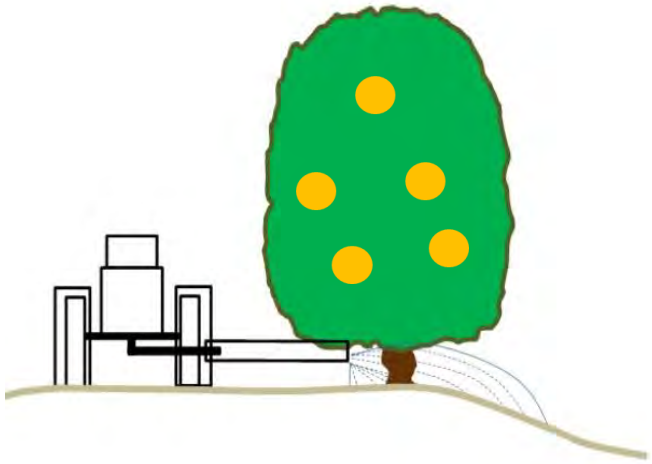
Increases the chances for foliage and fruit phytotoxicity in citrus

- **Maintain optimal OC nozzle angle**
- **During fruit bearing stage**

***Example*:** *less than 40 degrees*

Reduce the spray drift into canopy and fruits

Chemical weed control – *considerations*



- **Avoid spray contact with fruits and tree foliage**
  - Deliver the herbicide to target
  - Right spray-boom height
  - Optimal OC nozzle angle
  - **Maintain optimal spray pressure**

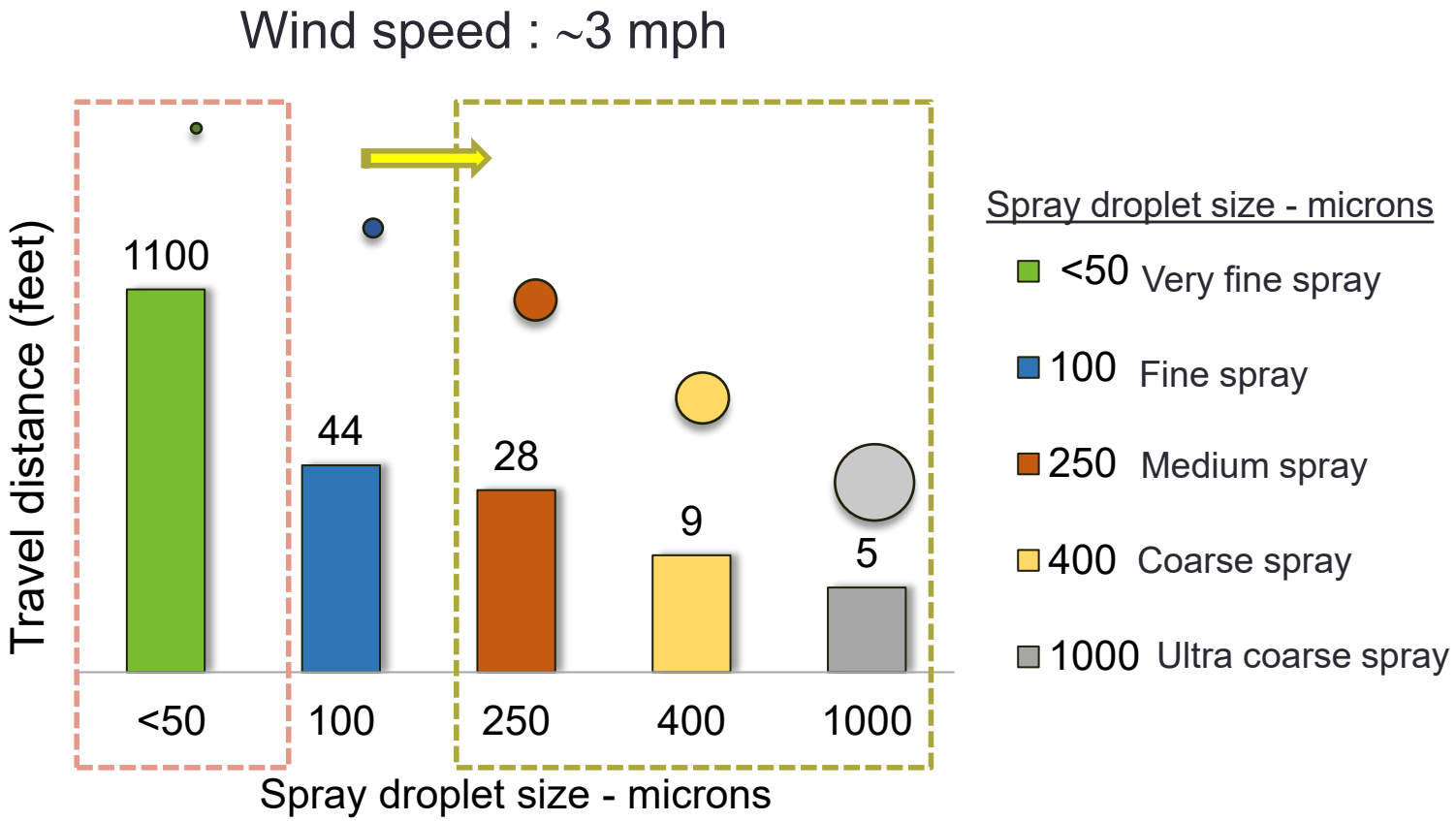
Chemical weed control – *considerations*

- **Maintain optimal spray pressure**

  Example*: *<u>20-30 psi</u>

  Reduce the production of smaller spray droplets

Lateral travel distance herbicide spray droplets travel

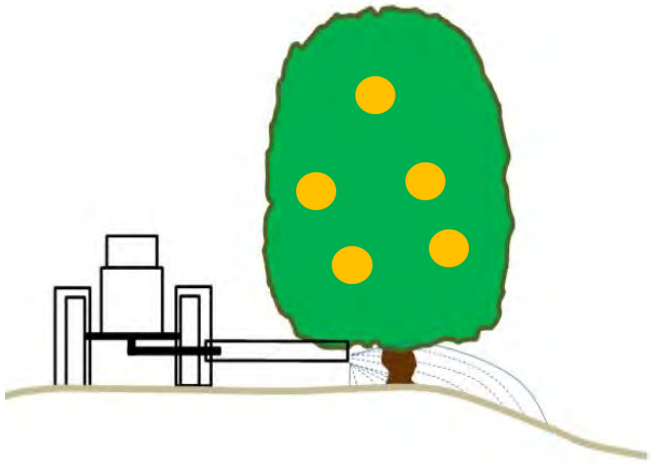


Smaller spray droplets can travel up to 1000 feet

Low spray pressure reduce the production of smaller spray droplets

Modified from Dexter, 1993, NDSU extension

Chemical weed control – *considerations*



- **Avoid spray contact with fruits and tree foliage**
  - Deliver the herbicide to target
  - Right spray-boom height
  - Optimal OC nozzle angle
  - Maintain optimal spray pressure

- **Consider rotating PRE-emergence herbicides**

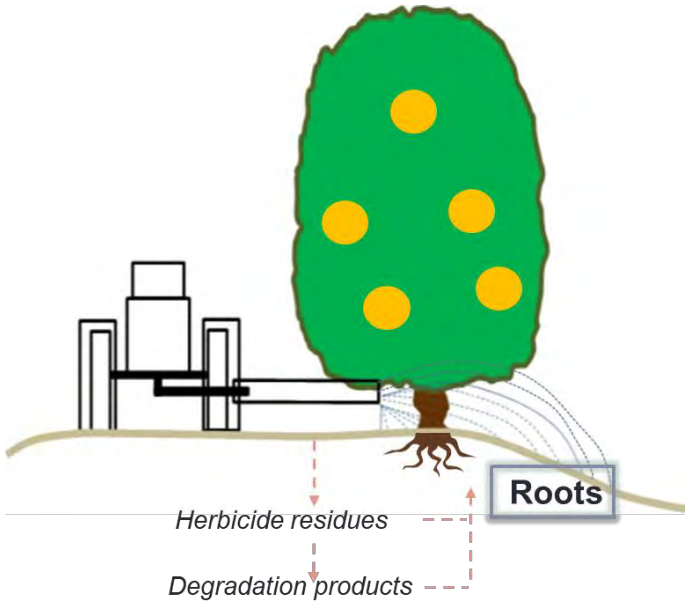
Rotate PRE-emergence herbicides

PRE-emergence herbicides

Active Ingredient	Example Product(s)	Mode of action grouping
Flumioxazi	Chateau	14 (E)
Norflurazo	Solicam	12 (F1)
Rimsulfuro	Pruvin	2 (B)

- Helps improve the spectrum of weeds managed
- Helps reduce the possibility of residue build-up & leaching into root zone

Chemical weed control – *tree-safety matters*



Follow the **max allowed annual amount** in the label accurately

- **Root uptake of herbicides**
  - High level of residues

***Diuron* root uptake injury**

Photo Credits: Mongi Zekri

Impacts of PRE herbicides on citrus root health

Rhizotron studies to evaluate the impact of herbicide programs on root development in citrus

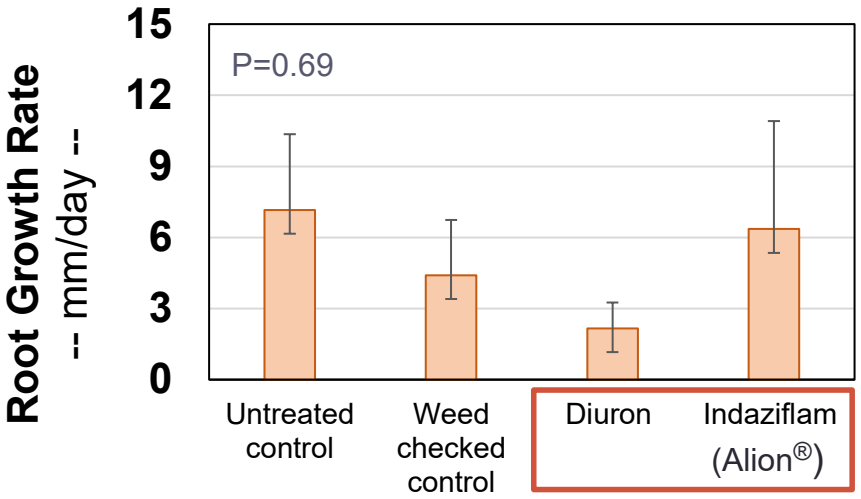
Tested pre-emergence herbicide programs did not significantly affected the roots

- *Observation period of ~3-months*

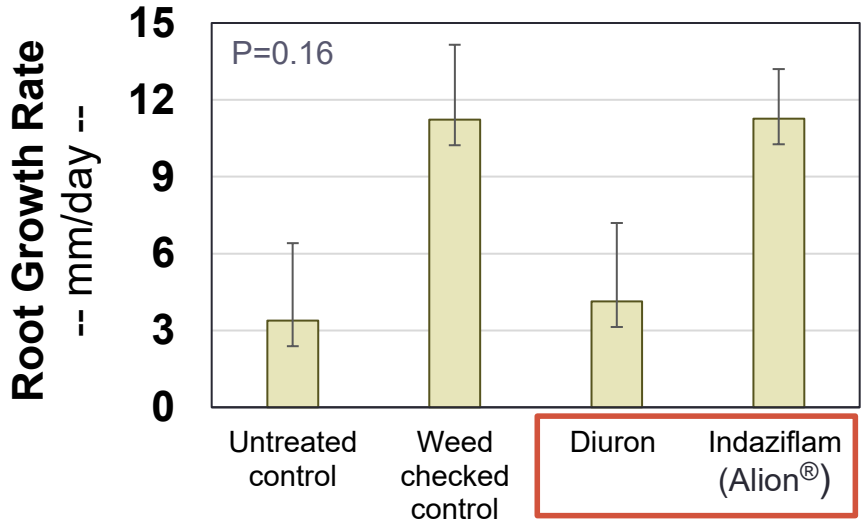
Number of reps: 4
Error bars: ±SD
Tukey's HSD (α 0.05)

Hamlin orange
Study Location 1
Similar trend in Location 2

– No significant differences between the treatments



Valencia orange
Study Location 1
Similar trend in Location 2



Source: Nirmal Timilsina (MS project)

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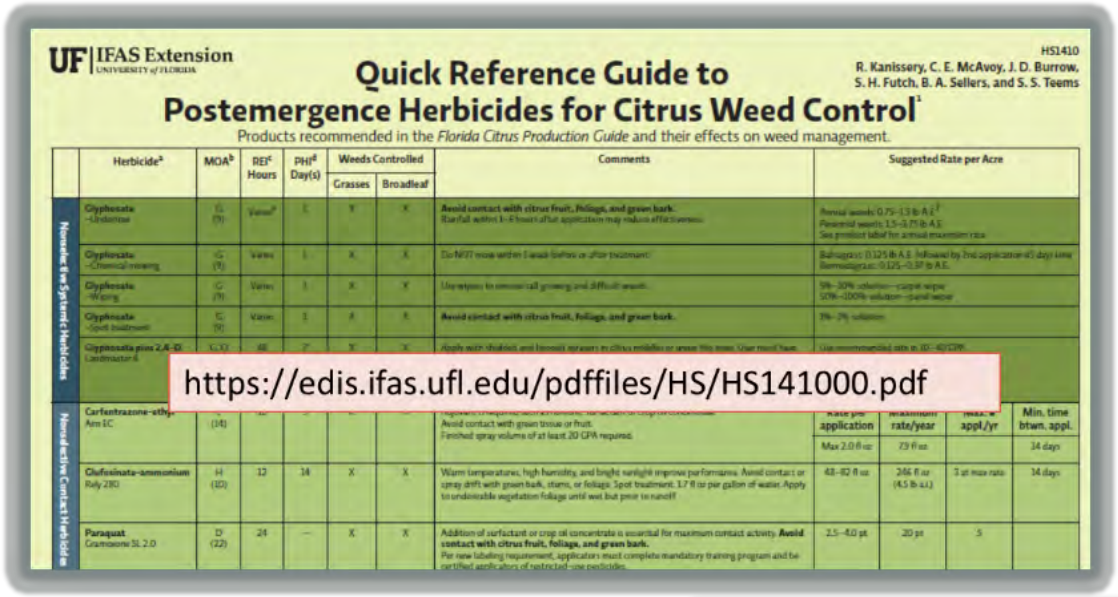
Summary: strategies for improving PRE-emergence performance

- **Enhancing efficacy**
  - *Timely application*
  - *Product selection*
  - *Tank mixing PRE-herbicides*
  - *Utilizing adjuvants (soil binding agents)*
- **Improving crop safety**
  - *Avoid spray contact with foliage/fruits*
  - *Rotate herbicide products*

‘Collecting measurements from herbicide treated plots’

– Nirmal Timilsina, MS graduate student

Herbicide quick ref tables/guides available:



UF IFAS Extension UNIVERSITY of FLORIDA

HS1410

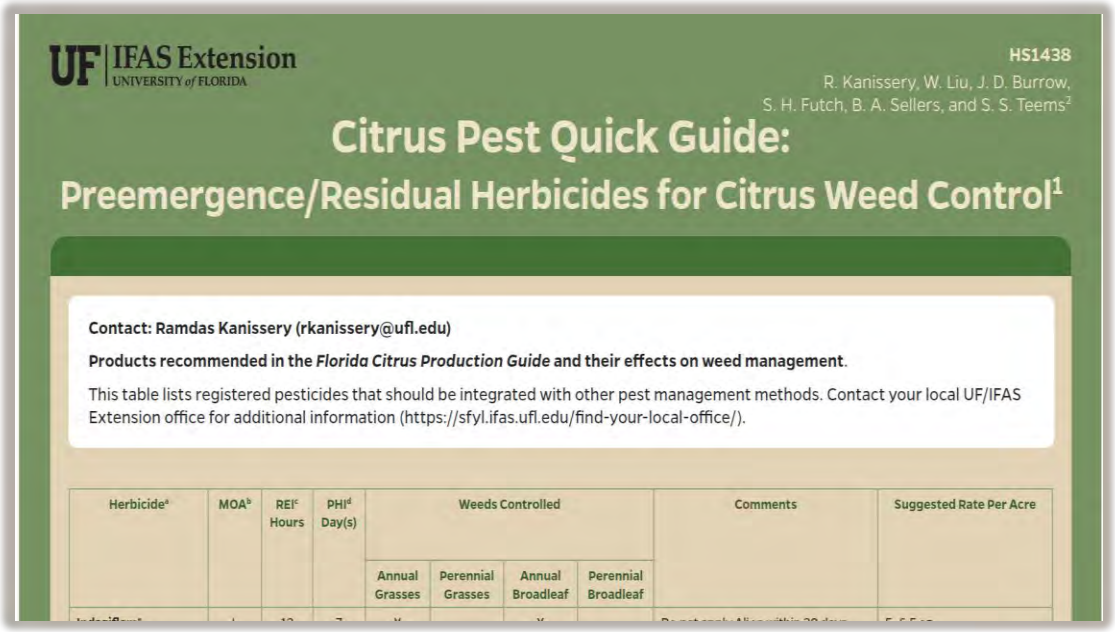
R. Kanissery, C. E. McAvoy, J. D. Burrow, S. H. Futch, B. A. Sellers, and S. S. Teems

Quick Reference Guide to Postemergence Herbicides for Citrus Weed Control[1]

Products recommended in the *Florida Citrus Production Guide* and their effects on weed management.

	Herbicide[a]	MOA[b]	REI[c] Hours	PHI[d] Day(s)	Weeds Controlled: Grasses	Weeds Controlled: Broadleaf	Comments	Suggested Rate per Acre
Nonselective Systemic Herbicides	Glyphosate -Undiluted	G (9)	Varies[e]	1	X	X	**Avoid contact with citrus fruit, foliage, and green bark.** Rainfall within 1–6 hours after application may reduce effectiveness.	Annual weeds: 0.75–1.5 lb A.E.[f] Perennial weeds: 1.5–3.75 lb A.E. See product label for annual maximum rate
	Glyphosate -Chemical mowing	G (9)	Varies	1	X	X	Do NOT mow within 1 week before or after treatment.	Bahiagrass: 0.125 lb A.E. followed by 2nd application 21 days later. Bermudagrass: 0.125–0.37 lb A.E.
	Glyphosate -Wiping	G (9)	Varies	1	X	X	Use wipers to remove tall growing and difficult weeds.	5%–30% solution—carpet wiper. 50%–100% solution—glove wiper
	Glyphosate -Spot treatment	G (9)	Varies	1	X	X	**Avoid contact with citrus fruit, foliage, and green bark.**	1%–2% solution
	Glyphosate plus 2,4-D Landmaster II	G, O (9, 4)	48	7	X	X	Apply with shielded and hooded sprayers to citrus orchards or areas this zone. Use most toxic	Use recommended rate in ID: 40 GPA
Nonselective Contact Herbicides	Carfentrazone-ethyl Aim EC	H (14)	12	1	X	X	Avoid contact with green tissue or fruit. Finished spray volume of at least 20 GPA required.	Max 2.0 fl oz	73 fl oz		14 days
	Glufosinate-ammonium Rely 280	H (10)	12	14	X	X	Warm temperatures, high humidity, and bright sunlight improve performance. Avoid contact or spray drift with green bark, stems, or foliage. Spot treatment: 1.7 fl oz per gallon of water. Apply to undesirable vegetation foliage until wet but prior to runoff.	48–82 fl oz	246 fl oz (4.5 lb a.i.)	3 at max rate	14 days
	Paraquat Gramoxone SL 2.0	D (22)	24	—	X	X	Addition of surfactant or crop oil concentrate is essential for maximum contact activity. **Avoid contact with citrus fruit, foliage, and green bark.** Per new labeling requirement, applicators must complete mandatory training program and be certified applicators of restricted-use pesticides.	2.5–4.0 pt	20 pt	5	

https://edis.ifas.ufl.edu/pdffiles/HS/HS141000.pdf



UF IFAS Extension UNIVERSITY of FLORIDA

HS1438

R. Kanissery, W. Liu, J. D. Burrow, S. H. Futch, B. A. Sellers, and S. S. Teems[2]

Citrus Pest Quick Guide:

Preemergence/Residual Herbicides for Citrus Weed Control[1]

Contact: Ramdas Kanissery (rkanissery@ufl.edu)

Products recommended in the *Florida Citrus Production Guide* and their effects on weed management.

This table lists registered pesticides that should be integrated with other pest management methods. Contact your local UF/IFAS Extension office for additional information (https://sfyl.ifas.ufl.edu/find-your-local-office/).

Herbicide[a]	MOA[b]	REI[c] Hours	PHI[d] Day(s)	Weeds Controlled: Annual Grasses	Weeds Controlled: Perennial Grasses	Weeds Controlled: Annual Broadleaf	Weeds Controlled: Perennial Broadleaf	Comments	Suggested Rate Per Acre
Indaziflam[1]									

Thank you…

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- Craig Campbell
- Tim Willis
- and more..

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