IST #31893 New Technology for Commercial Crop Production (IX)

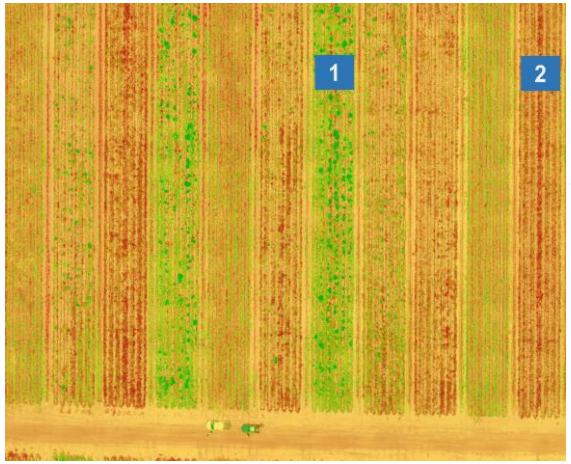
Weed Control in Horticultural Crops

- *Novel Approaches for Improving Efficacy, Sustainability and Crop-Safety*

Ramdas Kanissery

Assistant Professor – Weed Scientist

Southwest Florida Res. & Education Center
Immokalee, FL



Source: VSCNews magazine: 07, 2018

Source: Crops & Soils magazine : 11-12, 2012

UF IFAS UNIVERSITY of FLORIDA

Horticultural Sciences

https://swfrec.ifas.ufl.edu/programs/weed-science/

The big picture

Weed management challenges for future…..

- **Increasing demand for food production**
- Herbicide tolerance
- Lack of new chemistries
- Farm labor shortages
- Rising interest in organic production

Demand for food production is always rising

- World population is always increasing

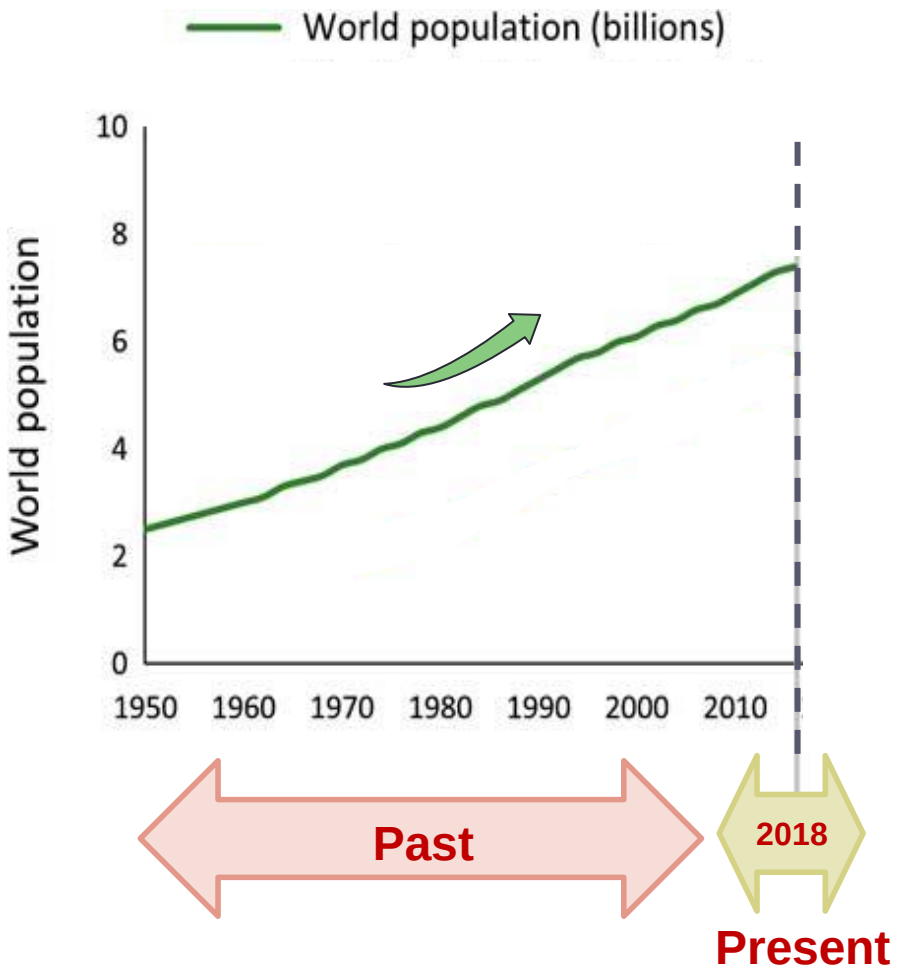


Image and information credits: Westwood et al. 2018

Demand for food production is always rising

- World population is always increasing
- Food production is short now

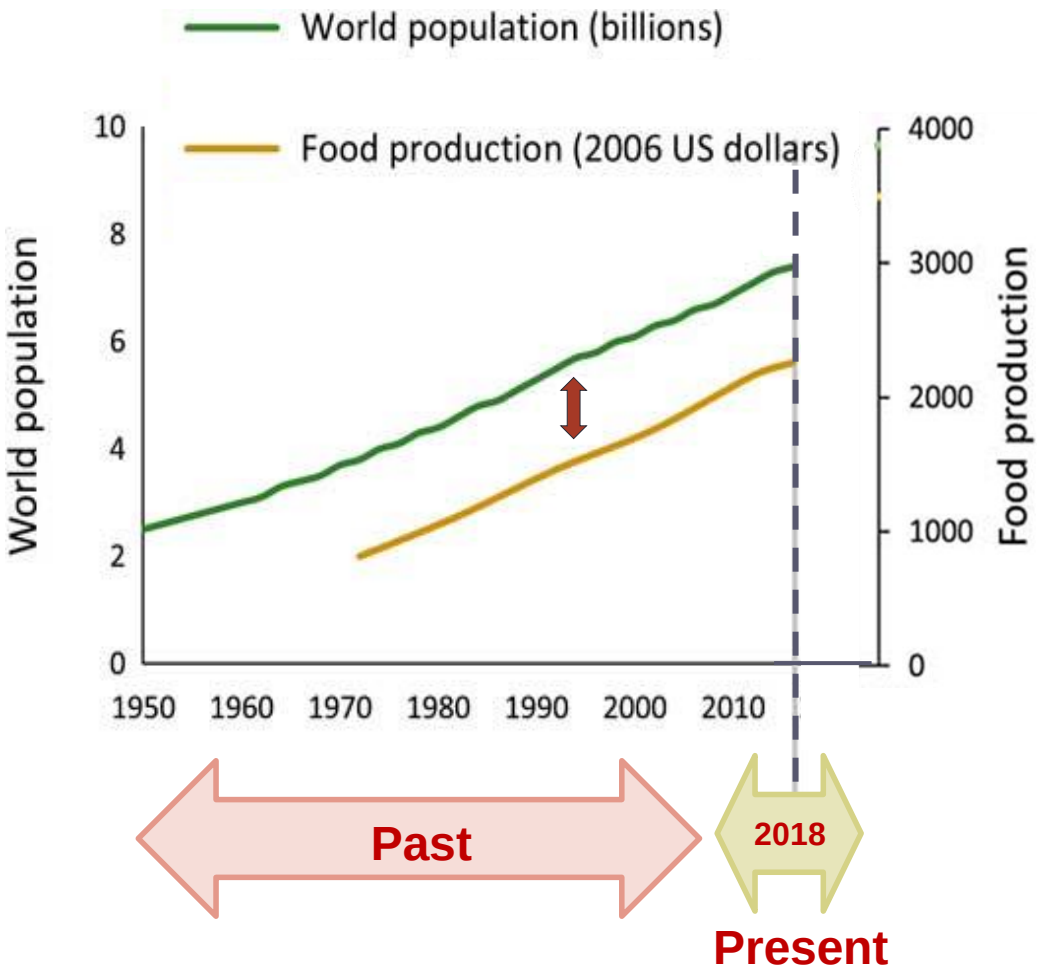


Image and information credits: Westwood et al. 2018

Demand for food production is always rising

- Food production is short now and will continue in the future

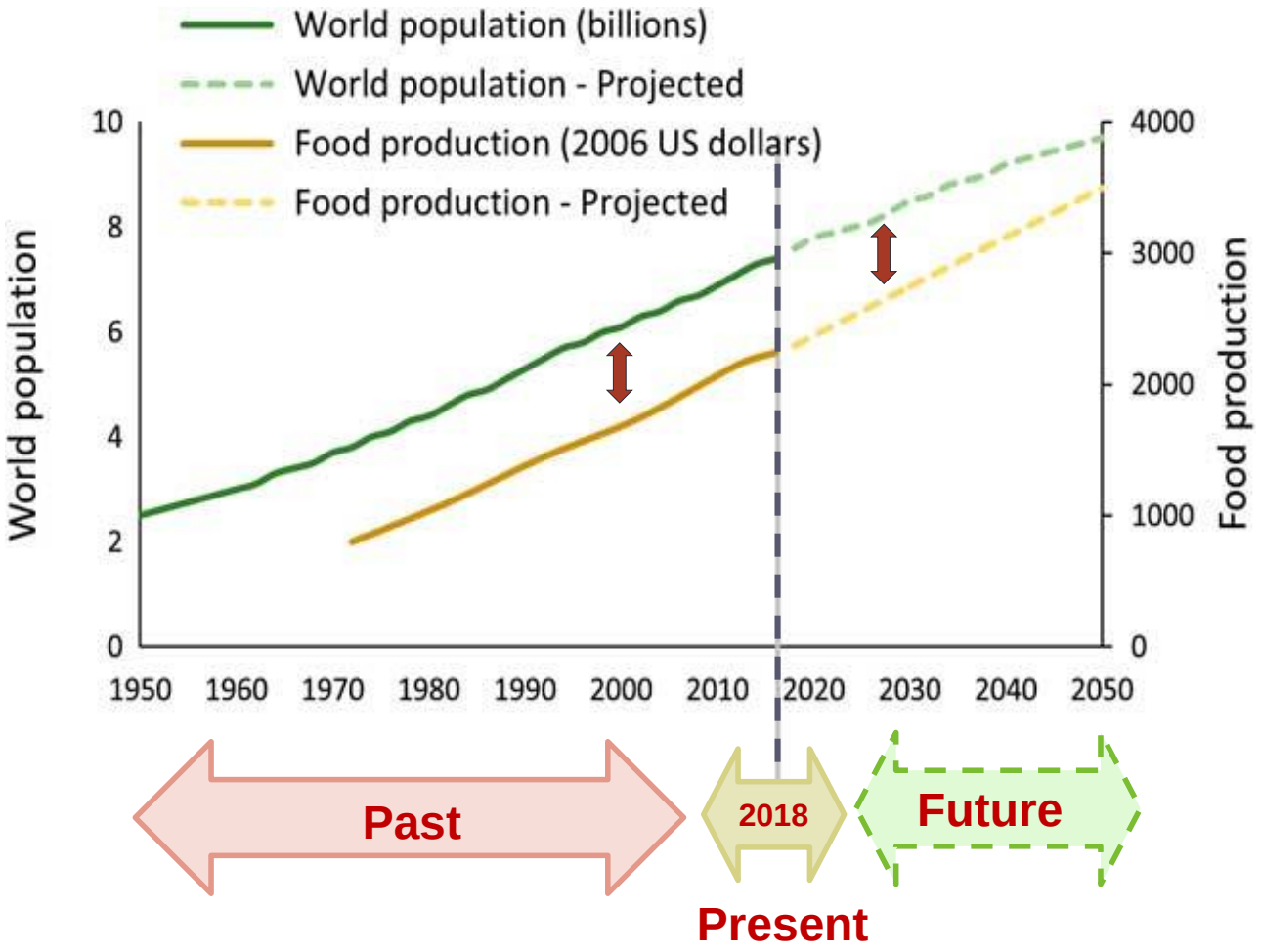
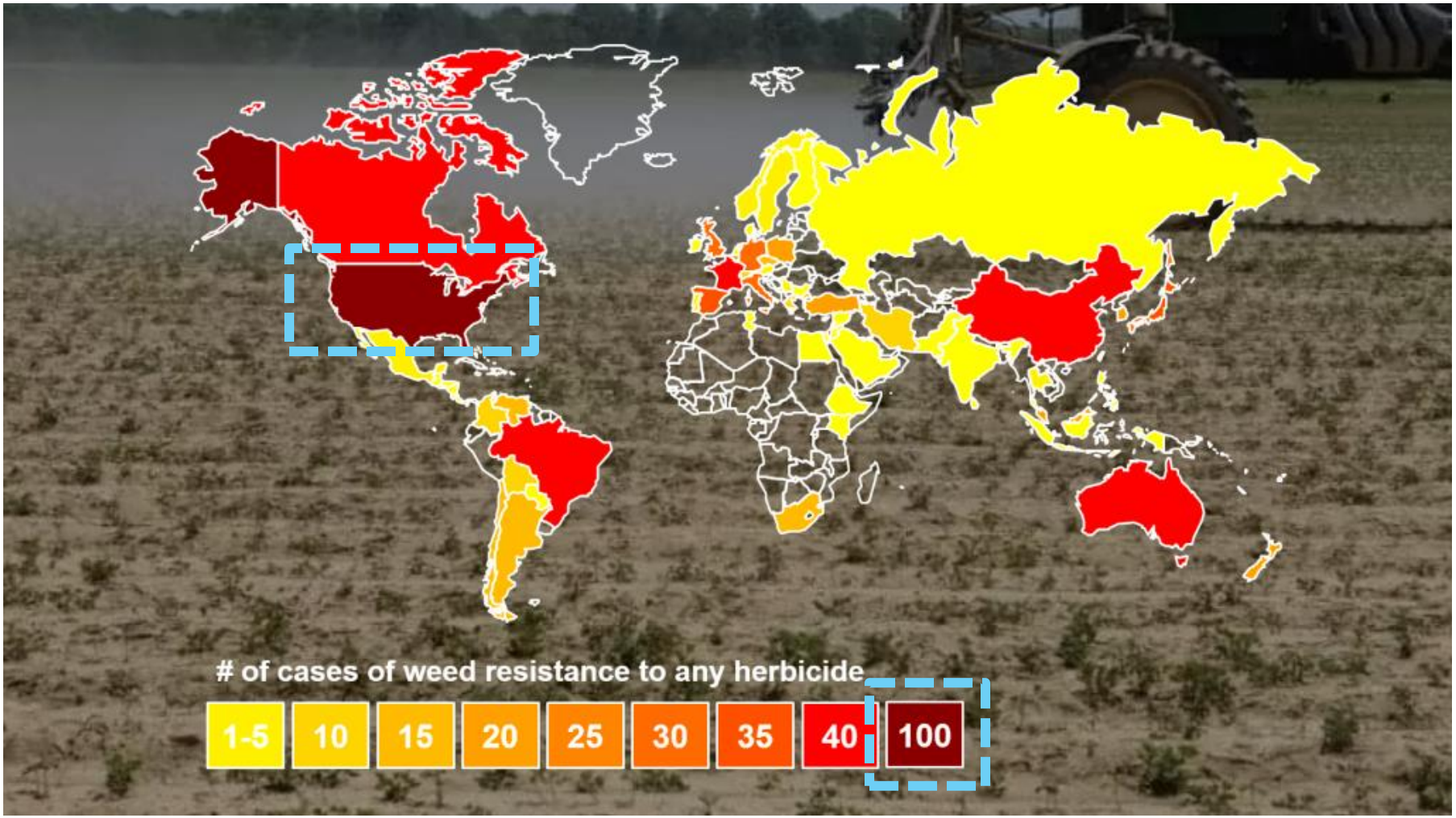


Image and information credits: Westwood et al. 2018

Weed management challenges for future…..

- Increasing demand for food production
- **Herbicide tolerance**
- **Lack of new chemistries**
- Farm labor shortages
- Rising interest in organic production

Herbicide resistance and tolerance in weeds is a becoming a global threat



~ 100 weeds resistant to any herbicides documented in US

Image and information credits: Blue River Technology
http://www.bluerivert.com

New herbicide chemistry development is lacking

- **Increase in herbicide resistant weeds**

- Lack of any **new herbicide chemistries** / mode of actions since 1980’

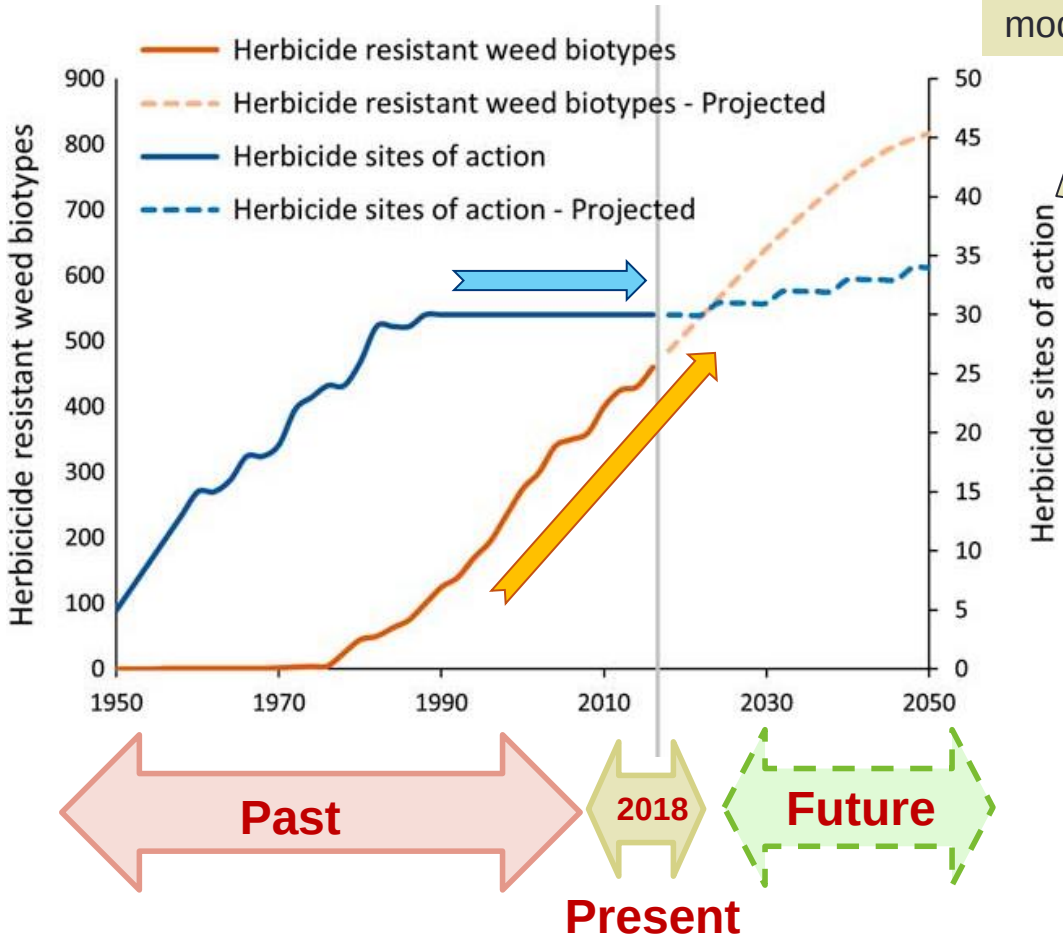
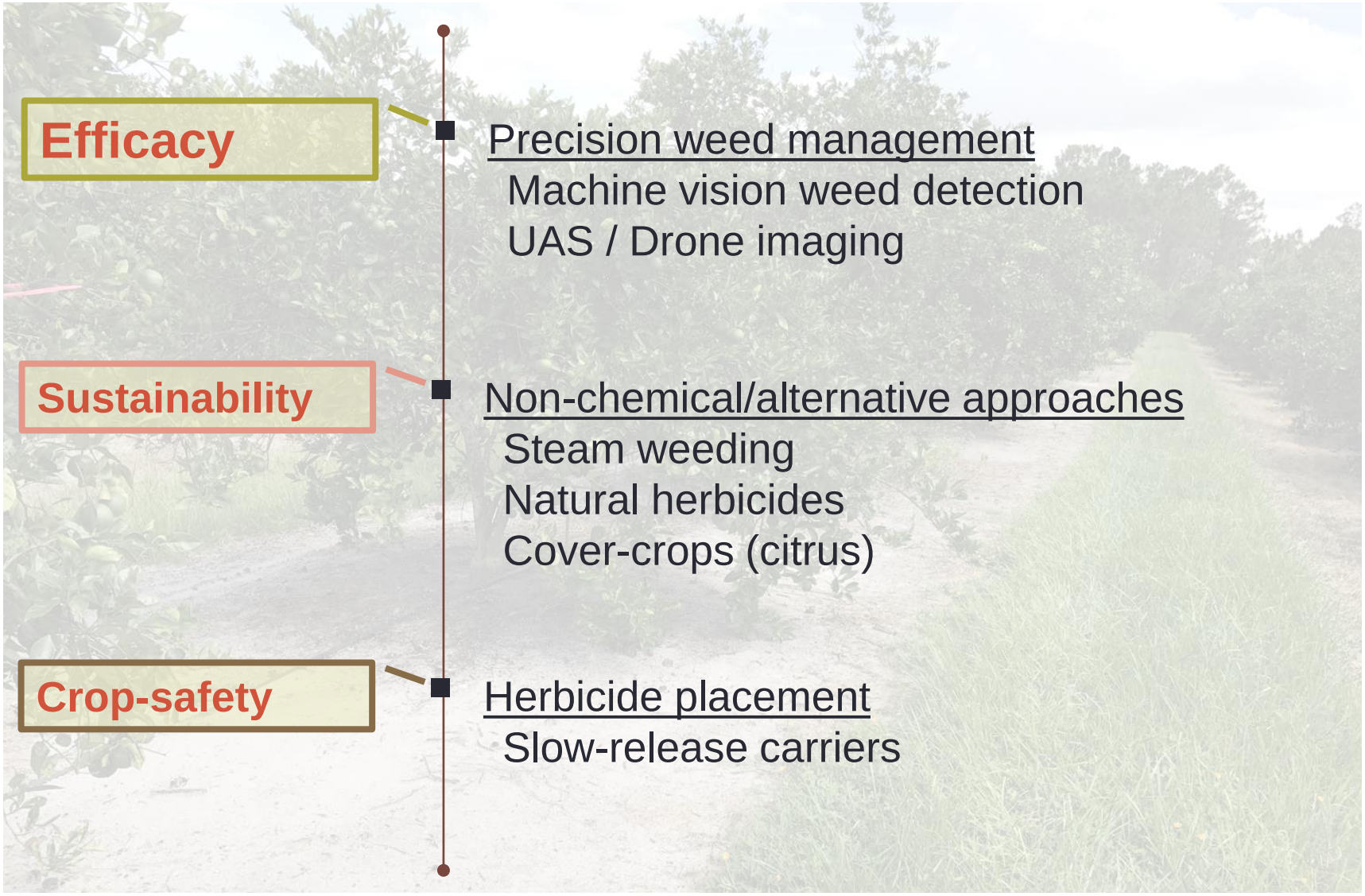


Image and information credits: Westwood et al. 2018

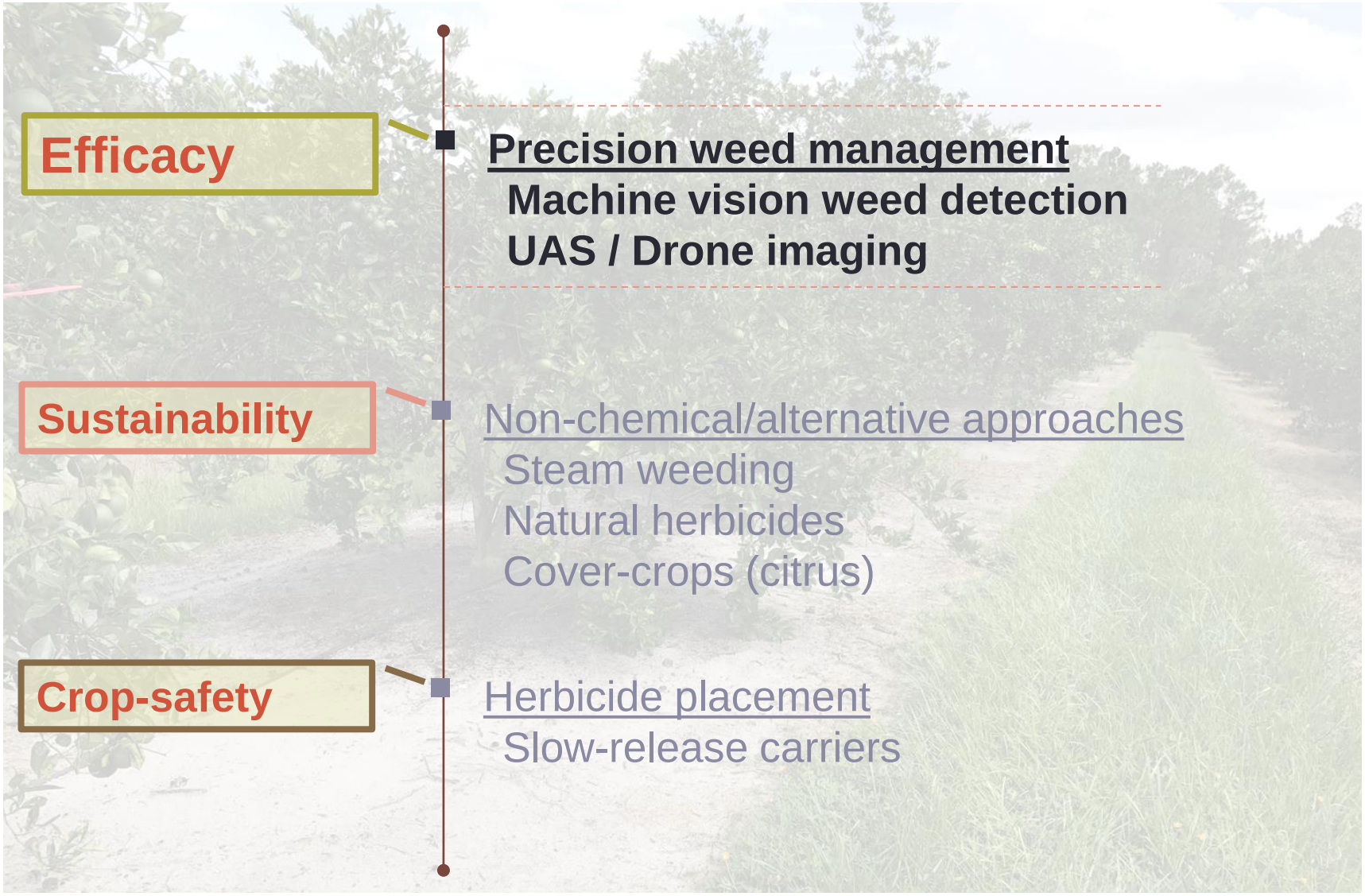
Weed management challenges for future…..

- Increasing demand for food production
- Herbicide tolerance
- Lack of new chemistries
- **Farm labor shortages**
- **Rising interest in organic production**

The need… Novel and alternative approaches in weed management

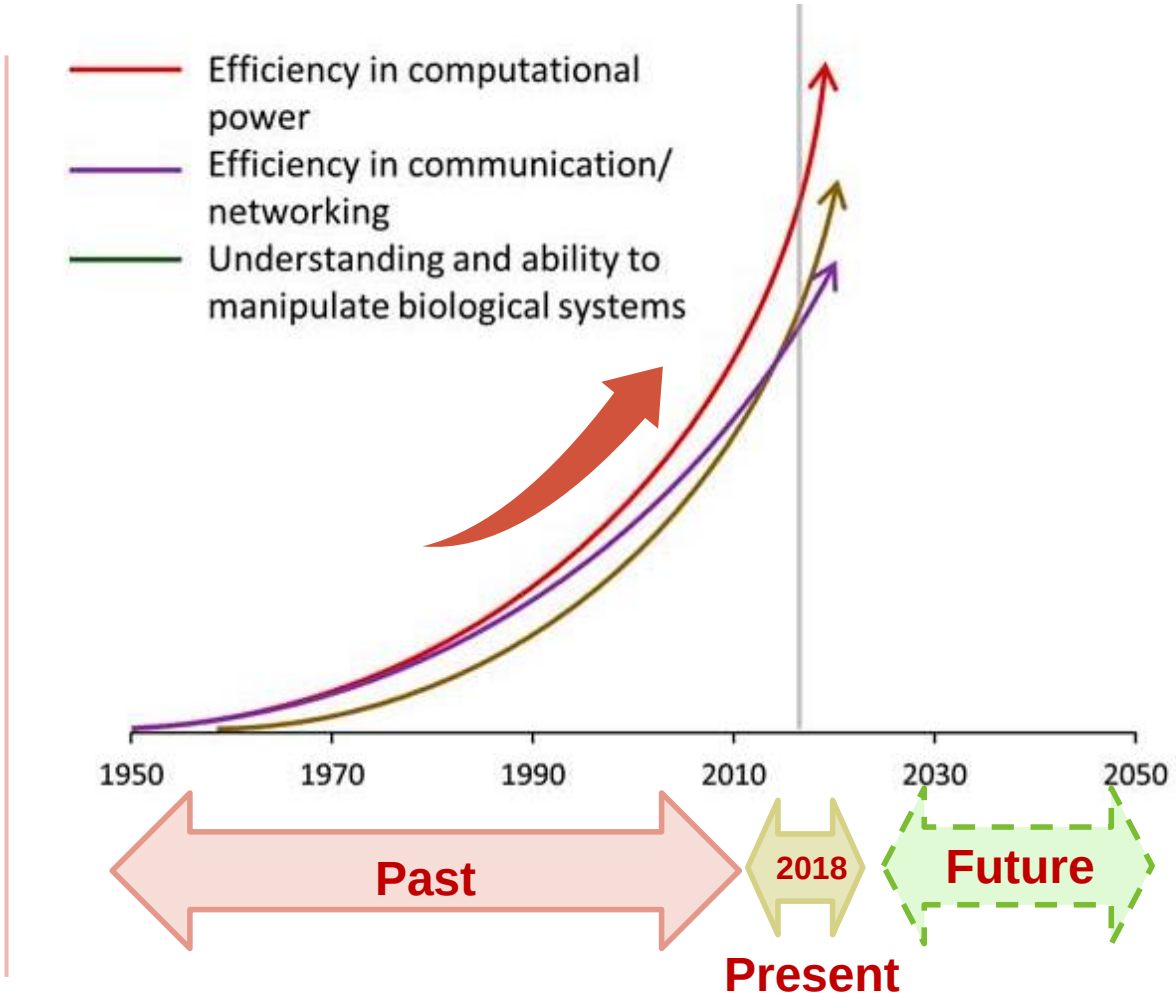


Novel and alternative weed management strategies



Precision weed management (PWM)

- *Trends in computational power & communication networking has been always rising*

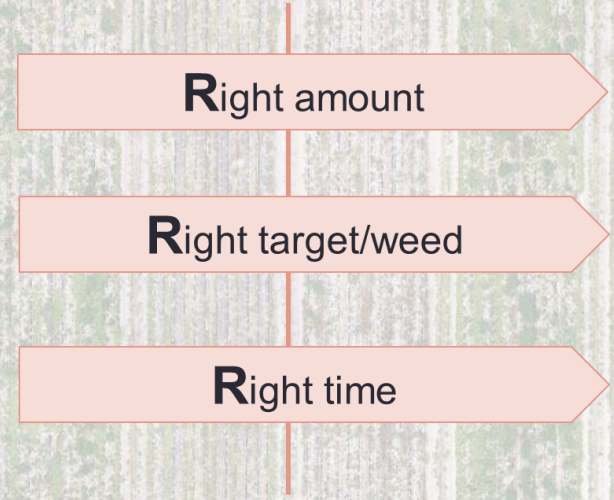


Precision weed management (PWM)

"Three **R**s of precision weed management"

- **R**ight amount
- **R**ight target/weed
- **R**ight time

Precision weed management (PWM)

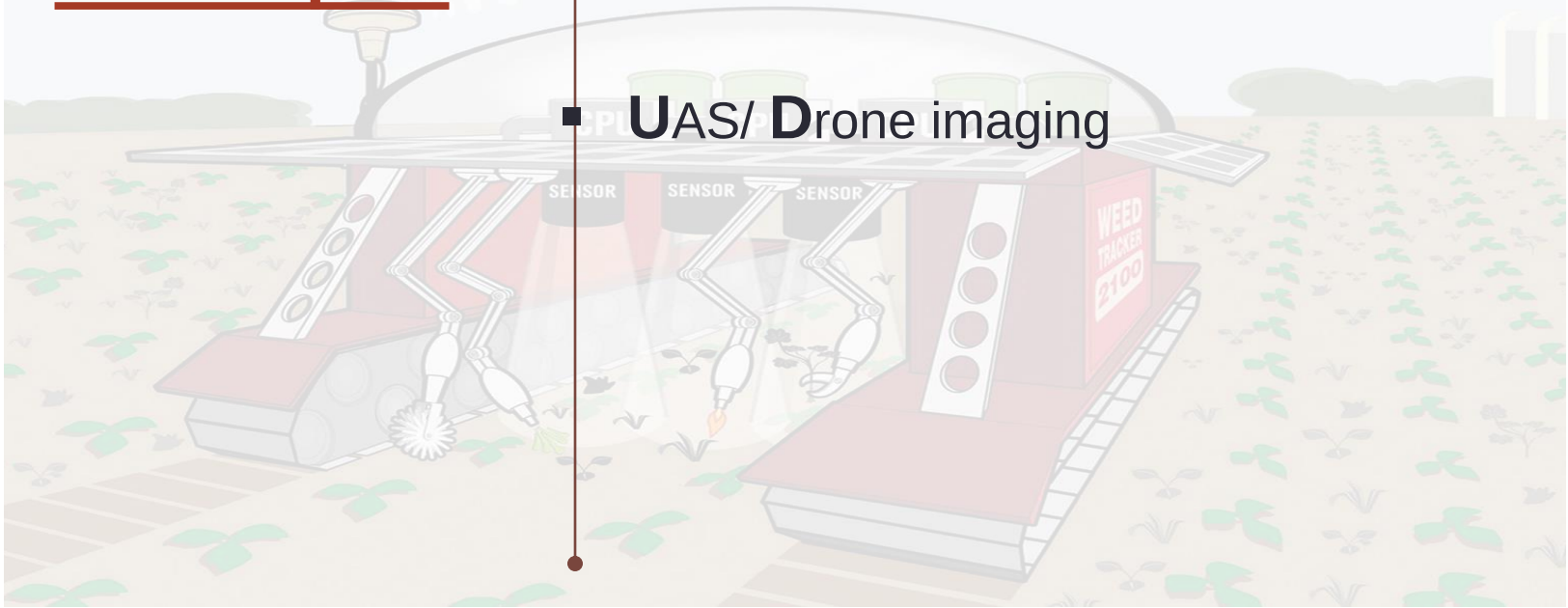


"**place the right amount of inputs *[herbicides]* on the right target *[weeds]* at the right time**"

Precision weed management (PWM)

Techniques

- **A**utomation **/ M**achine **L**earning
- **U**AS/ **D**rone imaging



Precision weed management (PWM)

Techniques

- **Automation / Machine Learning**

Synergy b/w

- Man
- Machine
- Sprayer

Precision weed management (PWM)

Techniques

- **Automation / Machine Learning**
- Machine vision-based applicators - “See & Spray”
  - Precision / targeted application
  - Site specific / “need only based” sprays
  - Reduce inputs up to 90%

Source(s): Zijlstra et al. 2011
Sharpe et al. 2019
http://www.bluerivert.com

Precision weed management (PWM)

Techniques

- **Automation / Machine Learning**
- Machine vision based applicators - “See & Spray”

Sensors – critical component
weed species discrimination

Source(s): Zijlstra et al. 2011
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Precision weed management (PWM)

Techniques

- **Automation / Machine Learning**
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Sensors – critical component
weed species discrimination

- Hyperspectral – high accuracy
- Multispectral
- Digital Color Images

Source(s): Zijlstra et al. 2011
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Precision weed management (PWM)

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- **Digital Color Images**

Source(s): Zijlstra et al. 2011
Sharpe et al. 2019
http://www.bluerivert.com

Color Image based weed detection

*"**Geranium weed"*** growing in the strawberry crop plasticulture beds

Image and information credits: Sharpe et al. 2019

Color Image based weed detection – **Leaf-trained**

‘Weed detection’ boxes generated on images for *Geranium weed* growing with the strawberry crop plasticulture

Image and information credits: Sharpe et al. 2019

Color Image based weed detection – **drawbacks**

- False-positive identifications

Automation / Machine Learning

Pros

- Potentially reduce chemical use

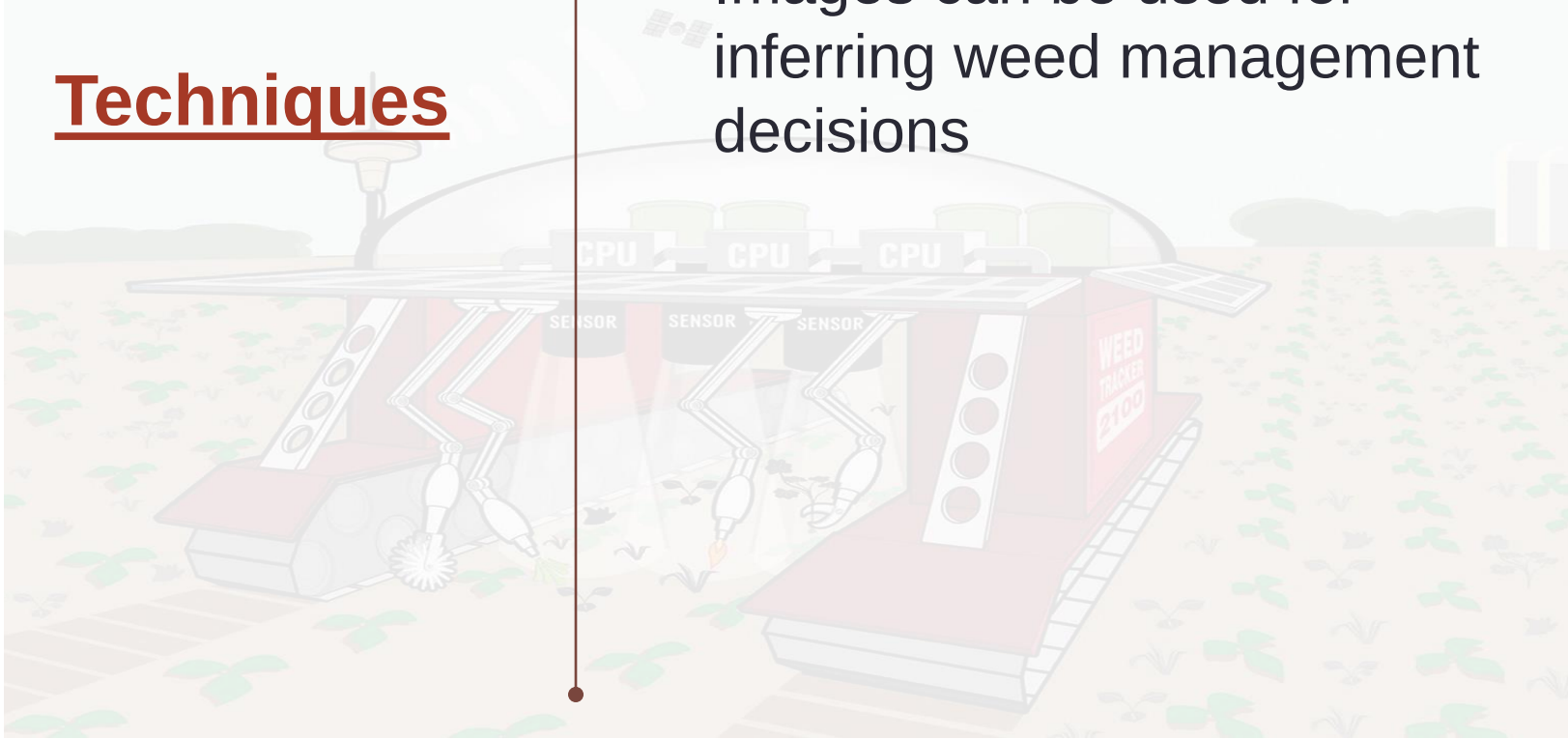
Cons

- lack of a robust weed sensor
- commercial-scale applicability to all crops, weed species, and growing conditions is challenging

Precision weed management (PWM)

Techniques

- **Unmanned aerial systems (UAS) / Drones**
  - Images can be used for inferring weed management decisions

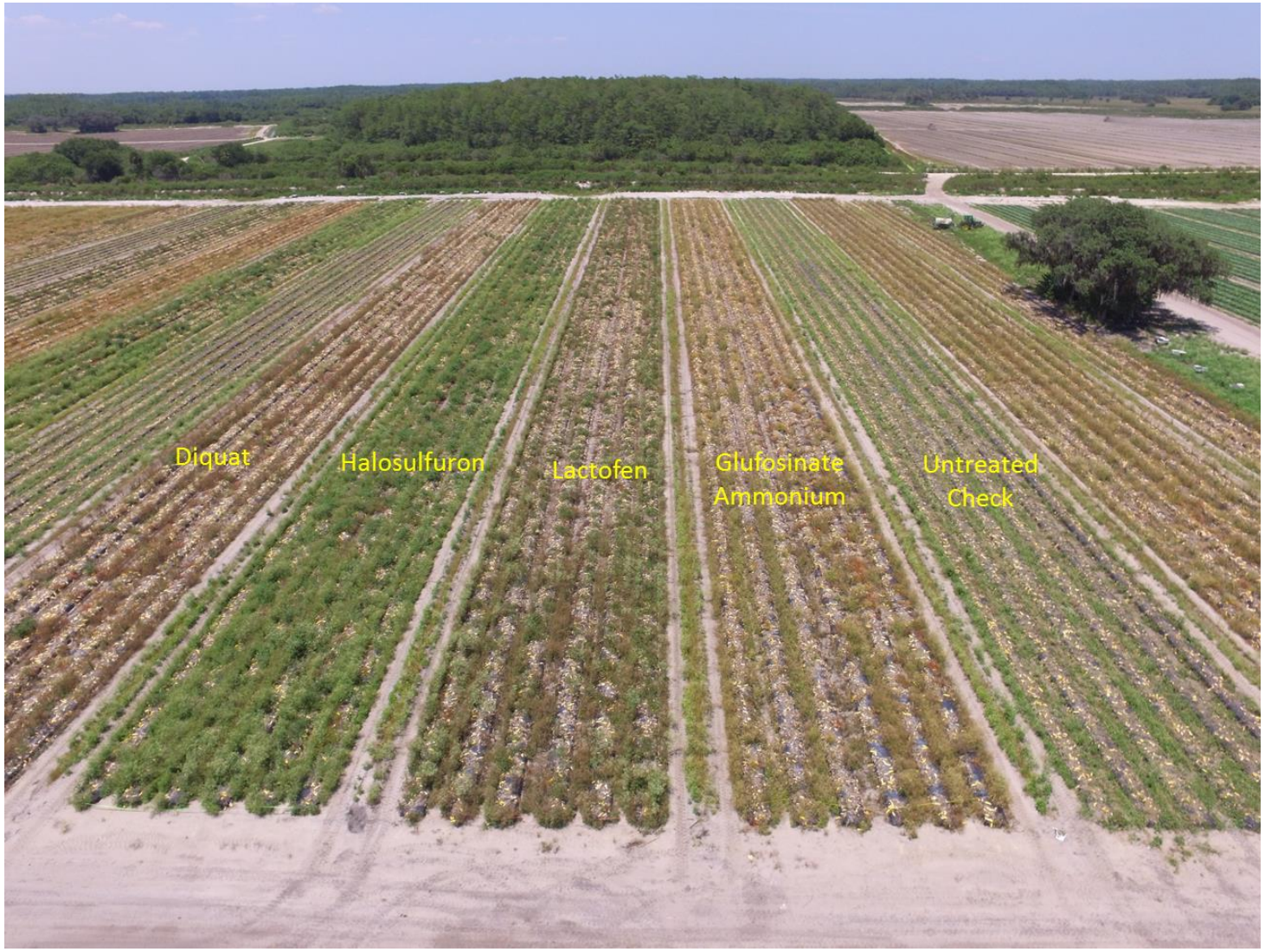


Precision weed management (PWM)

Parthenium weed

Heavy parthenium infestation in a cucumber farm

Immokalee, FL



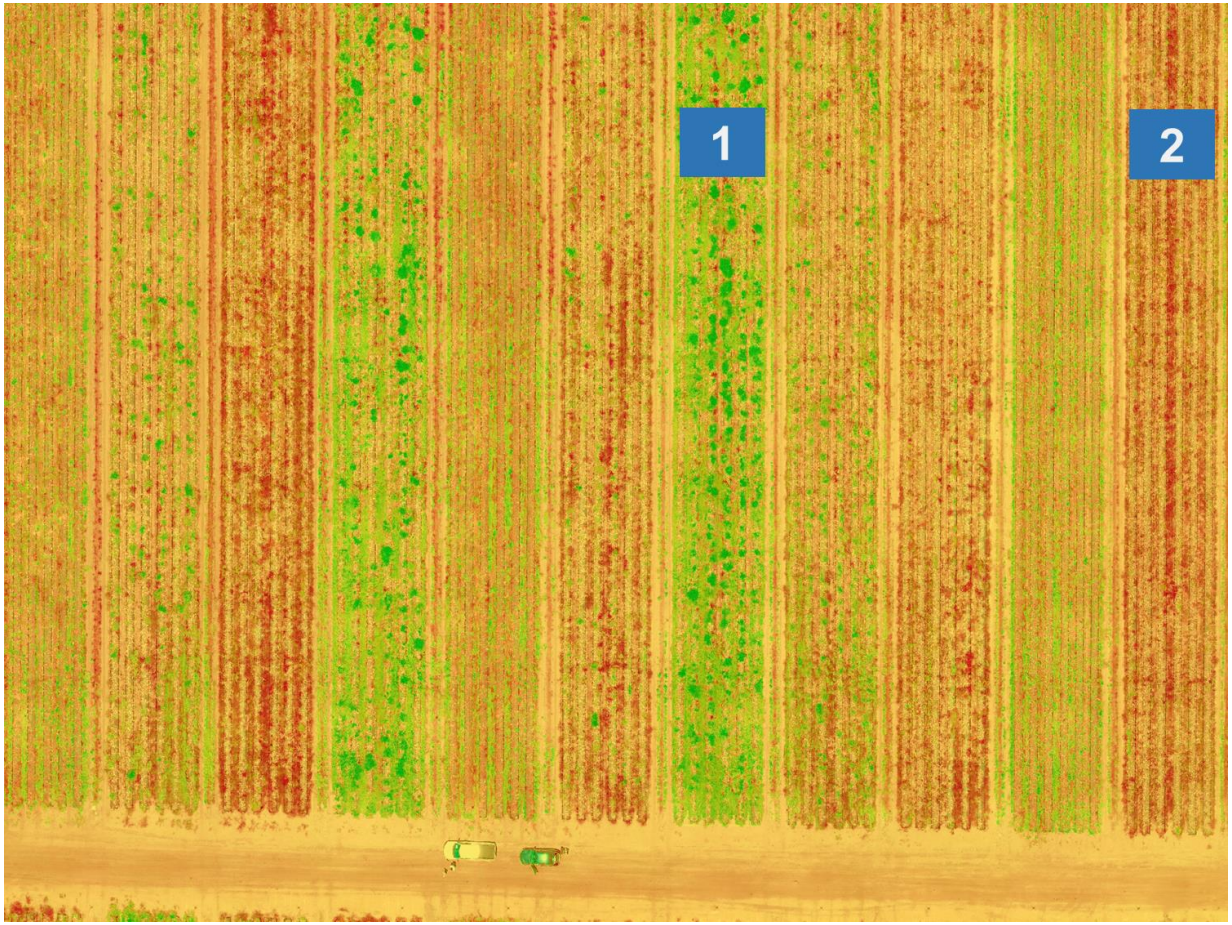
Parthenium weed control study in cucumber crop

Immokalee, FL - 2017

Unmanned **A**erial **S**ystem (UAS) based model to quantify herbicide efficacy

Visual Sensor: Drone image showing the efficacy of herbicide treatments

Unmanned **A**erial **S**ystem (UAS) based model to quantify herbicide efficacy

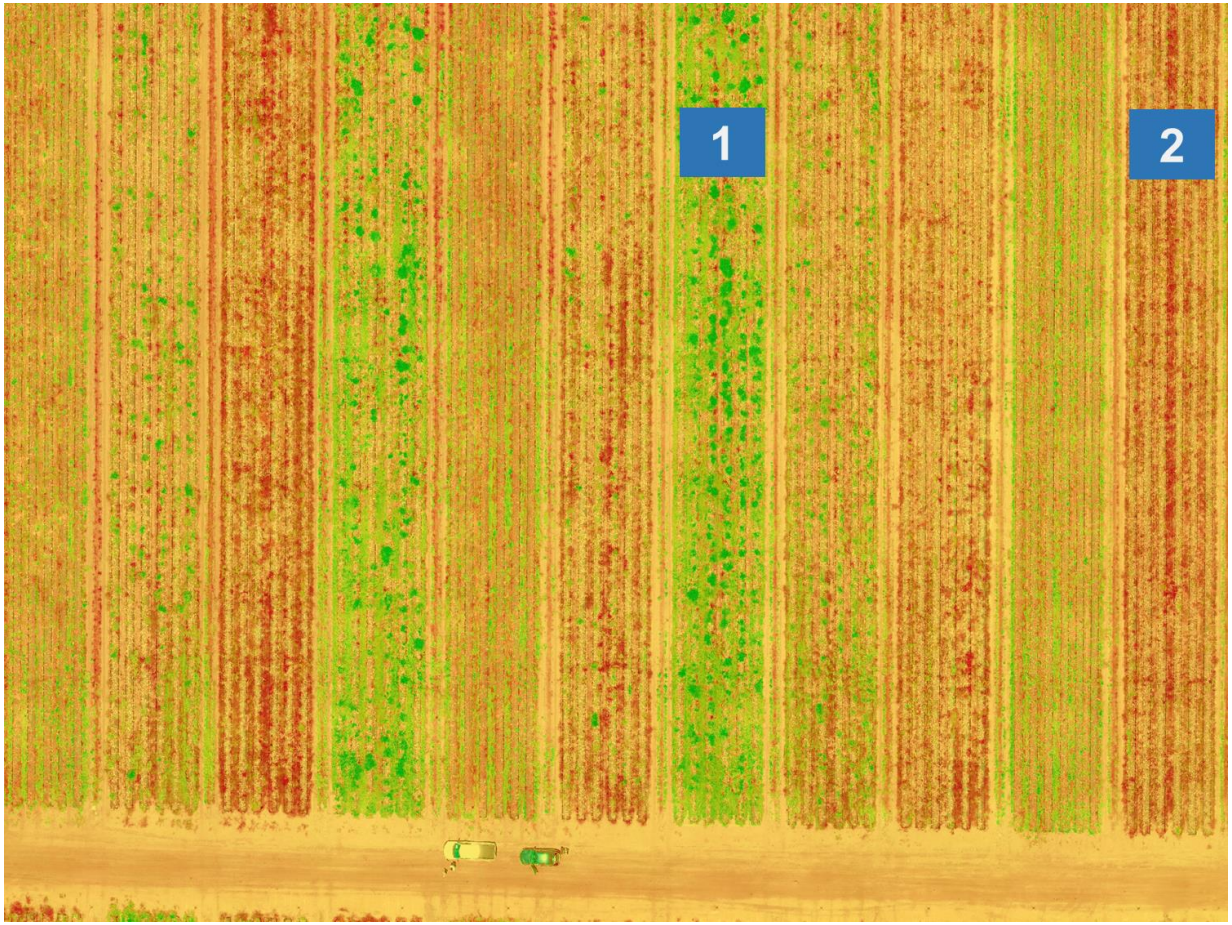


Multispectral Sensor shows photosynthetic activity of weeds

Unmanned **A**erial **S**ystem (UAS) based model to quantify herbicide efficacy

1 high weed activity

2 low or no activity



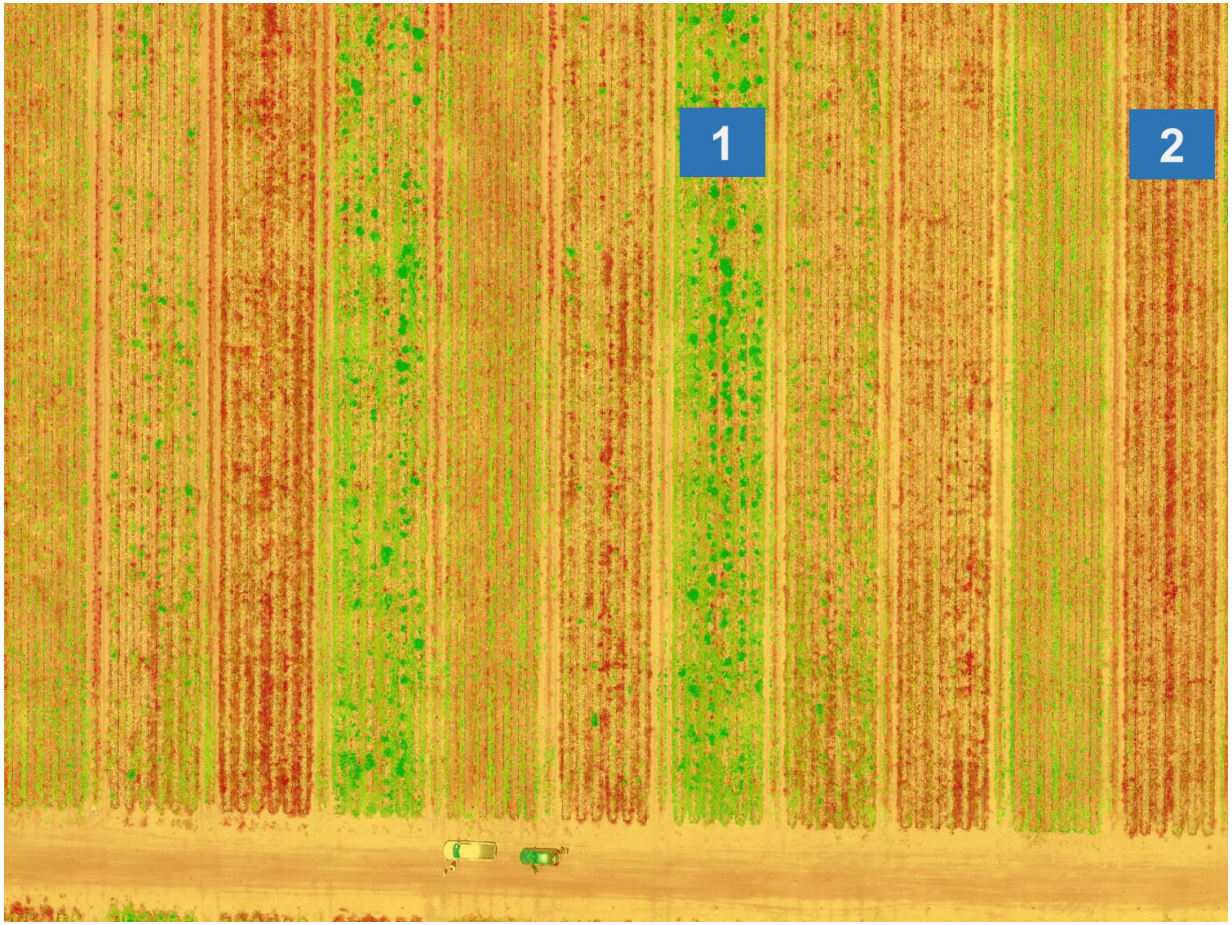
Multispectral Sensor shows photosynthetic activity of weeds

Unmanned **A**erial **S**ystem (UAS) based model to quantify herbicide efficacy

Vegetation vigor

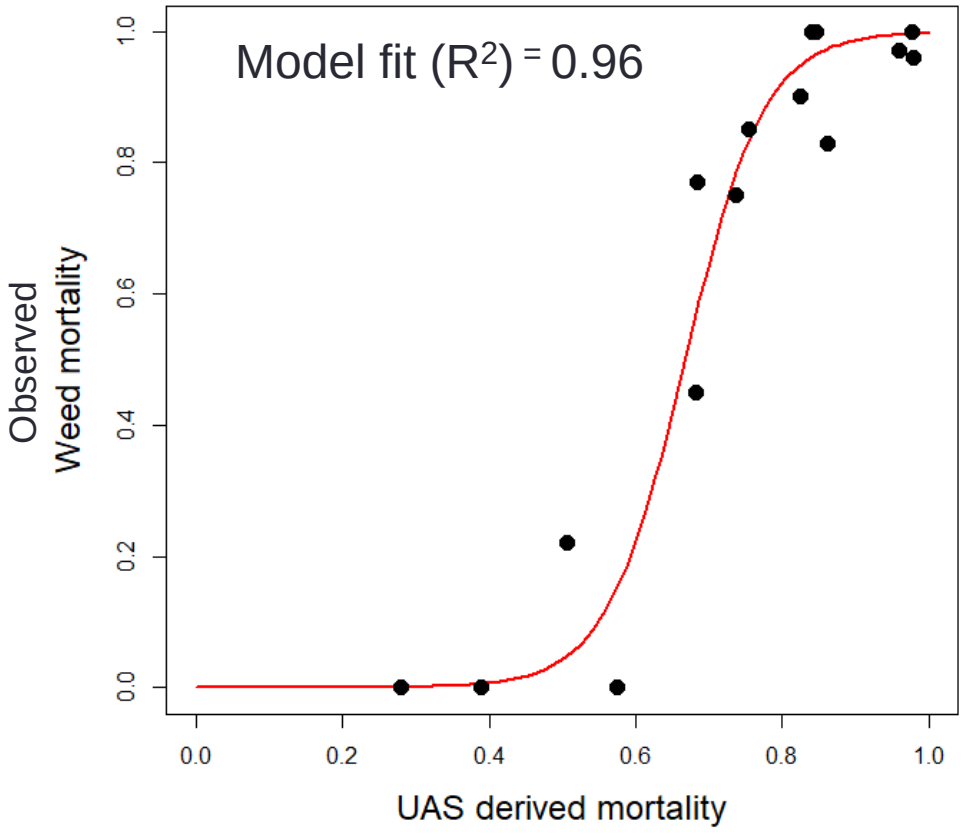
↓

Weed Mortality



Multispectral Sensor shows photosynthetic activity of weeds

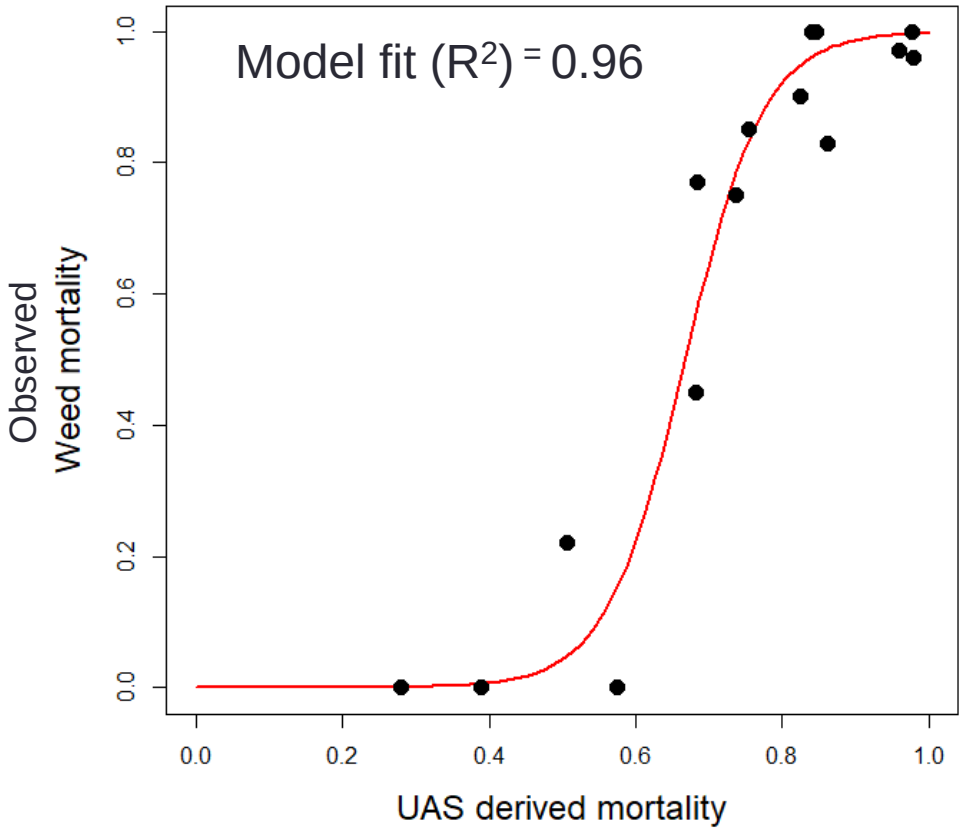
Unmanned **A**erial **S**ystem (UAS) based model to quantify herbicide efficacy



- To help growers optimally schedule their spray applications
- To avoid any redundant follow-up herbicide application in areas where weed control has been achieved to a large degree.

Kanissery, Singh and Fletcher, 2018

Unmanned **A**erial **S**ystem (UAS) based model to quantify herbicide efficacy



Pros

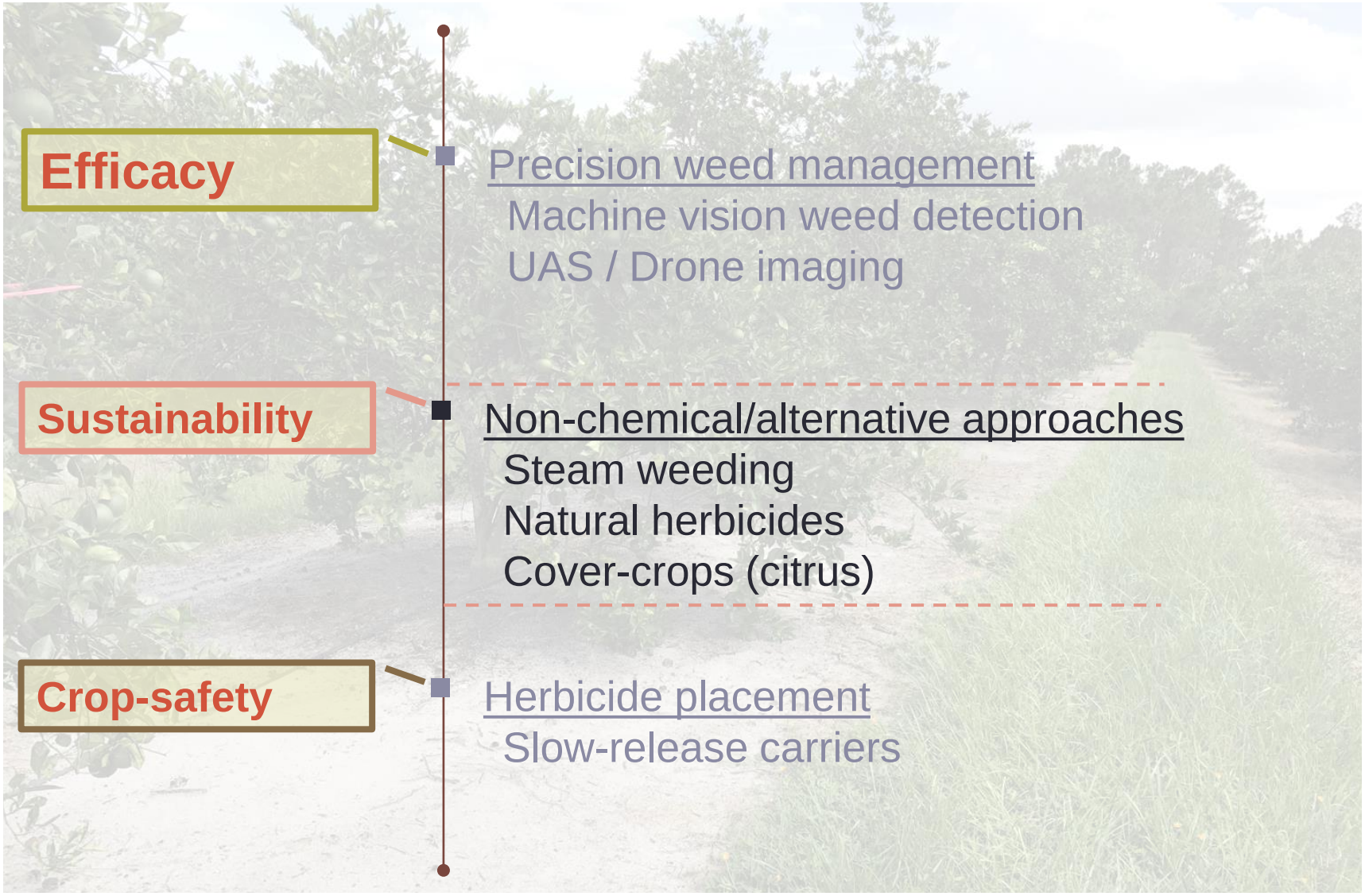
- Evaluating herbicide injury
- Calculating spray thresholds
- Planning site-specific application of herbicide

Cons

- Work with large data sets
- Hardware & Software knowhow

Kanissery, Singh and Fletcher, 2018

Novel approaches - *Weed Management in Horticulture Productions*



Steaming – as a tool in weed management

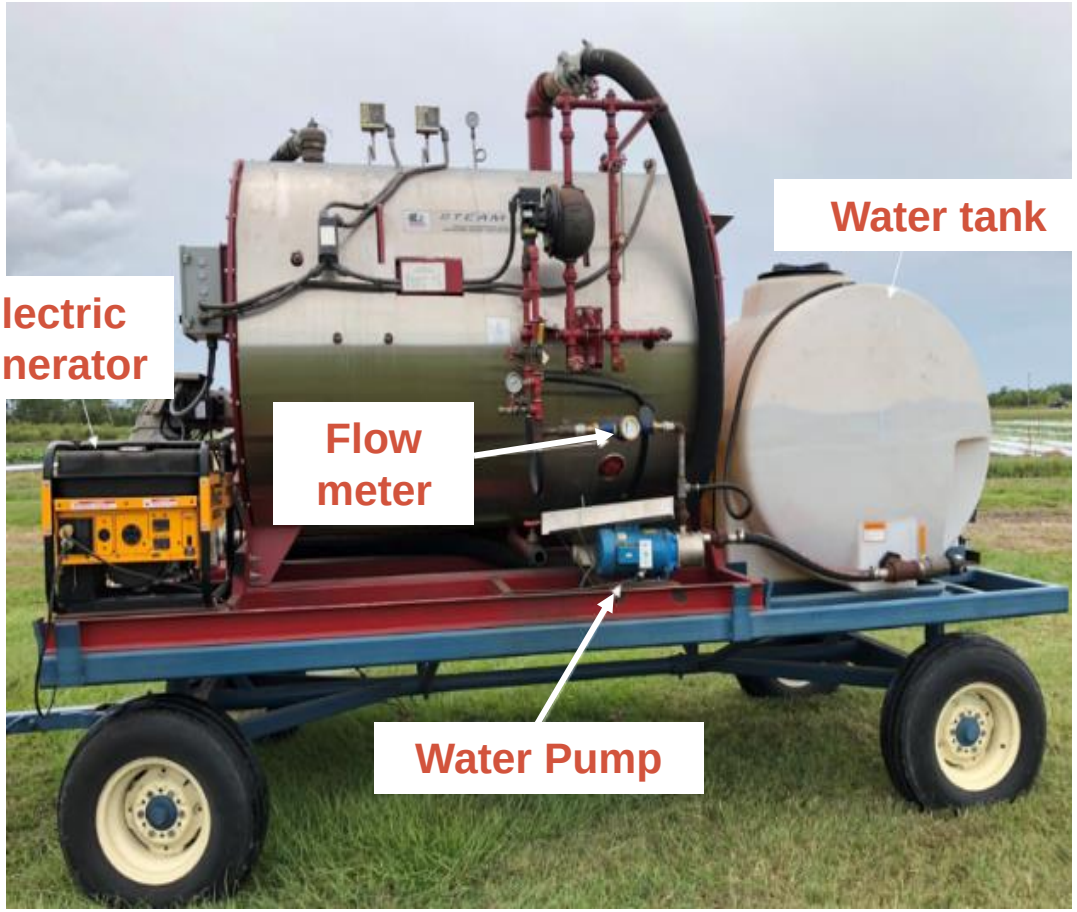
- *Thermal weed management strategies*
- *E.g., steam, hot water, flame etc.*

- Non-chemical weed management strategy in commercial horticulture production

Mobile boom connected to steamer

Steaming – in citrus weed management

- Steam generating system



Steaming – in citrus weed management

- Non-chemical weed management
- Sustainable

Steamer pulled by tractor

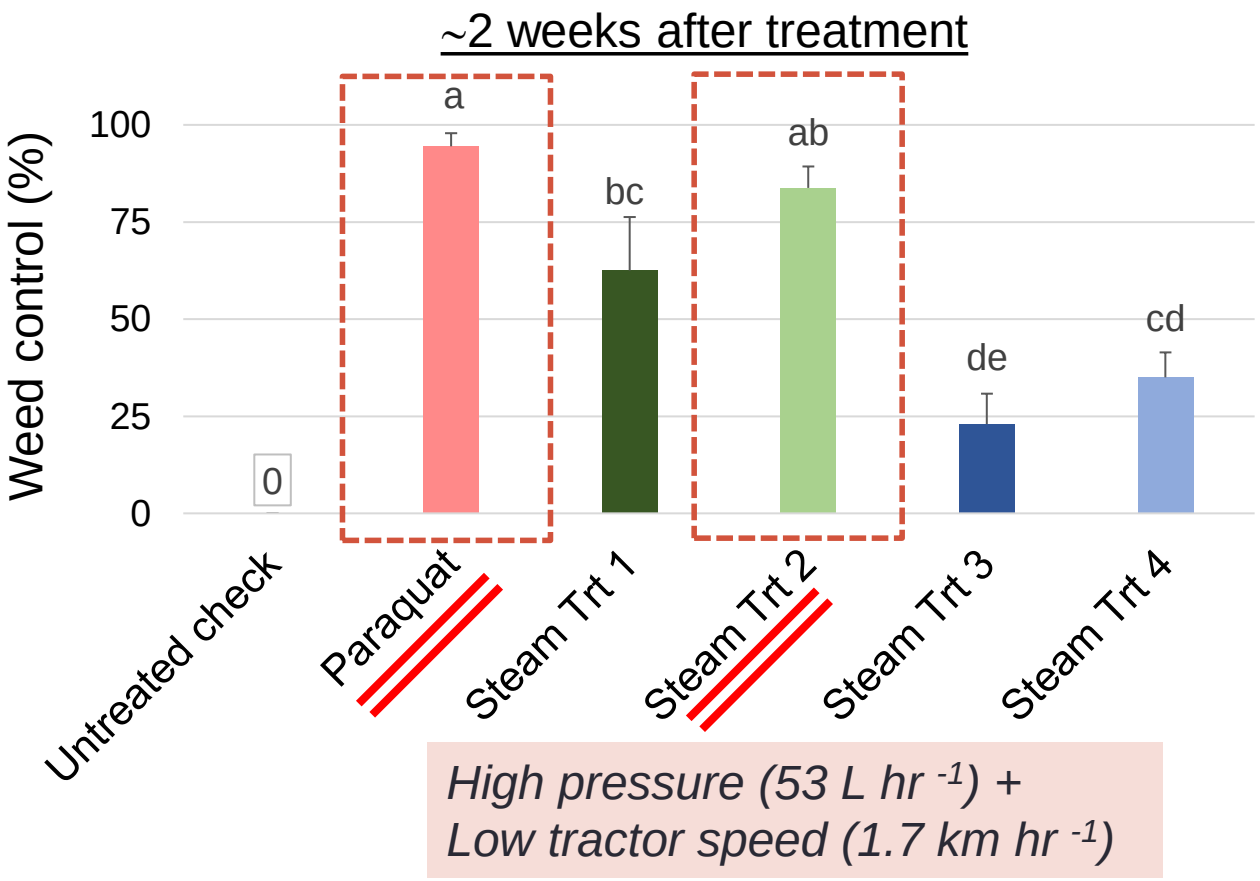
Steaming – in citrus weed management

Collaborator
Dr. Ampatzidis (ABE)

Treatments

combination of

- Steam pressure levels
- Tractor speed levels



High pressure (53 L hr $^{-1}$) +
Low tractor speed (1.7 km hr $^{-1}$)

- Replication (n) = 5
- Mean comparison: Tukey's hsd (α 0.05)

Abdulridha et al. 2019; doi: 10.13031/aea.13494

Steaming – in citrus weed management

E.g., of weeds controlled by steam

Sedges

Goatweed

Guinea grass

Abdulridha et al. 2019; doi: 10.13031/aea.13494

Steaming – in citrus weed management

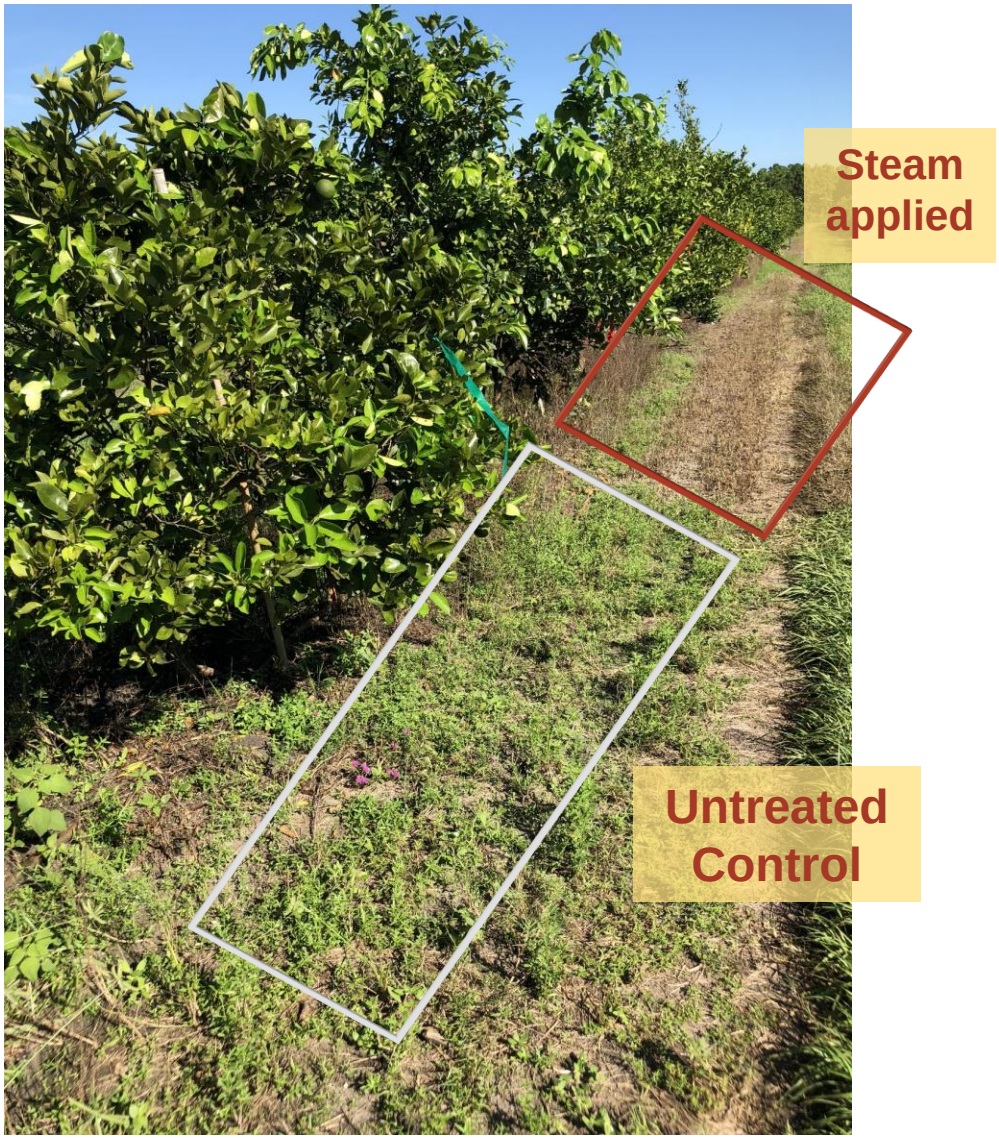
- For weed management in the citrus rows

~ 6 hrs. after steam application

Steam application for citrus row weed control

Steaming – in citrus weed management

- For weed management in the citrus rows



Goat weed

- Slow response to glyphosate & paraquat application

Steaming in combination with herbicide application

Goat weed control in citrus

- Steam was applied followed by a contact herbicide

Paraquat rate (pt. / acre)	No steam	With Steam
0		
1		
3		

Steaming in combination with herbicide application

Goat weed control in citrus

- Steam was applied followed by a contact herbicide
- Contact herbicide found effective even at lower application rate when combined with steam application

1 week after treatment	**No steam**	**With Steam**
Paraquat rate (pt. / acre)	**% weed control**	
0	**0**^{c}	**54**^{b}
1	**51**^{b} ⇨	**92**^{a}
3	**95**^{a}	**96**^{a}
CV	*19.64*	
P-value	*0.0021*	

- Replication (n) = 4
- Mean comparison: Tukey's hsd ($p < 0.05$)

Steaming in combination with herbicide application

Goat weed control in citrus

- Steam was applied followed by a contact herbicide

~1 month after treatment	No steam	With Steam
Paraquat rate (pt. / acre)	% weed control	
0	0^{c}	37^{b}
1	25^{b}	53^{ab}
3	85^{a}	81^{a}
CV	*15.36*	
P-value	*<0.0001*	

- Replication (n) = 4
- Mean comparison: Tukey's hsd ($p < 0.05$)

Steaming for weed control in ditch banks

2 days. after steam application

Steam weeding

Pros

- Reduce chemical foot-print
- An option for organic production

Cons

- Potential weed re-growth
- Relatively slower application process than herbicide sprays
- *E.g., Tractor speed should be ~1 mph for successful steam weeding*

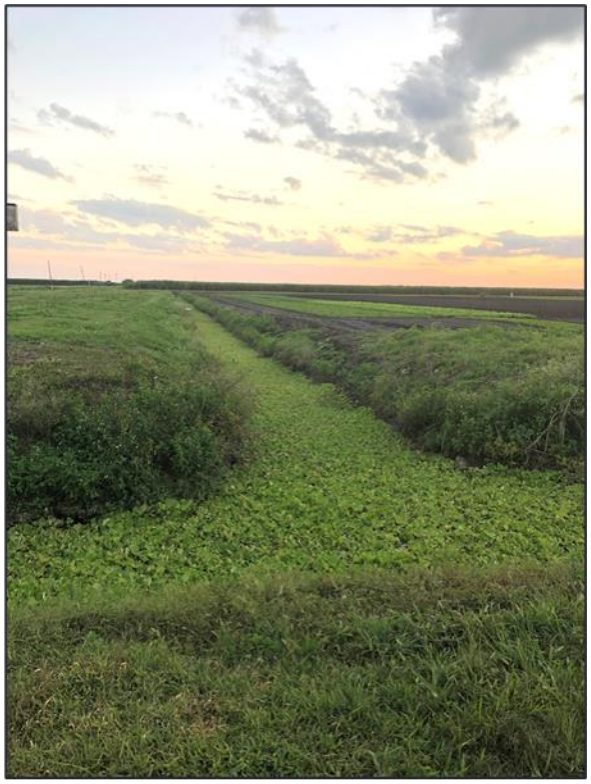
Utilizing **aquatic weeds as potential 'natural' or 'bio' herbicide** towards promoting sustainable agriculture

- Natural herbicides: 'green' products
- Plant-based herbicides
- Examples:

  Botanical oils (Clove oil, eugenol)

  Soaps (pelargonic acid)

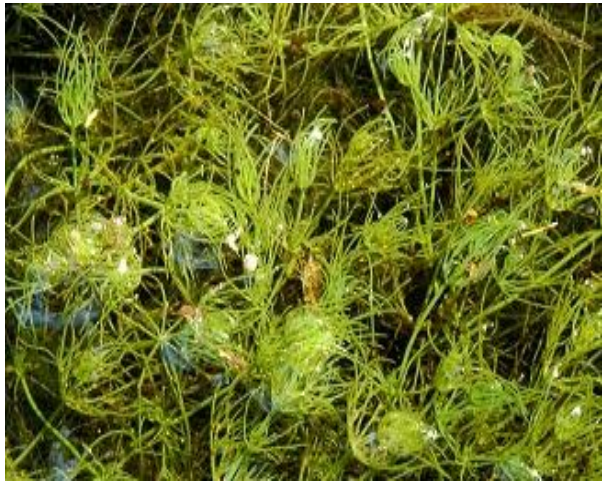
  Vinegar



Recycling aquatic weeds for suppressing terrestrial weeds

- novel and environmentally-friendly approach

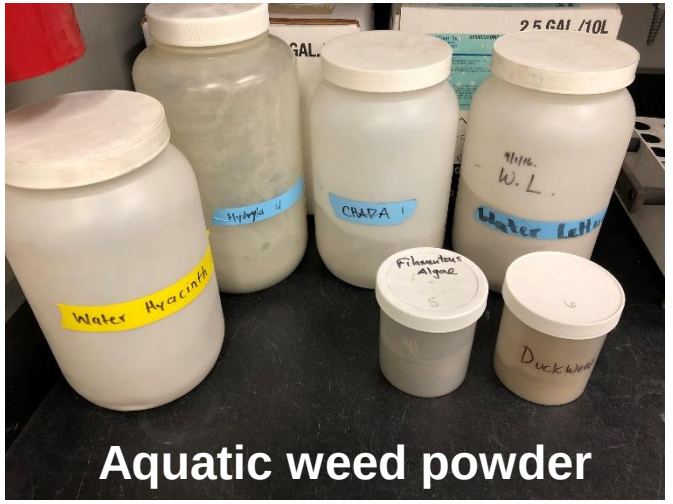
Recycling aquatic weeds for suppressing terrestrial weeds

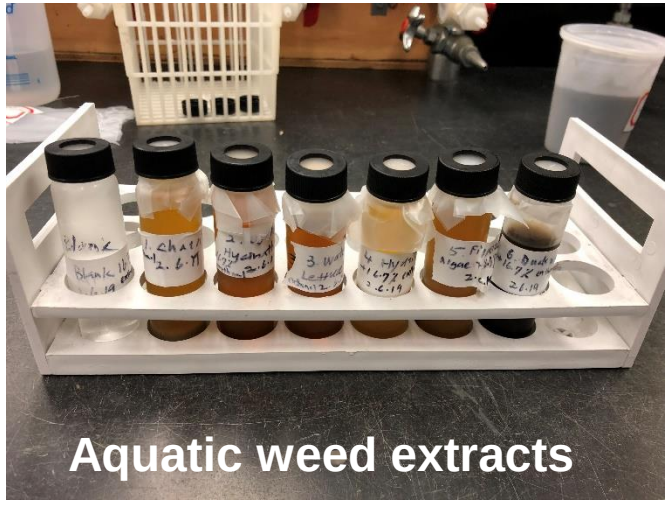


Muskgrass
***Chara* spp.**

Filamentous algae
Lyngbya wollei

- Fu et al (2020) - MS student project



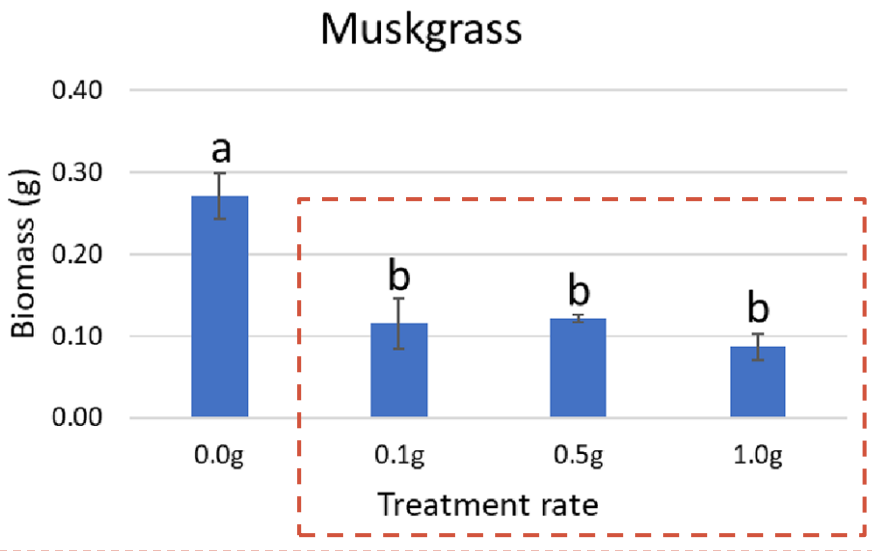


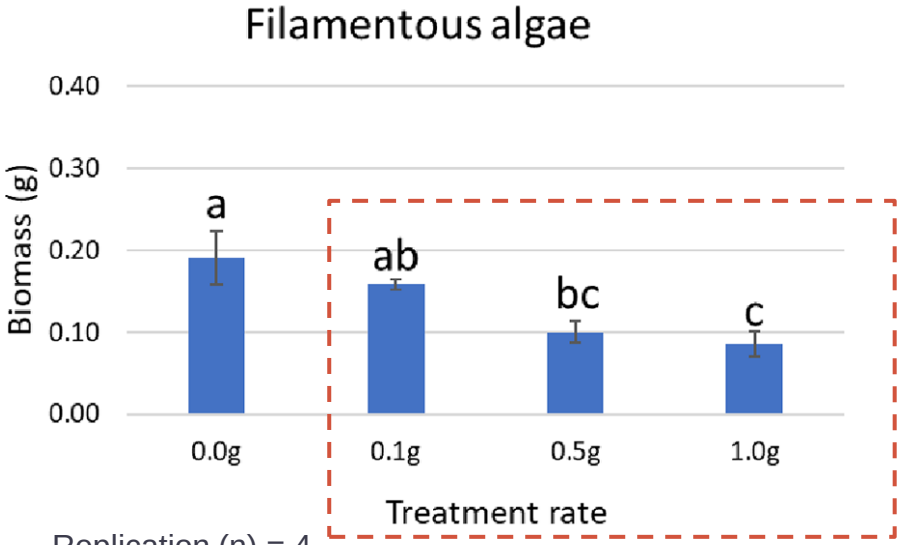
Effect of aquatic weeds on biomass of **Pigweed**

Aquatic weed extracts suppressed the germination and growth of Pigweed (Amaranth)

Possible allelopathic effects

- a problem weed in vegetables and other crops





- Replication (n) = 4
- Mean comparison: Tukey-Kramer ($p < 0.05$)

Fu et al.,2020
https://journals.plos.org/plosone/article/figure?id=10.1371/journal.pone.0237258.g006

Use of cover crops as a weed control strategy

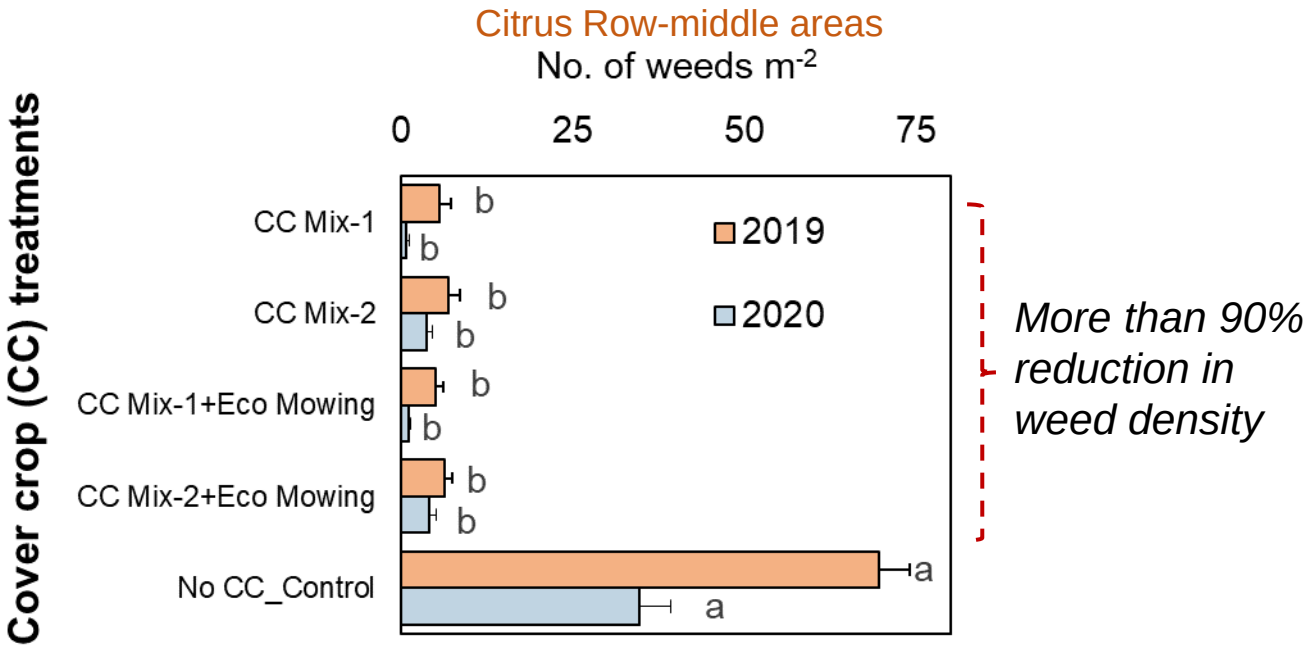
Cover crops for row-middle management in citrus

- Emerging practice in citrus production
- Soil quality improvement
- *Weed control* is an added benefit
- Possible allelopathic effects

Cove crop mix planted in citrus row middles

Use of cover crops as a weed control strategy in citrus

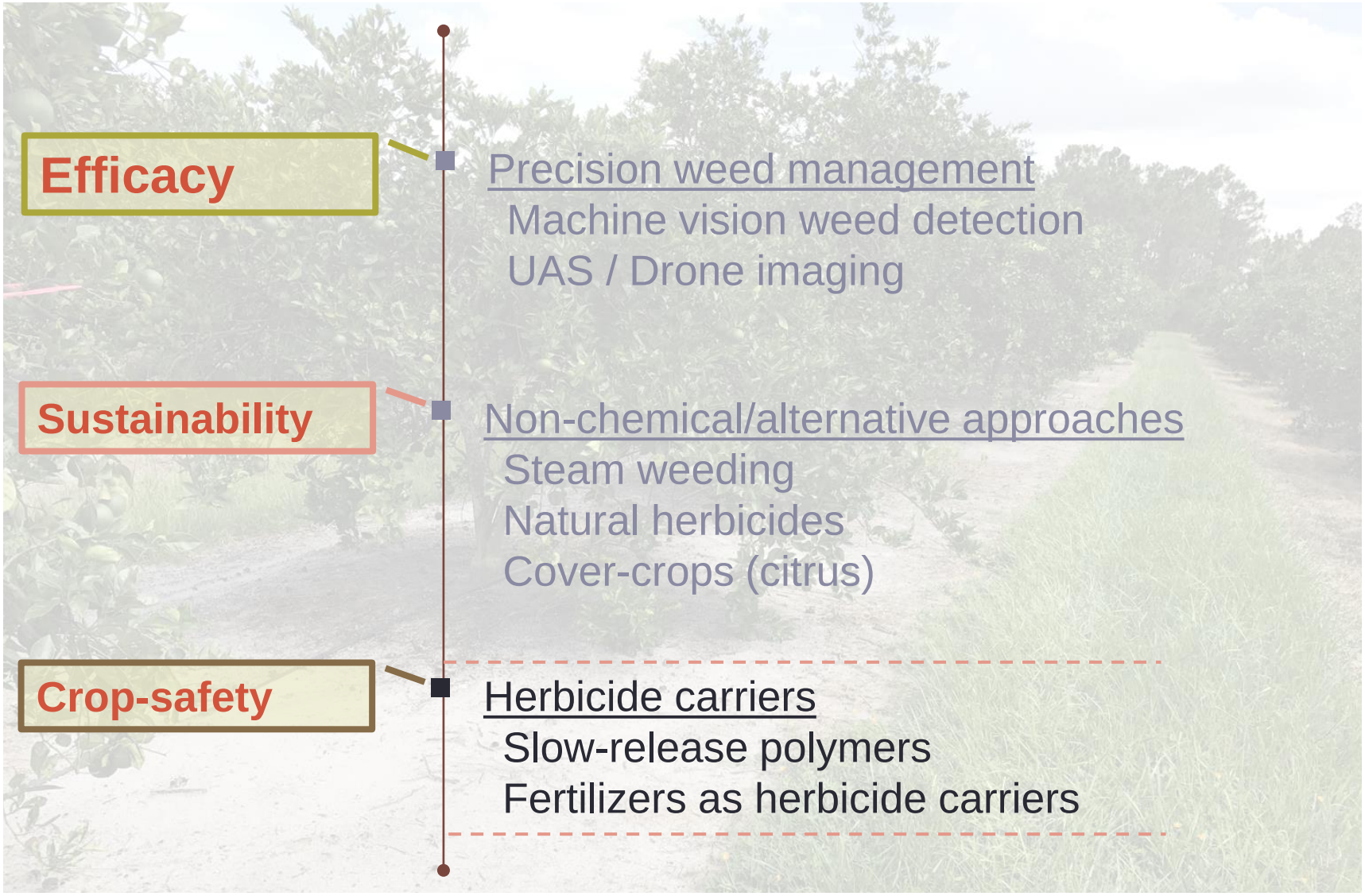
- **Cover crops significantly reduced the weed pressure** in treated row-middles when compared to non treated controls



- *E.g., of Cover crops planted : Daikon radish, White Clover, Crimson Clover & Buckwheat*

- No. of observations per treatment (n) = 18
- Bars with the same letters do not significantly differ (Tukey's HSD, $P<0.01$)

Novel and alternative weed management strategies



Nutsedge control is one of the main challenges faced by producers

- **Nutsedge** infestation in plasticulture production

Yellow Nutsedge taking over the plastic beds
Immokalee, FL

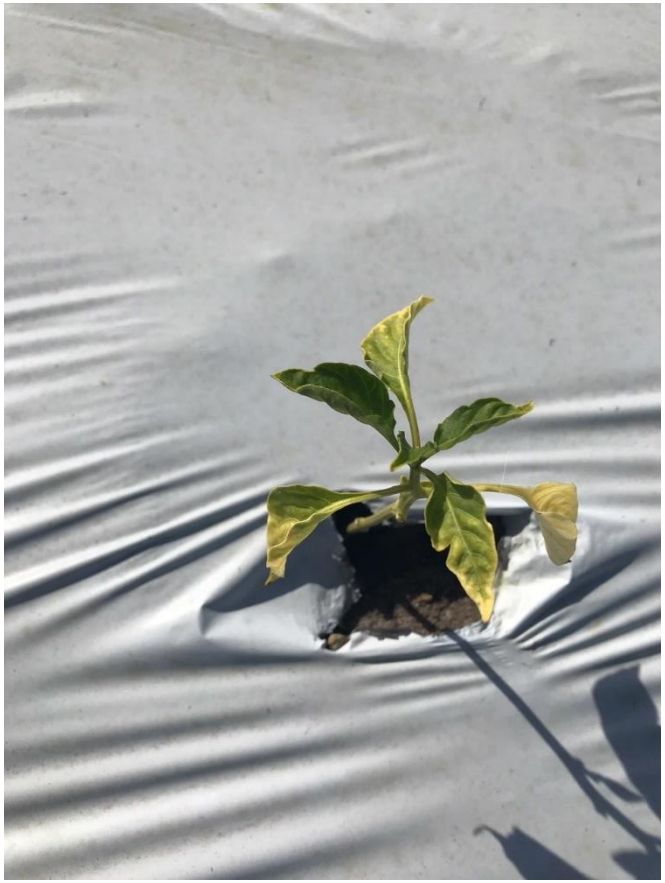
Nutsedge control is one of the main challenges faced by producers

Spraying herbicides on raised beds before installation of plastic mulch is among the control options

- S-metolachlor (Dual Magnum)
- Fomesafen (Reflex)

Residual herbicide persistence in vegetables is a great concern for growers

- **S-metolachlor** sprays on beds manage nutsedge effectively
- However, potentially injure the transplants

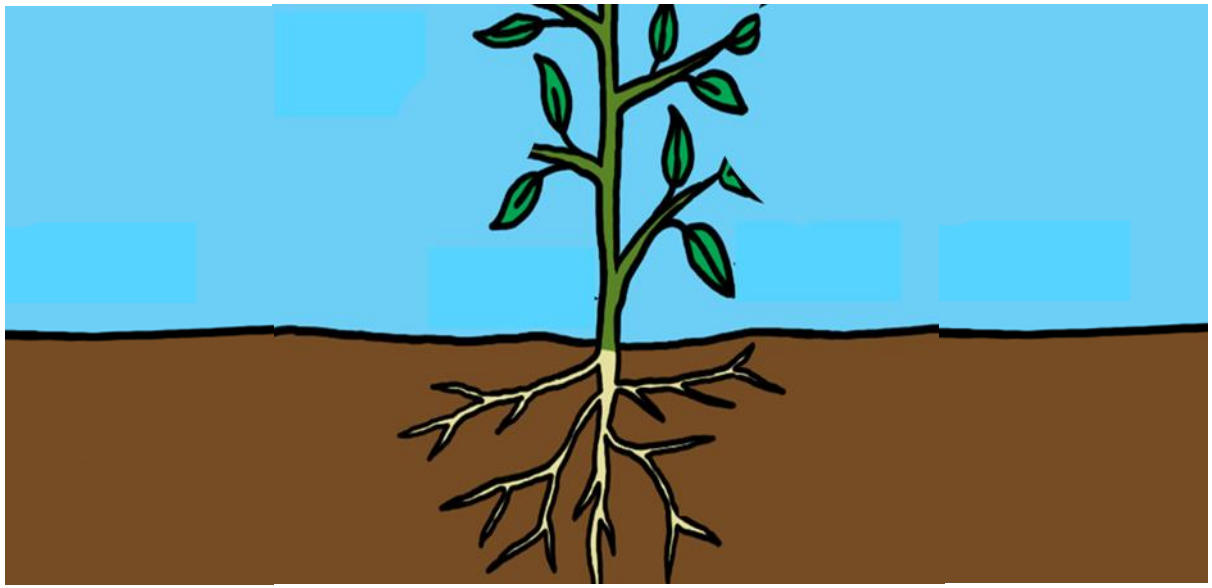


S-metolachlor (Dual Magnum): injured pepper transplant from metolachlor application under the plastic beds

The concept of **herbicide carriers**

- For **crop-safe placement** of herbicide under the plastic mulch on raised beds
  - Placing herbicide in the weed activity zone
  - Keeping the chemicals out of crop root zone
  - Utilizing slow-release technology
- Slow-release polymer granules (also known as *hydrogels*)
- Fertilizers, manures, compost etc. are also being evaluated as carriers

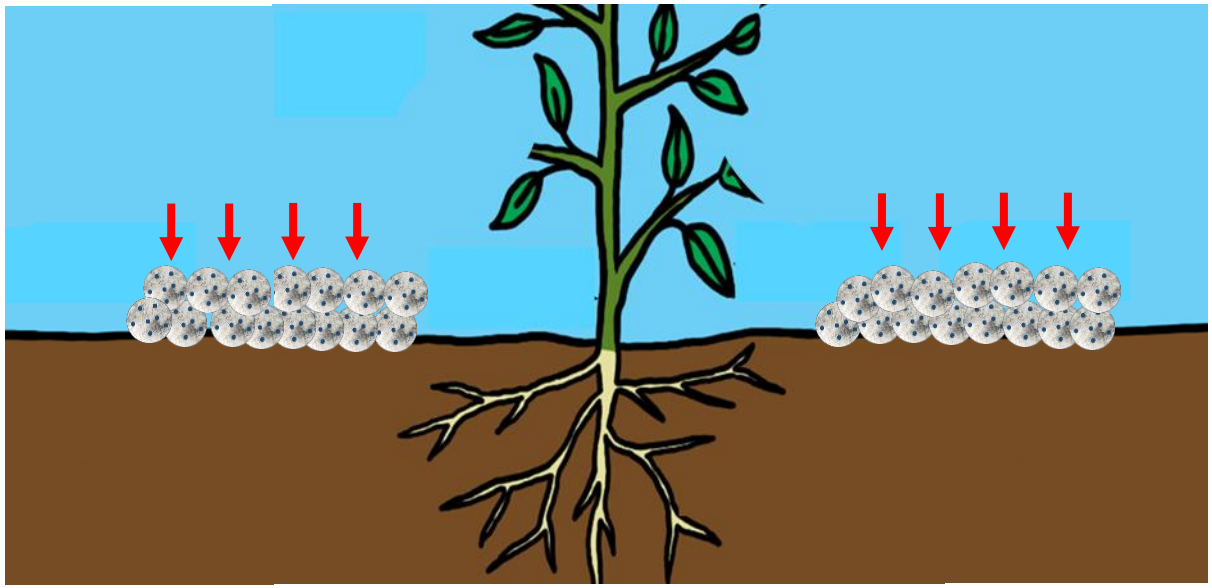
How **herbicide carriers** works ?



- Side dress application on raised beds before installing plastic mulch

How **herbicide carriers** works ?

Key: Herbicide - carrier complex

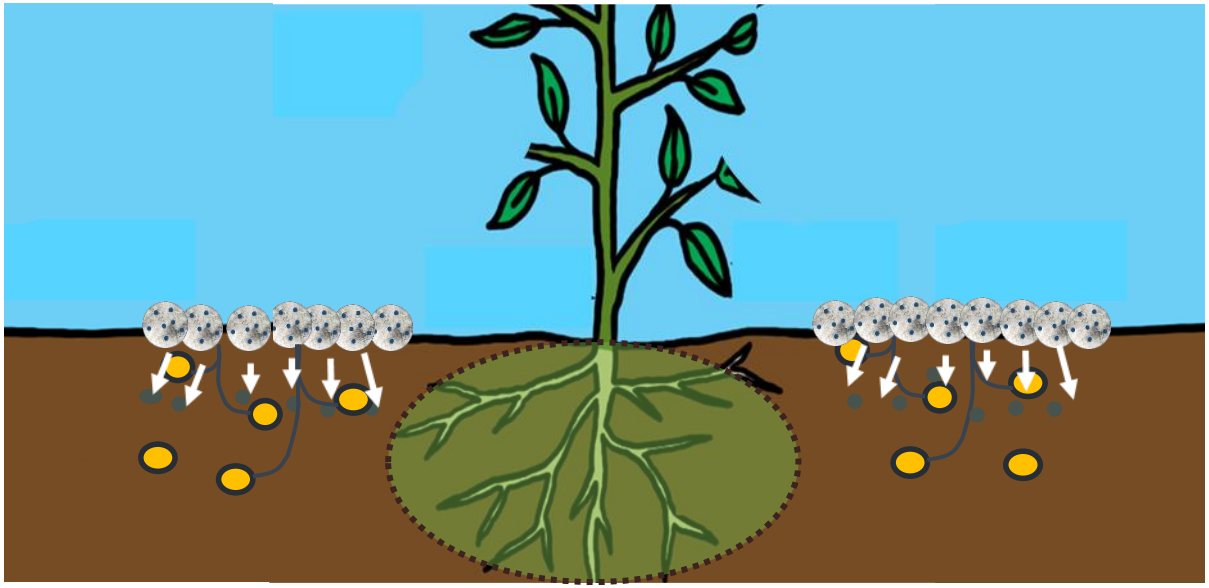


- Side dress application on raised beds before installing plastic mulch

How slow-release carriers works ?

Key

- Herbicide-carrier complex
- Nutsedge tubers
- Herbicide



- Side dress application on raised beds before installing plastic mulch

Hydrogel based pre-emergent herbicide application on raised bed plasticulture production

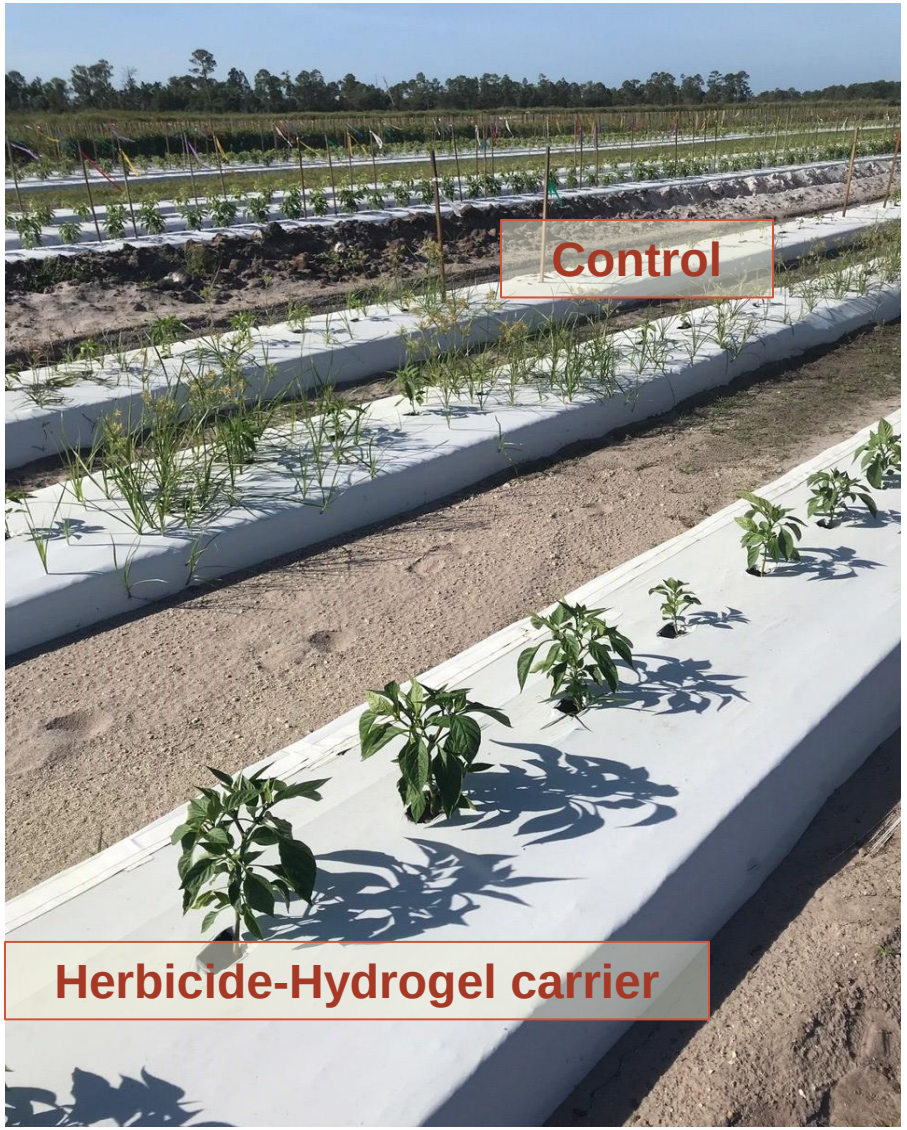
Hydrogels based herbicide application under the plastic in pepper production Immokalee, FL

Hydrogel based pre-emergent herbicide application on raised bed plasticulture production

Pre-emergent herbicide with hydrogel applied on bed under plastic

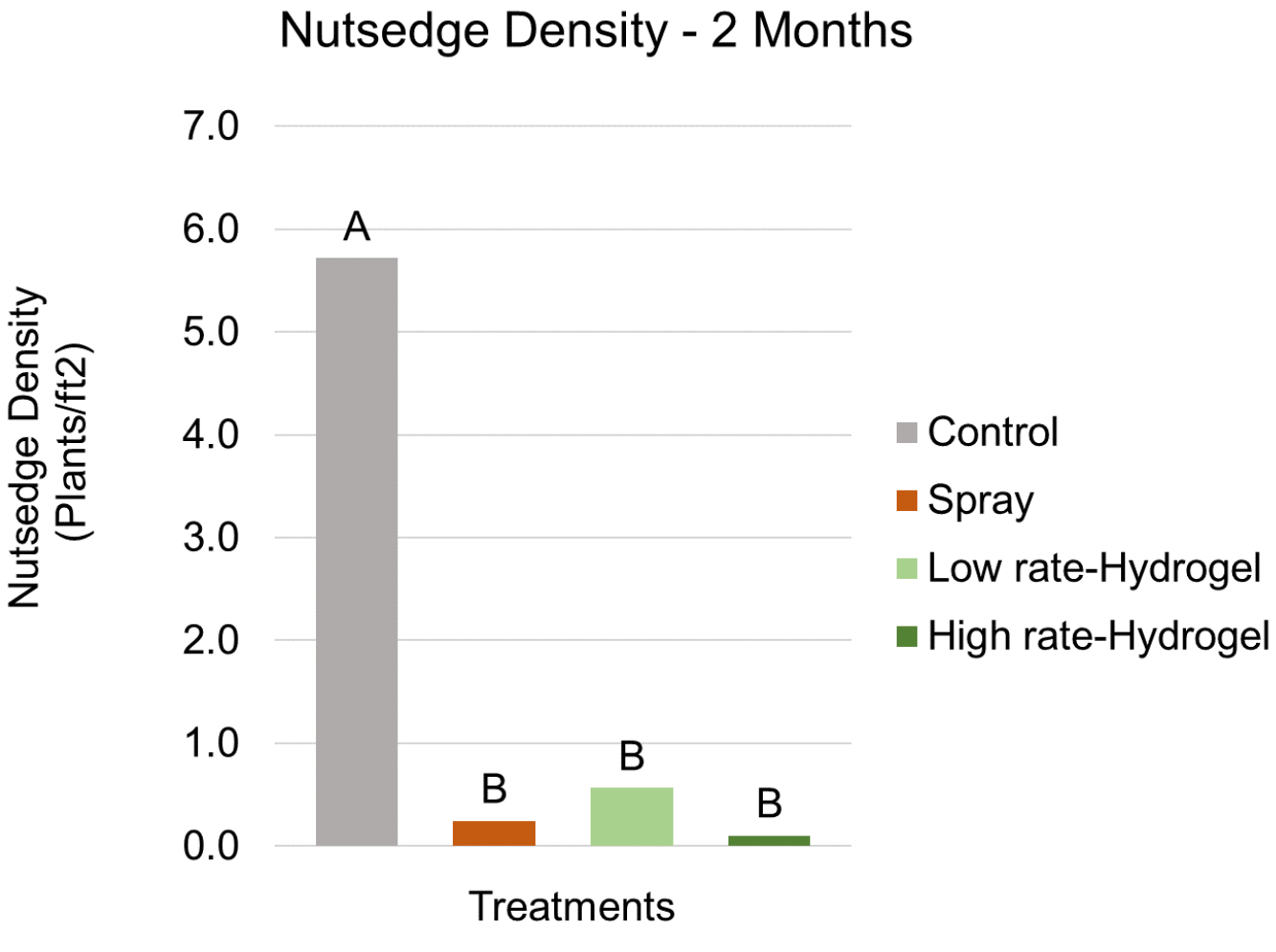
Untreated control

Hydrogel based pre-emergent herbicide application



Hydrogel as herbicide carriers in vegetable plasticulture

- Both spraying and hydrogel-based treatments of s-metolachlor were effective in suppressing Nutsedge



Mean Separation Tukey's HSD at P ≤ 0.05

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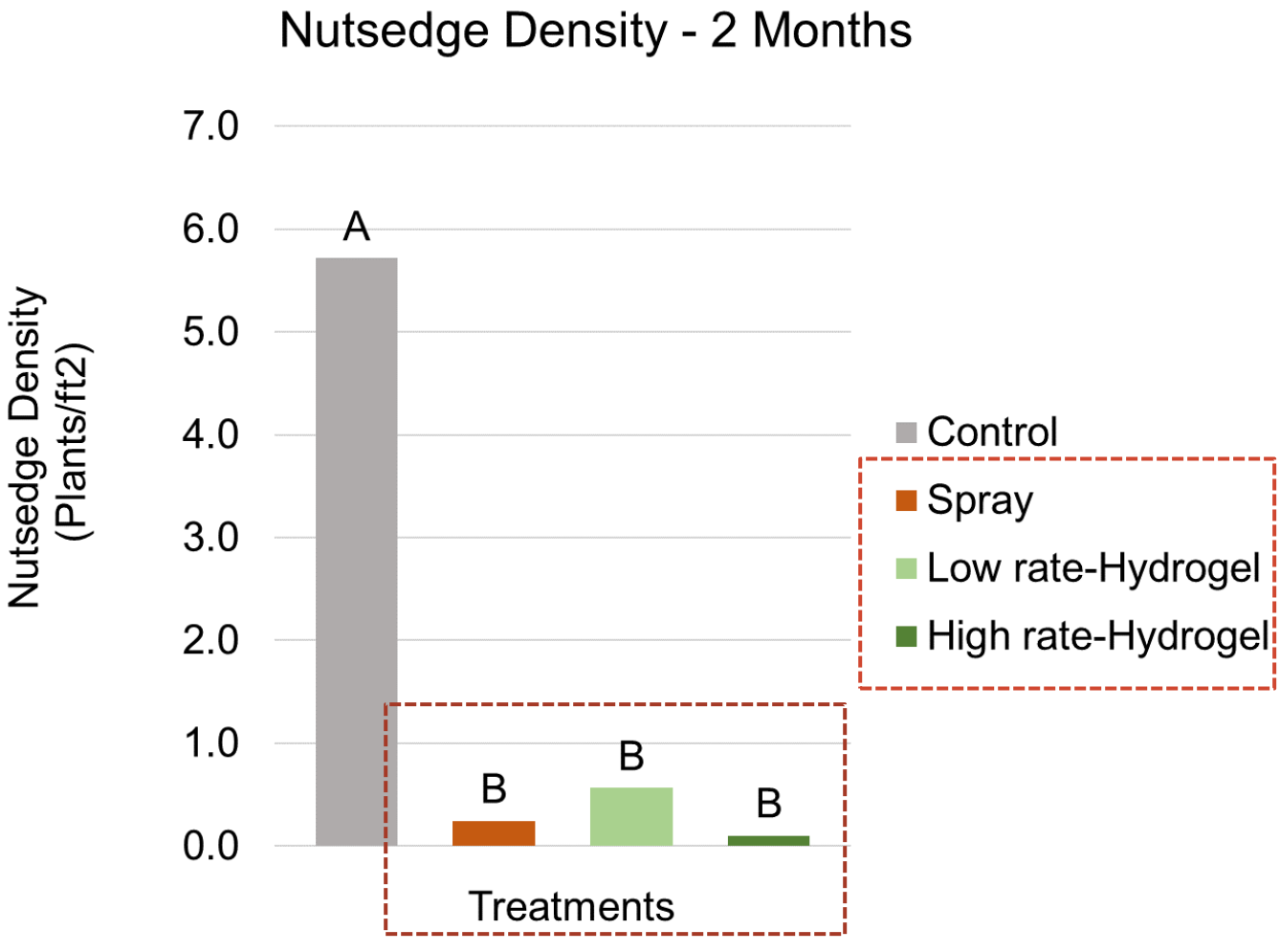
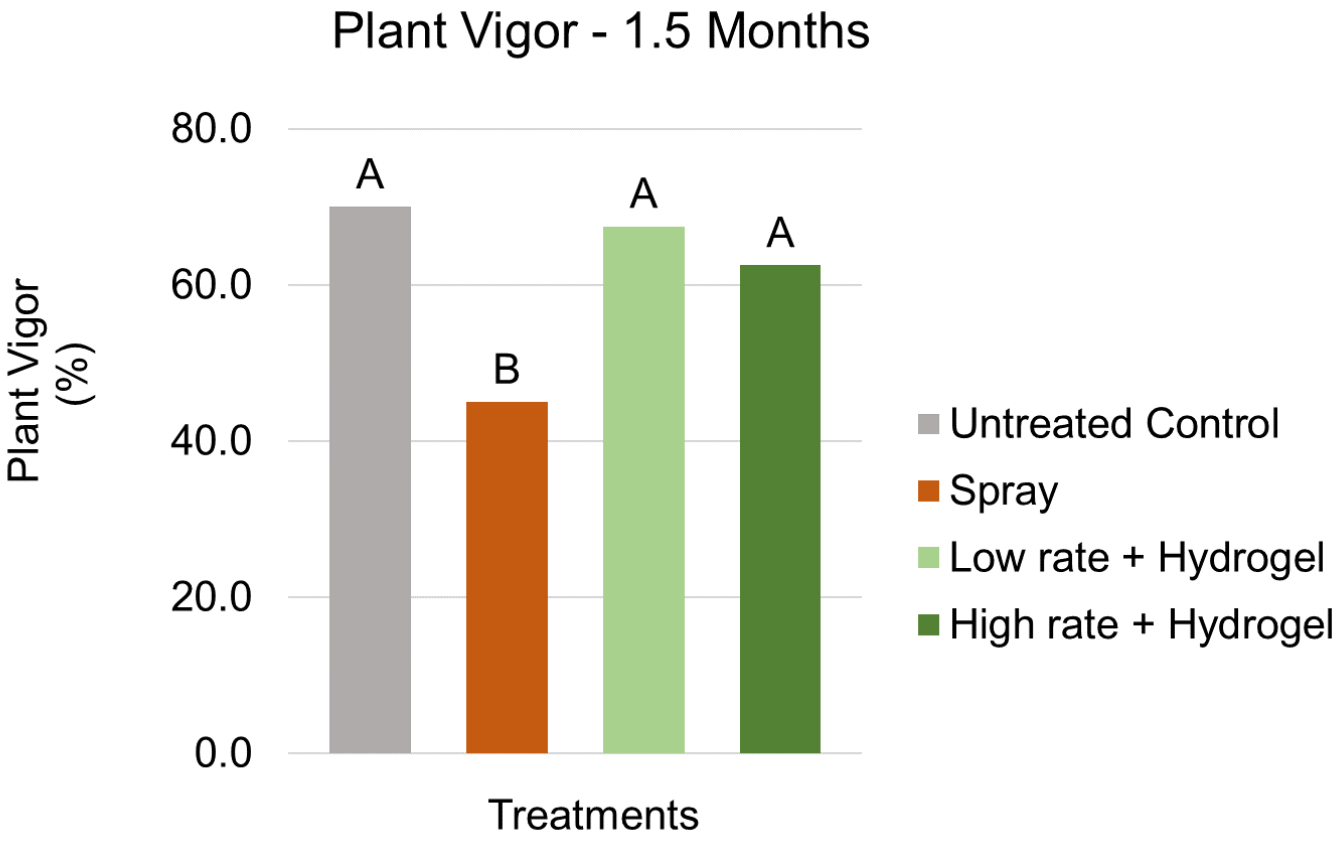


Mean Separation Tukey's HSD at P ≤ 0.05

Hydrogel as herbicide carriers in vegetable plasticulture

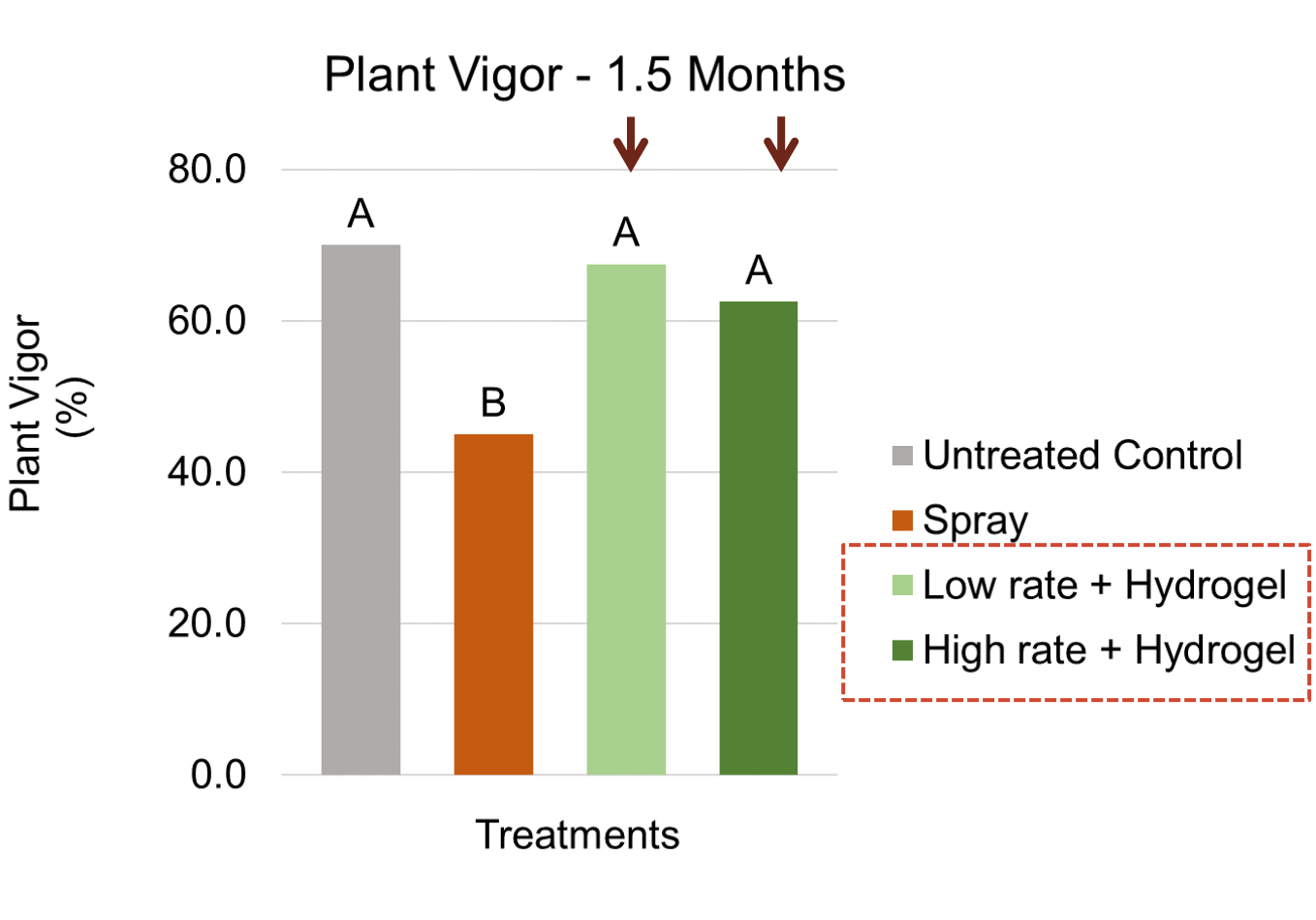
- **Plant vigor of pepper** plants were periodically measured using a hand-held spad meter



Mean Separation Tukey's HSD at $P \leq 0.05$

Hydrogel as herbicide carriers in vegetable plasticulture

- Hydrogel based treatments had better plant vigor



Mean Separation Tukey's HSD at $P \leq 0.05$

Hydrogel as herbicide carriers in vegetable plasticulture

- Pepper yield data was collected

Treatment	Rate (pt/A)	No. marketable fruits	Wt. marketable fruits (g)
Untreated Control	n/a	12^{b}	1893
Spray	1.50	23^{ab}	3777
Low rate + Hydrogel	0.75	35^{a}	5461
High rate + Hydrogel	1.50	30^{ab}	5413
P-value		*0.02*	*0.05*

Mean Separation Tukey's HSD at $P \leq 0.05$

Hydrogel as herbicide carriers in vegetable plasticulture

- Bell pepper yield improved with carrier-based application

Treatment	Rate (pt/A)	No. marketable fruits	Wt. marketable fruits (g)
Untreated Control	n/a	12^{b}	1893
Spray	1.50	23^{ab}	3777
Low rate + Hydrogel	0.75	35^{a}	5461
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P-value		*0.02*	*0.05*

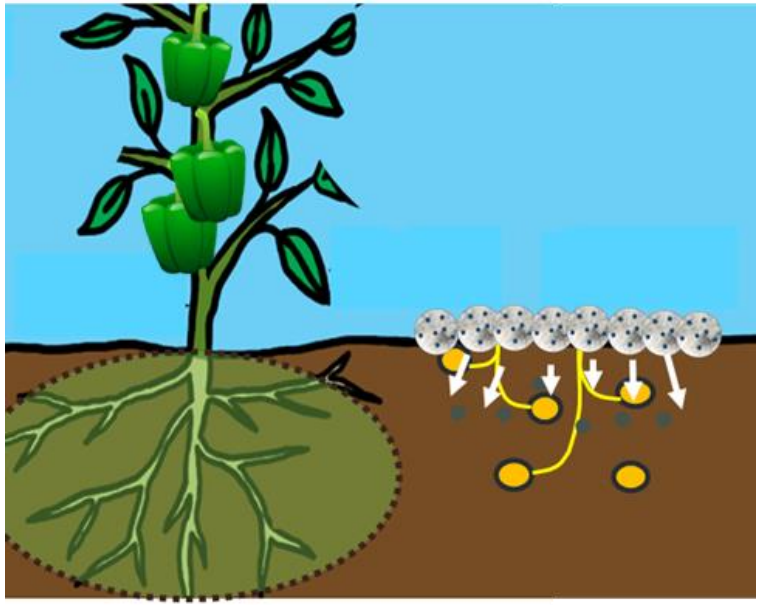
Mean Separation Tukey's HSD at P ≤ 0.05

Ongoing project: Herbicide carriers and safeners for vegetable plasticulture

Several fertilizers and manures are currently being evaluated as herbicide carriers – *“weeding by feeding”*

- Polymer coated urea
- Chelated Fe EDTA
- Borax
- Compost etc.

Herbicide carriers



Pros

- Improved crop-safety
- Potentially increase the herbicide retention in soil

Cons

- Risk of carry-over toxicity to subsequent crops
- Techniques / equipment to scale up the application in commercial farms

Summary

Summary

Novel and alternative weed management approaches

- **Automation / Machine Learning**
  - *Discriminating the weeds from crop*
  - *Sensors & training*
- **UAS / Drone imaging**
  - *Informed weed management decisions*
- **Steaming**
  - *Efficacy comparable to ‘contact’ herbicides*
  - *Potential weed re-growth possible*

Summary

Novel and alternative weed management approaches

- **Natural herbicides**
  - *Screening of aquatic weeds for herbicidal activity*
  - *Allelopathic effects*
- **Cover crops**
  - *Weed suppression in citrus production*
- **Herbicide carriers**
  - *Slow-release techniques*
  - *Scaling up the application - challenge*

Acknowledgements

SWFREC weed science team (2018-2021)

From left: ***Shea Teems, Biwek Gairhe, Robert Riefer, Ramdas Kanissery***

Not in picture: ***Cami McAvoy, Miurel Brewer, Terea Bentley, Maria Martinez, Ruby Tiwari, Nirmal Timilsna***

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Dr. Peter Dittmar
Dr. Jehangir Bhadha
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and more..

https://swfrec.ifas.ufl.edu/programs/weed-science

Thank you…

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