A Virtual Event

2024 Carrot Research Symposium
Sponsored by the University of California Cooperative Extension

Wednesday, March 20, 2024, | 9:00 AM-12:00 PM
Zoom Webinar

Continuing Education Units
1.5 Hours Other 🥕

Updates on Kern County Trials

Jaspreet Sidhu

UCCE Kern

2023 Trials

- Variety trials
- Cavity spot variety screening
- Nematicide screening
- Pre-emergent herbicide screening
- Organic fungicide screening for Alternaria leaf blight

Organic variety trial

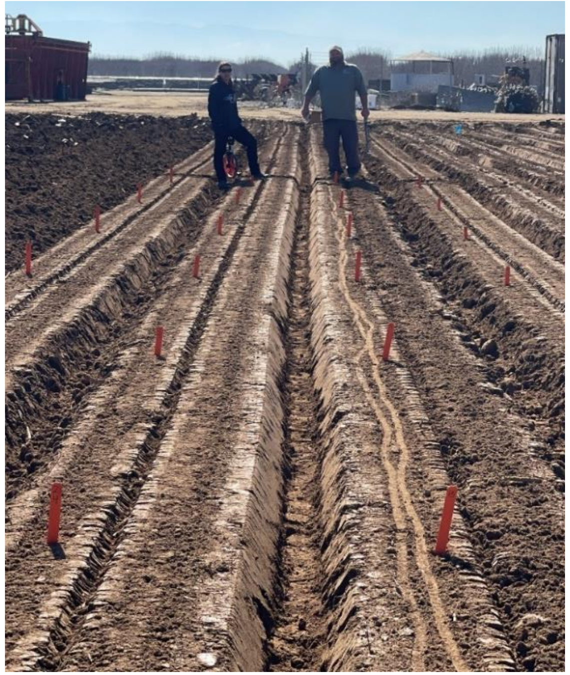
Planted on Aug 7, 2023
Harvested Jan 10, 2023, Field day
10 red entries
Foliar disease severity, root weight, root shape, uniformity, and smoothness

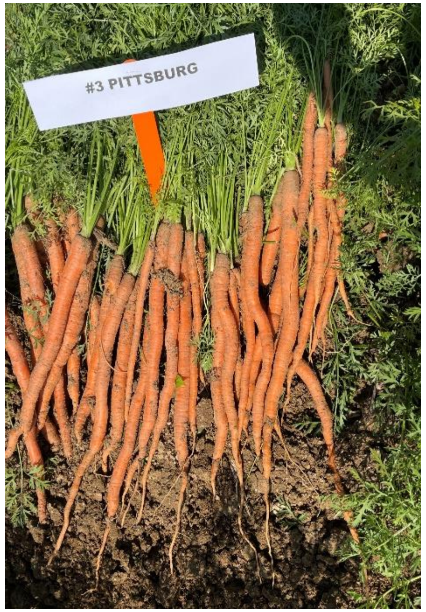
Combined with the domestication trial

Brasilia - Brazil

Conventional variety trial

Planted on Feb 8, 2023
38 Cut and Peel
34 Cello
30 Colored
5 seed companies and USDA Breeding program
Field day: June 23, 2023

Cavity spot variety screening

Dr. Phil Simon’s breeding program

- 56 carrot lines, including 5 cultivars (suscept. Atomic Red)
- 3’ beds with 3 reps, planted in October
- No fungicides
- Carrots harvested and % disease incidence and disease severity index (DSI) was calculated (based on Dr. McDonalds)
- Data on forking

Cavity spot variety screening

Moderate disease pressure in the nursery

Disease severity index ranged from 0-25%

Percent disease incidence 0-47%

Forking between 4-79%

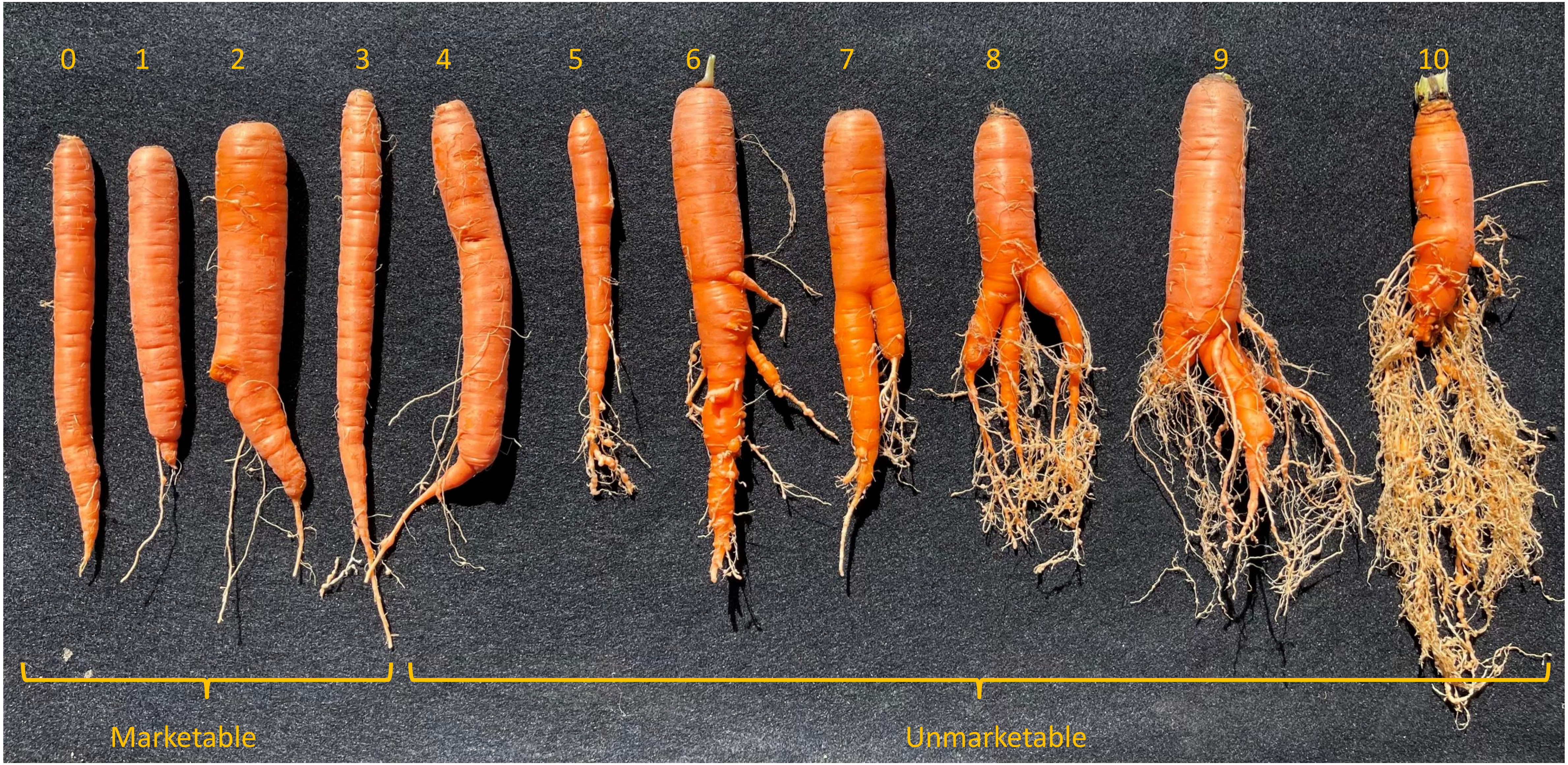




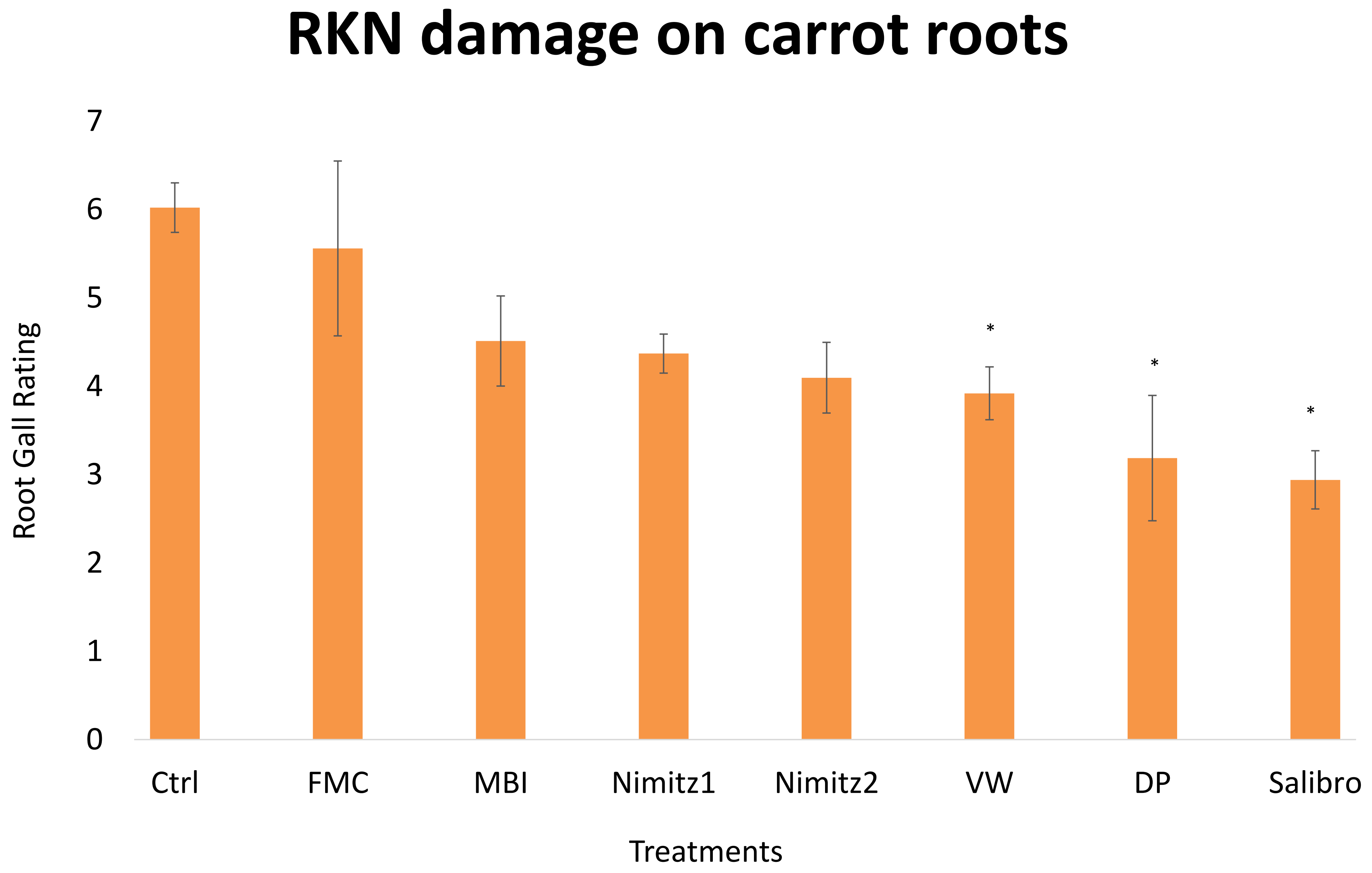
Nematicide screening trial

Trt		Rate
1	Control	
2	Nimitz2	3.5 pints/A Applied on June 1
3	MB1	20 fl oz/ A At Planting, 7 days after planting, and 14-28 days interval as needed
4	FMC	13.7 FL OZ/ A 0-2 days before seeding
5	Nimitz1	5pt/A Applied on June 1
6	Salibro	30.7 fl oz/ A, At planting 28 days after planting
7	DP1	11.4 fl oz/A at planting
8	Velum+Watermaxx	6.5 fl oz/ A 2 qtz/A At planting, 7 days after planting

0-10 scale for carrots



Carrot roots showing damage caused by RKN in the trial

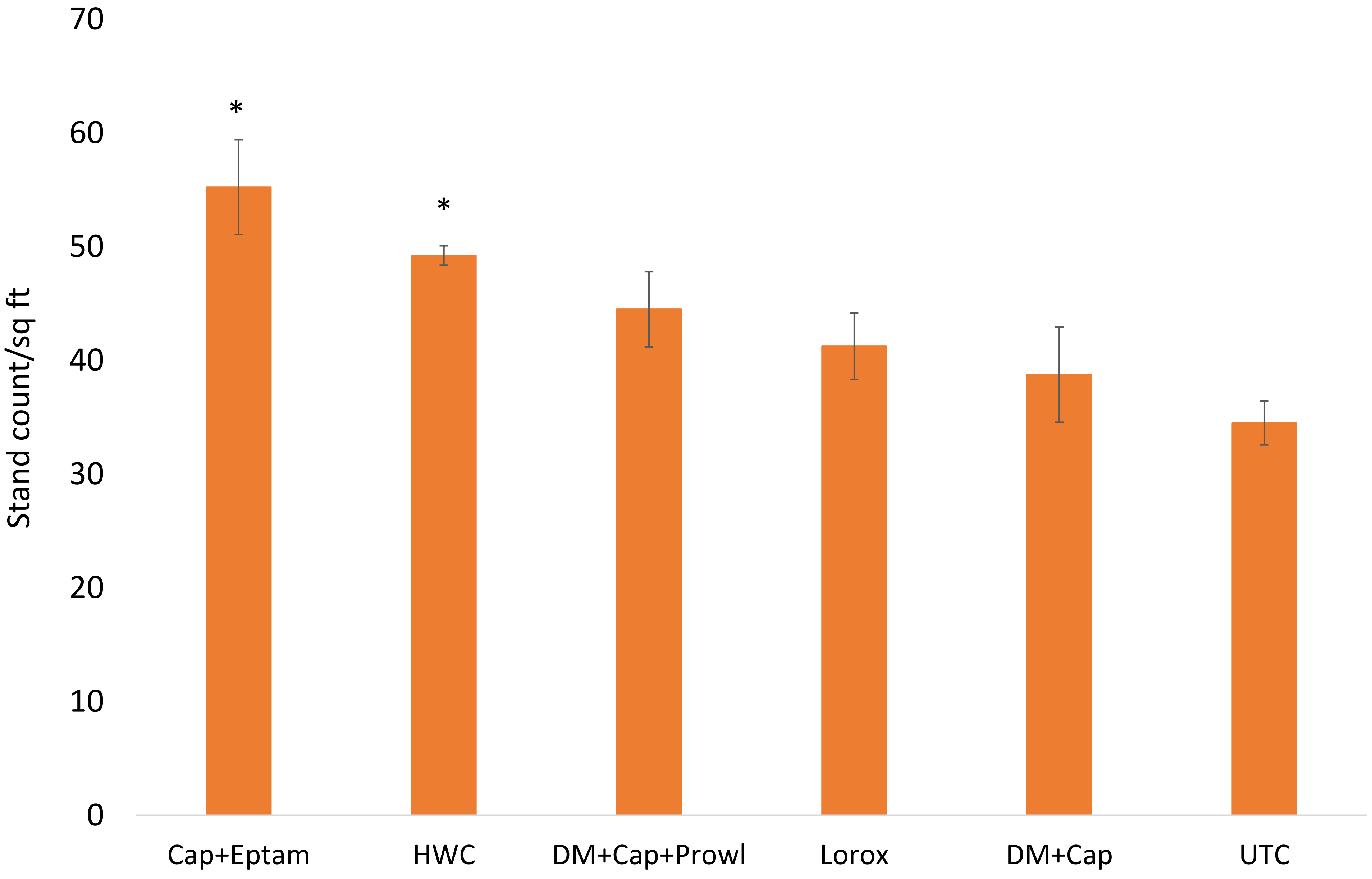

RKN damage on carrot roots
Root Gall Rating
0
1
2
3
4
5
6
7
Ctrl
FMC
MBI
Nimitz1
Nimitz2
VW
DP
Salibro
*
*
*
Treatments

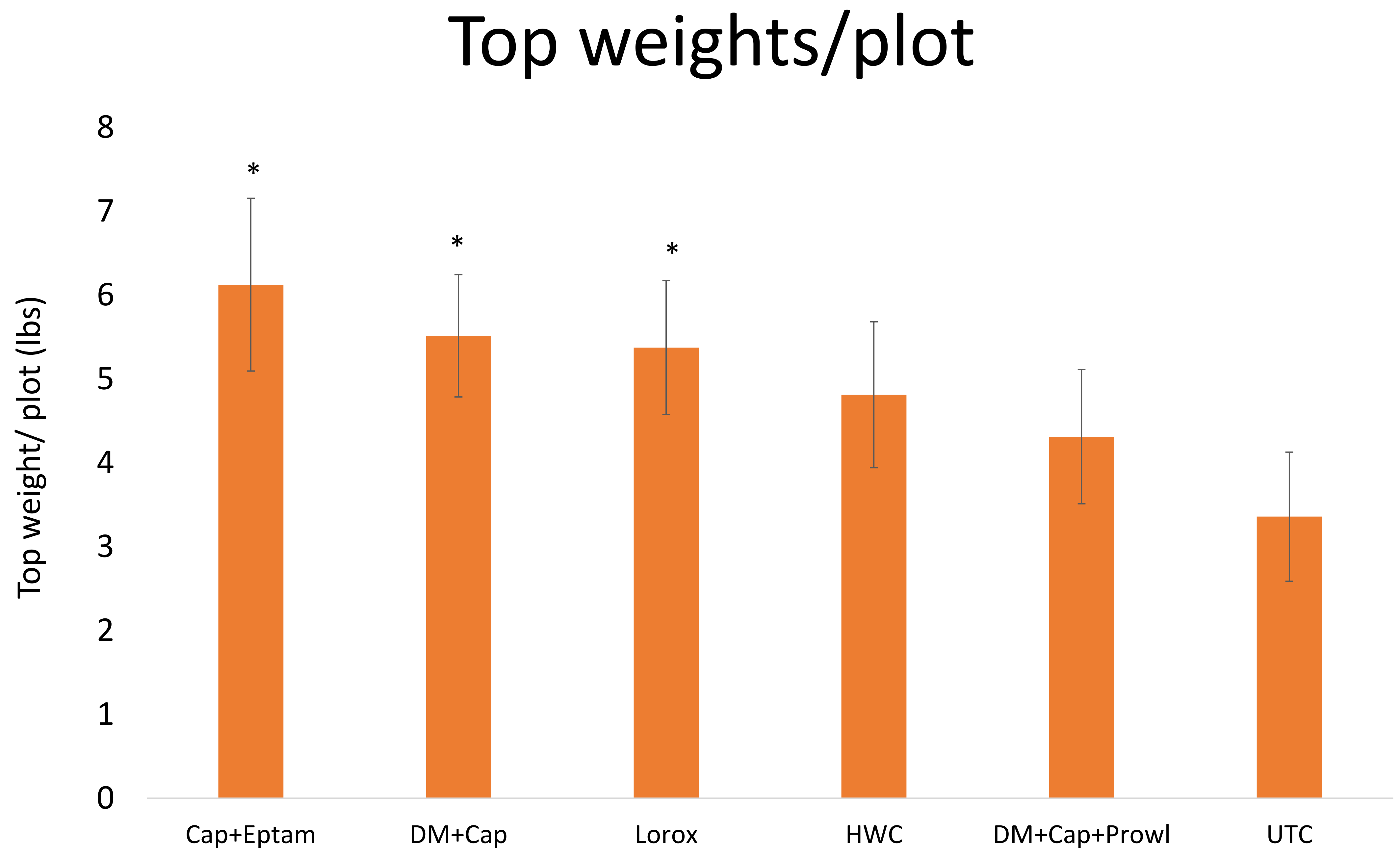
Herbicide Screening

	Pre emerge treatments	Rate / A
1	UTC	
2	HWC	
3	Lorox	1lb/A
4	Dual Mag (DM)+Caparol	0.25pts/A + 2Pts/A
5	DM+Caparol+Prowl	0.25pts/A + 2Pts/A + 2 Pts/A
6	Caparol+Eptam	2pt/A + 3.5Pts/A

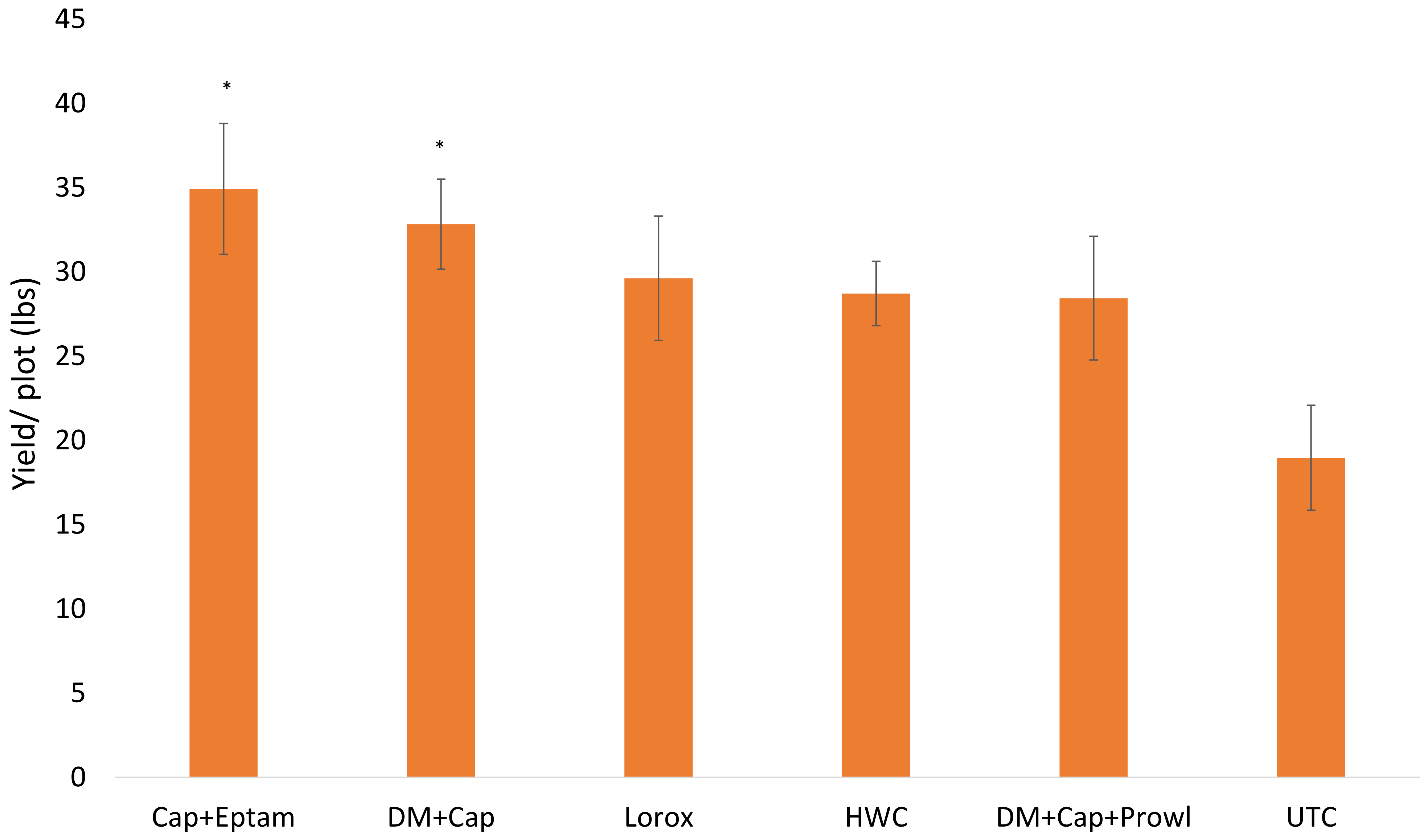
Plot size: 30” wide,30 ft long

Stand count/ Sqft (5 weeks after treatment)




Top weights/plot
Top weight/ plot (lbs)
8
7
6
5
4
3
2
1
0
*
*
*
Cap+Eptam
DM+Cap
Lorox
HWC
DM+Cap+Prowl
UTC

Yield/plot


45
40
35
30
25
20
15
10
5
0
Yield/ plot (lbs)
*
*
Cap+Eptam
DM+Cap
Lorox
HWC
DM+Cap+Prowl
UTC


1
UTC

2
HWC

6
Cap+Ept

4
DM+Cap

1

Moving Forward

- Maintain the cavity spot nursery and continue screening biologicals and varieties
- Keep expanding and maintaining the RKN nursery
- Evaluate a combination of nematicides and soil surfactants as pre and post applications.
- Evaluating organic and conventional fungicides for Alternaria leaf blight management.
- Conventional and organic variety trials
- IR4 trial evaluating use of Zidua (pyroxasulfone) in carrots

Acknowledgements

- Dr. Isolde Francis
- Jed Dubose
- Jennifer Fernberg
- Cristal Hernandez

Bolthouse FARMS

CALIFORNIA FRESH CARROT ADVISORY BOARD

GRIMMWAY FARMS

BAYER

Gowan USA

CFCAB project

Evaluation of Fungicide Performance Delivered by Solid-set Overhead Sprinkler Irrigation System on Alternaria Leaf Blight and Assessments on Cottony Rot

Sean Wang[1,2], Susannah Da Silva[1,2], Bob Hochmuth[3], Derek Hurley[2], Ben Broughton[3], Jeff Rollins[1], and Mathews Paret[1,2,*]

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[2]North Florida Research and Education Center, University of Florida, Quincy, FL

[3]North Florida Research and Education Center, University of Florida, Live Oak, FL

2024 University of California Cooperative Extension Carrot Research Symposium Webinar, Mar 19

UF UNIVERSITY of FLORIDA

PLANT PATHOLOGY
UF/IFAS

Alternaria Leaf Blight

- Warm, wet conditions ideal for spread
- Begins as water-soaking on foliage, developing into small brown to black spots with yellow margins, eventually resulting in complete necrosis
  - Often on leaf margins
  - Can be present on stems
  - Can move rapidly in ideal environmental conditions

Alternaria Leaf Blight

- Severe foliar damage can result in harvesting issues and decreased yields
- Two fungal species of Alternaria causing Alternaria leaf blight in carrots found in Florida
  - *Alternaria dauci*
  - *Alternaria alternata*
- Disease management tactics
  - Use of clean, certified carrot seed
  - Plant disease tolerant varieties
  - Fungicide use (to control disease) & rotation (to avoid resistance)
  - Crop rotation

Mature spores (with long tail, center) of A. dauci beside young spores.
Photo credits: Mason Newark

Rationale of the current study

- Historically, fungicide efficacy studies are conducted using delivery mechanism that comprise of a backpack sprayer system pressurized by CO_2.
- However, majority of carrot producers in CA and other states use a solid-set overhead sprinkler irrigation system for fungicide delivery.
- Hypothesis: Fungicide performance delivered by soil-set irrigation system could vary compared to tractor application

Alternaria leaf blight trial setup in Live Oak, FL, spring 2023

- Plot Dimensions
  - 40-ft x 24-ft
  - 4 beds/plot
  - Single bed has 8 rows of carrots
- 16 treatment plots
  - 3 replicates per treatment
  - 6 chemicals, 2 checks
  - 2 application methods
    - Tractor spray
    - Riser/irrigation injection

- Riser setup:
  - 4 risers/plot
  - 180^o spray range at plot ends, 360^o spray range for risers in middle of plot

Field Layout

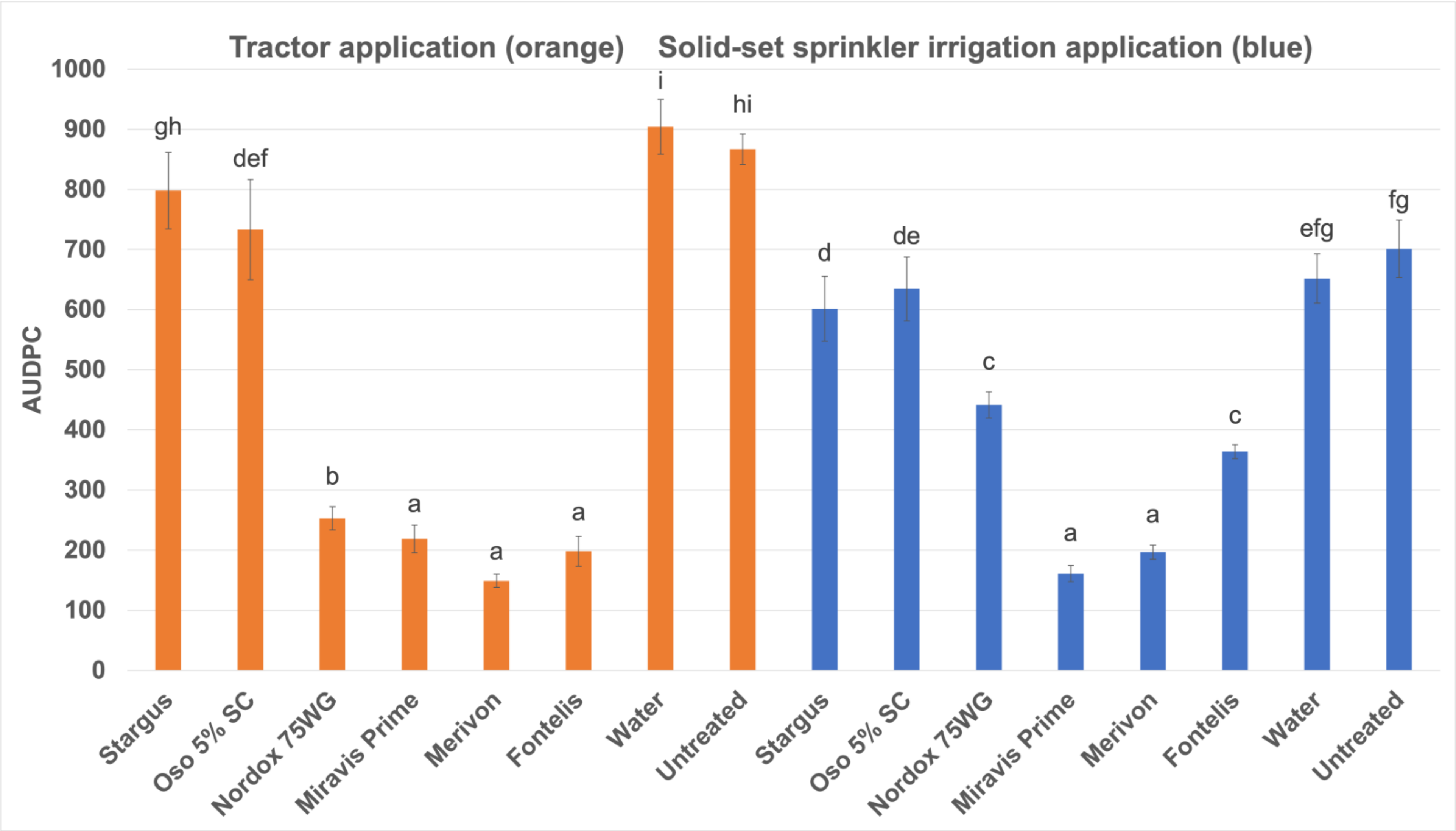
- Each treatment comprises 4 beds each, and then replicated 3 times
- Planted with Maverick variety on 1/8/23 at 550,000/A
- Weekly applications of test products
- Weekly disease severity evaluations using Horsfall-Barratt scale by 3 separate individuals. Assessments was conducted for each bed in a plot
- Field visit and assessment by growers at the end of the trial

Treatment Procedure

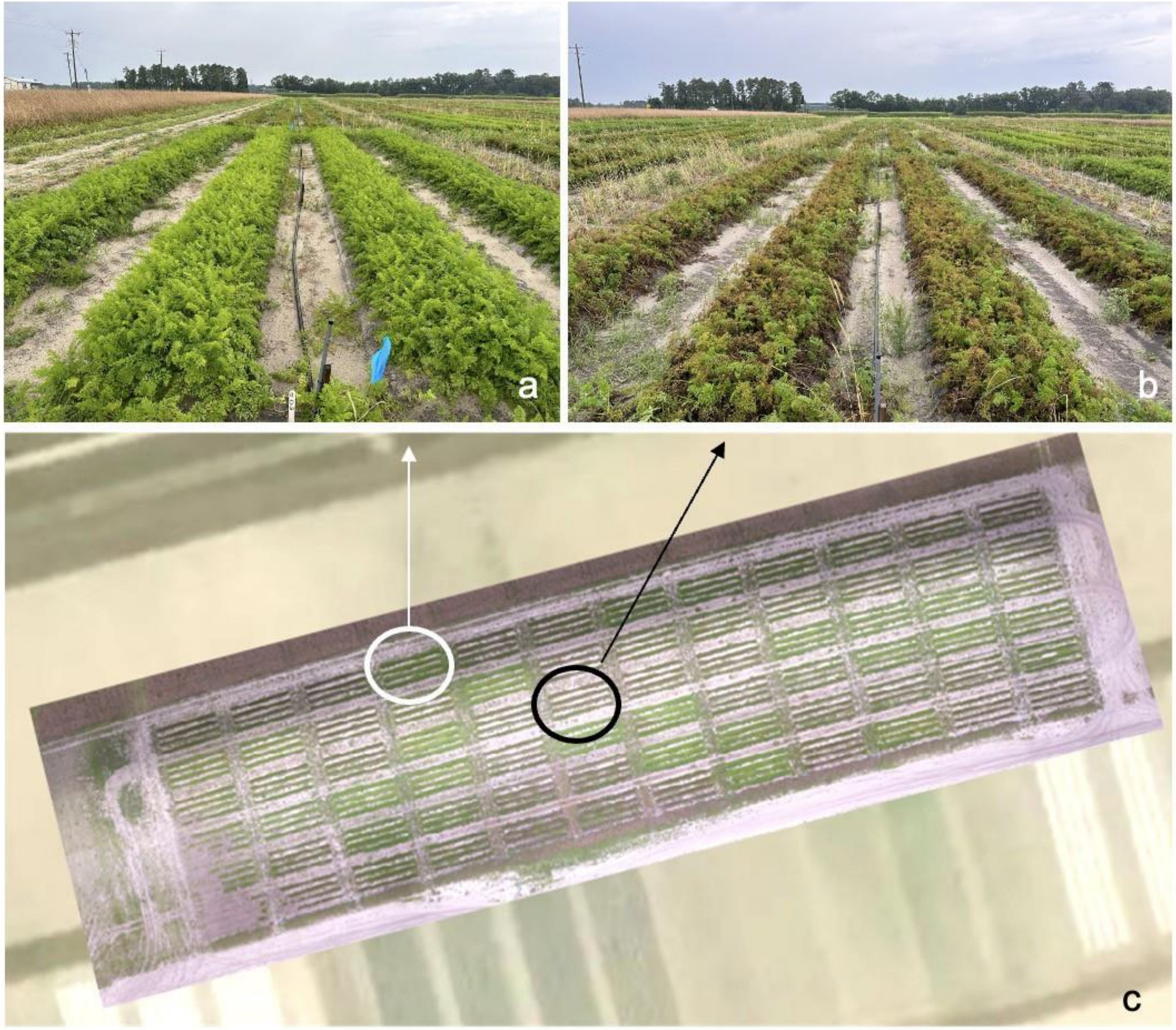
- Treatments injected at 50 psi using CO_2 directly into line after non return valve to sprinklers.
- Each treatment block irrigates at 40-45 psi.
- Each line is equipped with a shutoff valve and a non-return valve.
- Treatments slowly injected until line is primed with treatment then allowed to flow until treatment is finished.
- After treatment is complete line is allowed to flush and valve to line is closed to allow chemical to stick.
- Tractor applied treatments were sprayed between 15-25 psi

Treatment chemicals, rates, and application dates for the Alternaria leaf blight trial during in 2023

Treatment	Application dates
1. Stargus (3 qt/A) - Tractor application	Week 1: 4/5/2023 Week 2: no application (rain) Week 3: 4/19/2023 Week 4: 4/25/2023 Week 5: 5/3/2023 Week 6: 5/10/2023 Week 7: no application (rain) Week 8: 5/25/2023
2. Oso 5% SC (6.5 fl oz/A) - Tractor application	
3. Nordox 75WG (2.5 lb/A) - Tractor application	
4. Miravis Prime (6.8 fl oz/A) - Tractor application	
5. Merivon (5.5 fl oz/A) - Tractor application	
6. Fontelis (16 fl oz/A) - Tractor application	
7. Water - Tractor application	
8. Untreated	
9. Stargus (3 qt/A) - Irrigation application	
10. Oso 5% SC (6.5 fl oz/A) - Irrigation application	
11. Nordox 75WG (2.5 lb/A) - Irrigation application	
12. Miravis Prime (6.8 fl oz/A) - Irrigation application	
13. Merivon (5.5 fl oz/A) - Irrigation application	
14. Fontelis (16 fl oz/A) - Irrigation application	
15. Water - Irrigation application	
16. Untreated	



The final area under the disease progress curve (AUDPC) for Alternaria leaf blight. The error bars represent the standard error of the mean. The letters indicate statistical significance at the 0.05 level using SNK analysis.



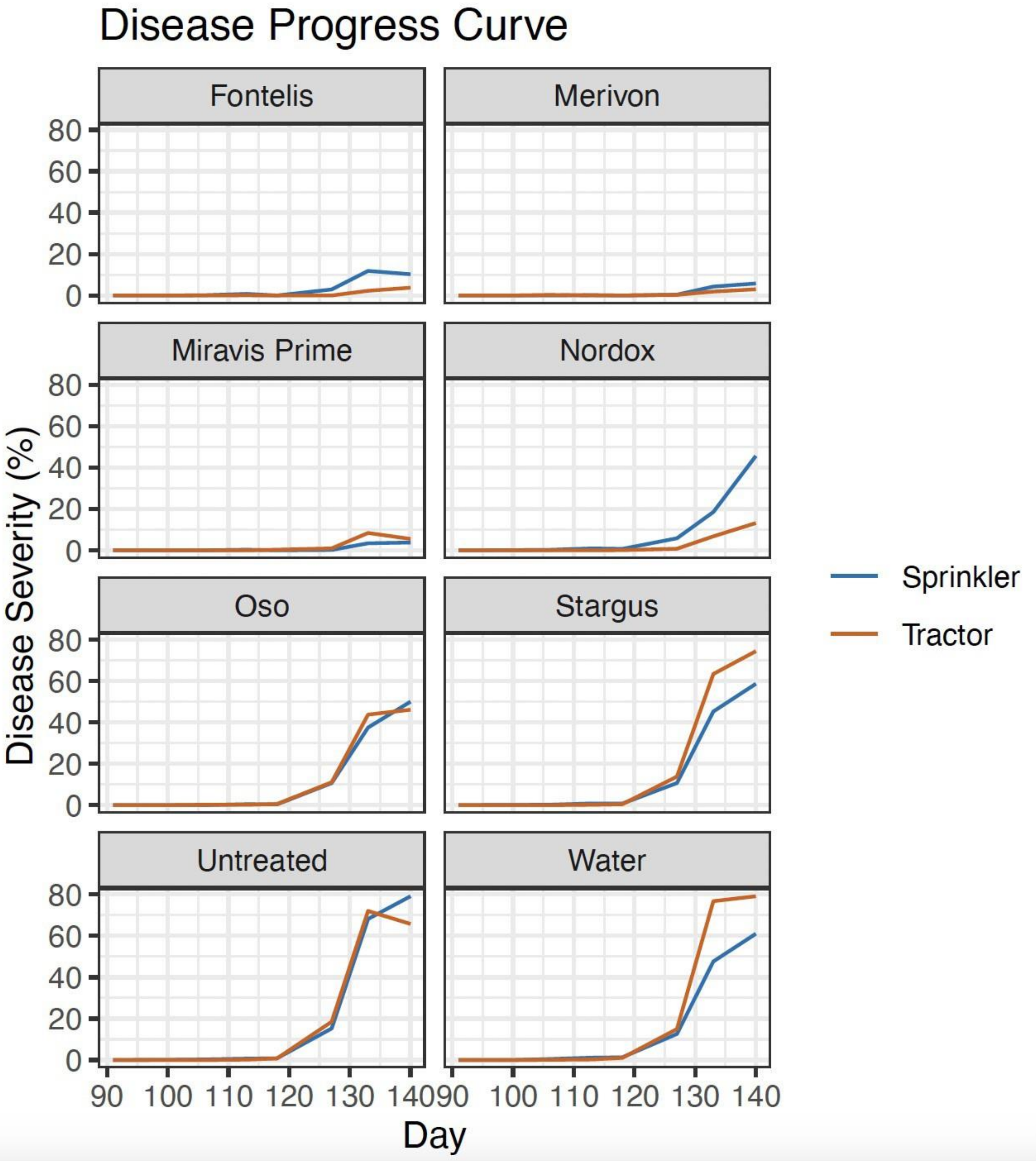
Alternaria leaf blight in carrot field. a. Merivon treatment via tractor application method; b. Untreated treatment; c. Drone photo of the carrot trial 140 days after planting.

Results Summary

Alternaria leaf blight disease severity (%) changes between different treatments starting from planting date. Red = tractor application, Blue = solid-set overhead sprinkler irrigation application.

Current

Repeat of the experiment in progress



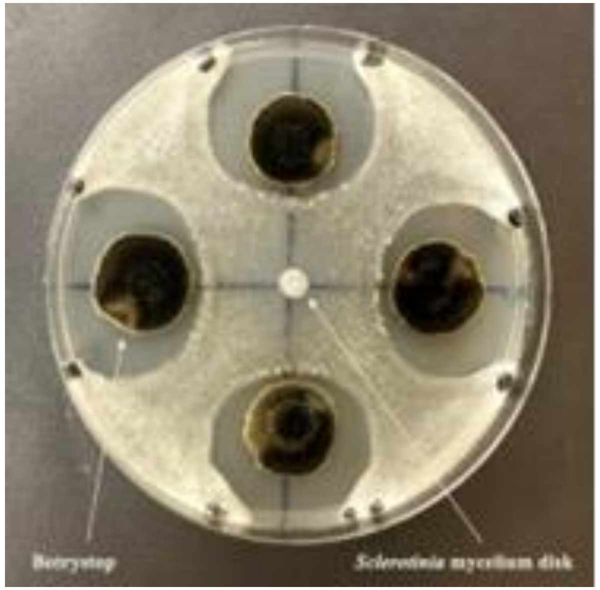
Cottony rot

- Cool, wet conditions ideal for spread
- An early-stage infection causing yellowing of foliage in multiple plants in the field. Severe defoliation especially of older leaves can be noticed in affected areas.
- The sclerotia produced by *Sclerotinia sclerotiorum* are over-wintering structures and are irregular in shape and are black in color. Sclerotia can survive in soil very easily for many years.

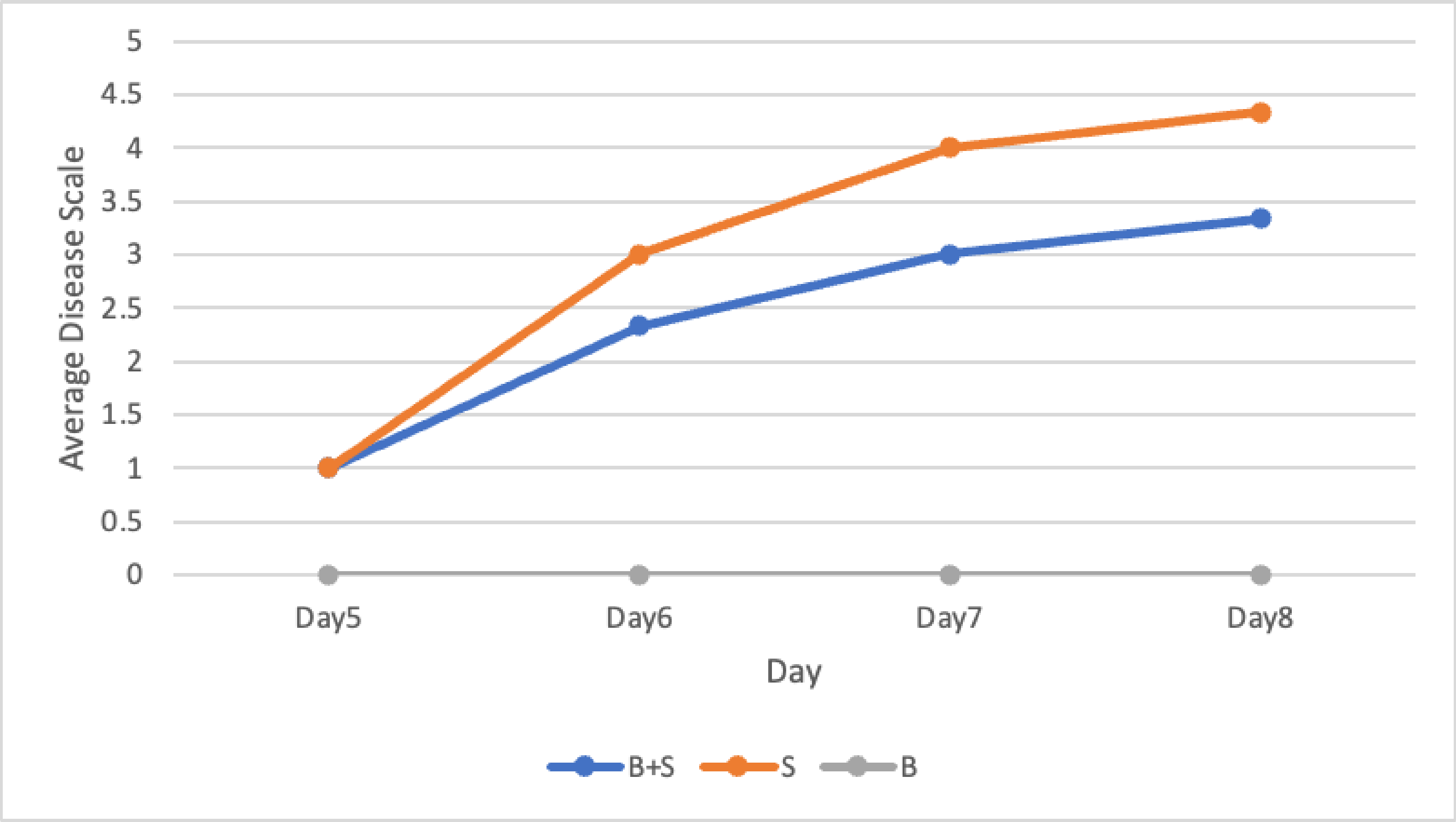
Cottony rot studies

In vitro tests demonstrated efficacy of Botrystop (*Ulocladium oudemansii* strain U3) against *Sclerotinia sclerotiorum*

Disease development is observed starting from 5 days after inoculation until one leaf in each replicate reaches 100% infected area. a. B+S = BotryStop with *Sclerotinia*; b. *Sclerotinia*; c. BotryStop. A scale of 0-5 was used for assessing disease severity.



Average disease scale on leaves with B+S = BotryStop with *Sclerotinia sclerotiorum*; S= *S. sclerotiorum* control; and B= Botrystop by itself (non-pathogen control). A scale of 0-5 was used for assessing disease severity.



Powdered oats inoculum approach

Current

Field trial in progress

Sclerotinia inoculum caused carrot plant death within 7-13 days. Left = Day 0; Middle= Day 7; Right = Day 13.

Conclusion

- Alternaria Leaf Blight: Merivon, Miravis Prime, and Fontelis are the most effective fungicides.
- Fontelis and Nordox performed significantly better with tractor application compared to solid-set.
- Stargus performed significantly better in solid-set compared to tractor
- To refine ALB management strategies, future research will explore optimizing application timings and rates for different fungicides and cultivars across diverse field conditions.

- Cottony rot: A novel powdered oats method for consistent *Sclerotinia* inoculum preparation was developed.
- *In-vitro* experiments identified BotryStop as a potential biocontrol agent against *Sclerotinia*
- Preliminary lab and greenhouse studies indicated BotryStop's potential in protecting carrot plants, showcasing higher survival rates in treated plants compared to controls.
- Optimizing BotryStop application methods and validating its efficacy in diverse field settings are crucial steps.

Acknowledgements

- Ben Broughton, UF-NFREC, Live Oak
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- Dean Mobley, UF-NFREC, Live Oak
- Dr. Sudeep Sidhu, UF-NFREC, Live Oak
- Darren Raj, Agribugs
- Dr. Russ Hamlin, Jason Chandler and Logan Petrey, Grimmway Farms
- California Fresh Carrot Advisory Board
- University of California Cooperative Extension

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University of California
Agriculture and Natural Resources

Updates to Produce Safety Rule proposed revisions to Subpart E – Agricultural Water

Linda J. Harris, Ph.D.
Professor of Cooperative Extension

March 18, 2024

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WESTERN CENTER for FOOD SAFETY
UC DAVIS

FDA U.S. FOOD & DRUG ADMINISTRATION

FDA Proposed Rule
Subpart E
Agricultural Water

Published in Federal Register December 5, 2021

Docket FDA-2021-N-0471

https://www.regulations.gov/document/FDA-2021-N-0471-0001

Comment period closed April 5, 2022

>130 comments

When will the FINAL rule be published?

- FDA provides some information on the process: https://www.fda.gov/media/81779/download
  - If no substantive comments received
    - ≤ 60 days of close of comment period
  - If substantive comments received
    - less clear
- Example: Produce Safety Rule
  - Proposed: January 16, 2013
  - Final: November 27, 2015 (about 3 years)
- Subpart E is much smaller document
  - So: >60 days but < 3 years?
  - Currently @ 1 year and 11 months

Definitions

- **<u>Agricultural water</u>** must be safe and of adequate sanitary quality for its intended use.
  - **Agricultural water** means water used in covered activities on covered produce where water <u>is intended to, or is likely to, contact covered produce or food contact surfaces</u>.
  - **Covered produce** means produce that is subject to the requirements of the Produce Safety Rule. The term <u>"covered produce" refers to the harvestable or harvested part of the crop</u>.

Produce Safety ALLIANCE

SUPPLEMENTAL MATERIAL

Is this Agricultural Water?

Carrots

Drip irrigation

"intended to or likely to contact"✓

Carrots are "covered produce" ✓

Produce Safety ALLIANCE

SUPPLEMENTAL MATERIAL

No change to the underlying regulatory requirement of subpart E: **21 CFR 112.41**

All agricultural water must be safe and of adequate sanitary quality for its intended use.

Current Rule

U.S. FOOD & DRUG ADMINISTRATION

<u>FDA defines</u> adequate sanitary quality:

Pre-harvest applications:

Microbial water quality profile:
GM <126 CFU/100 ml
STV <410 CFU/100 ml
Generic *E. coli*

Harvest and Post-harvest applications:

Microbial water quality profile:
No detectable
Generic *E. coli*
(<1 CFU/100 ml)

Proposed Rule

<u>Farm makes a determination</u> of adequate sanitary quality:

- Review whole water system
- Each grower to set standards and to understand why those standards provide water that is "safe and of adequate sanitary quality"
  - Should be able to explain to inspectors

Agricultural Water Assessment

- *Growers would be required to evaluate these factors to identify conditions reasonably likely to introduce known or reasonably foreseeable hazards onto produce or food contact surfaces*

Ag Water system	• Source and location (surface, ground, municipal) • Water distribution system (open or closed) • Degree of protection from possible contamination including other users, animal impacts, and adjacent land uses
Ag Water practices	• Type of application method (overhead, drip, furrow, flood) • Time interval between last direct application and harvest
Crop characteristics	• Susceptibility to surface adhesion or internalization
Environmental Conditions	• Frequency of rain or extreme weather that might impact the agricultural water system or might damage produce • Air temperatures • Sun (UV) exposure
Other factors	• Includes results of testing

Produce Safety ALLIANCE

Draft SUPPLEMENTAL MATERIAL

Agricultural Water Assessment (AWA)

- *Outcomes: Farms would use the outcomes of the AWA to determine corrective or mitigation measures*

If…	Then…		
Ag water not safe or not of adequate sanitary quality	Immediately discontinue use	and	Take corrective measures before use at pre-harvest
One or more known or reasonably foreseeable hazards related to animal activity, BSAAOs, or human waste for which mitigation is necessary	Implement mitigation measures promptly, no later than the same growing season		
One or more known or reasonably foreseeable hazards NOT related to animal activity, BSAAOs, or human waste for which mitigation is necessary	Implement mitigation measures as soon as practicable, no later than the following year	or	Test water as part of the AWA as needed
No known or reasonably foreseeable hazards for which mitigation is necessary	Inspect and maintain water system regularly and at least once a year		

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Draft SUPPLEMENTAL MATERIAL

Agricultural Water Assessment

Corrective measures

- Re-inspecting the entire affected agricultural water system under the farm's control and, among other steps, making necessary changes **OR**
- Treating the water in accordance with the standards in FSMA PSR

Mitigation measures

- Making necessary changes such as repairs
- Increasing time interval: minimum 4 days between last direct application → harvest (microbial die-off)
- Increasing time interval for harvest → storage (microbial die-off)
  - Other activities such as: Commercial washing
- Changing water application method
- Treating water (PSR standards)
- Taking alternative mitigation measures supported by scientific information

U.S. Department of Health and Human Services

Agricultural Water Assessment Builder

Posted 10 am 3-21-2022

Site Navigation

https://agwaterassessment.fda.gov/assessment

Welcome to the Agricultural Water Assessment Builder!

Thank you for choosing to use the Agricultural Water Assessment Builder. The Agricultural Water Assessment Builder v. 1.0 is a user-friendly tool designed to help farms understand the proposed requirements for an agricultural water assessment in the “Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption Relating to Agricultural Water” proposed rule (agricultural water proposed rule). If finalized, the rule would replace the microbial criteria and testing requirements for pre-harvest agricultural water for covered produce (other than sprouts) in the 2015 Produce Safety Final Rule with provisions for systems-based agricultural water assessments. Relevant definitions and resources can be viewed by clicking the icon next to the title of this page.

New Term, Same Practices

Corrective Measures (in 2015 Final Subpart E)

- Applying a **time interval for microbial die off**
  - Between last application and harvest
  - Between harvest and end of storage and/or removal during activities such as commercial washing
- Re-inspect water system and **make necessary changes**
- **Treat the water**

Mitigation Measures (in 2021 Proposed Subpart E)

- **Making necessary changes** such as repairs
- **Increasing time interval**: minimum 4 days between last direct application → harvest (microbial die-off)
- **Increasing time interval** for harvest → storage (microbial die-off)
  - Other activities such as: Commercial washing
- Changing water application method
- **Treating water** (PSR standards)
- Taking alternative mitigation measures supported by scientific information

Water Treatment and the PSR

Has always been an option within the PSR (§ 112.46)

- Routine operating procedure OR
- Corrective measure

Still the case within the proposed rule

- Outcomes of the Ag Water Assessment drive decisions vs. standards which were originally tied to populations of *E. coli* (GM & STV)

Produce Safety
ALLIANCE

Commonly Used Water Treatment Chemicals or Devices

- **<u>Physical (Pesticide device)</u>**
  - Heat Sterilization
  - Ultra Violet Light (UV)
  - Filtration (Membrane, or other media)
  - Ozone generator

- **<u>Chemical</u>**
  - Peroxyacetic Acid (PAA)
  - Chlorine Dioxide / Chlorine Gas
  - Sodium or Calcium Hypochlorite
  - Copper / Silver Ionization
  - Bromine

- Many crop inputs are distributed with water.
- The interaction of the chemistries and impact on efficacy needs to be considered.

Courtesy of Dr. Channah Rock, University of Arizona

Reassessment of agricultural water

- Conduct each year, **AND**
- Anytime there is a significant change in:
  - The agricultural water system(s)
  - Agricultural water practices
  - Crop characteristics
  - Environmental conditions
  - Other things likely to introduce a hazard
    - i.e. changing to a surface water source
- Evaluate: Impact of the changes, new hazards
- Record:
  - Written determination of whether corrective or mitigation measures needed

Records

- Written records of the pre-harvest agricultural water assessment (AWA) during initial assessment and reassessment, including:
  - Description of factors evaluated
  - Written determination of whether corrective or mitigation measures are needed
- Growers testing pre-harvest ag water as part of their assessment must maintain documentation related to sampling and testing procedures
- Supervisors must review written pre-harvest AWA and determinations

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Draft SUPPLEMENTAL MATERIAL

Exemptions

Farms exempt from conducting a pre-harvest AWA if the water:

- Meets certain harvest and post-harvest agricultural water criteria*
  - E.g., untreated groundwater with test results for generic *E. coli*
- Received from a public water system or supply that meets established requirements (i.e. certificates of compliance, public system results)*, **OR**
- Is treated in accordance with standards outlined in FSMA PSR*

*likely require records

FDA Proposes Subpart E Compliance Dates

- FDA proposes compliance dates for **proposed pre-harvest agricultural water** requirements for covered produce other than sprouts

Business Size	Proposed Water Related Compliance Dates
All other businesses (>$500K)	9 months after the effective date
Small businesses (>$250K-500K)	1 year, 9 months after the effective date
Very small businesses (>$25K-250K)	2 years, 9 months after the effective date

Draft SUPPLEMENTAL MATERIAL

More information: Supplemental Fact Sheets

Agricultural Water Proposed Rule

FDA U.S. FOOD & DRUG ADMINISTRATION

Agricultural Water Assessment

The FDA is proposing to revise certain pre-harvest agricultural water requirements for covered produce (other than sprouts) in Subpart E of the FDA Food Safety Modernization Act (FSMA) Produce Safety Rule. This proposal, if finalized, would replace the pre-harvest microbial quality criteria and testing requirements for such produce in the Produce Safety Rule with requirements for systems-based pre-harvest agricultural water assessments that covered farms would use for hazard identification and risk management decision-making purposes. As part of the assessment, the farms would be required to evaluate the following factors to identify conditions that would be reasonably likely to introduce known or reasonably foreseeable hazards into or onto produce or food contact surfaces:

- https://www.fda.gov/media/154334/download

Agricultural Water Proposed Rule
Factors to consider as part of Agricultural Water Assessment

FDA U.S. FOOD & DRUG ADMINISTRATION

Agricultural Water Assessment

The FDA is proposing to revise some of the pre-harvest agricultural water requirements for covered produce (other than sprouts) in Subpart E of the FDA Food Safety Modernization Act (FSMA) Produce Safety Rule. This proposal, if finalized, would replace the pre-harvest microbial quality criteria and testing requirements for such produce in the Produce Safety Rule with requirements for systems-based pre-harvest agricultural water assessments. If finalized, covered farms would be required to conduct pre-harvest agricultural water assessments once annually, and whenever a change occurs that increases the likelihood that a known or reasonably foreseeable hazard will be introduced into or onto produce or food contact surfaces.

The following chart summarizes the factors that covered farms would be required to consider as part of the assessment. The proposed requirements can be found in the Federal Register.

- https://www.fda.gov/media/154447/download

carrots for resistance to cavity spot and other diseases - 2023

MARY RUTH MCDONALD, UMBRIN ILYAS AND

PHIL SIMON

University of Guelph, Ontario, Canada,

USDA-ARS, University of Wisconsin

- Trials in Ontario, Canada
- High organic matter soil (71%, pH 5.7)
- Cavity spot occurs regularly at this site
- Seeded May or June, harvested in October

Objectives

To screen carrots from the USDA-ARS breeding program for resistance to cavity spot

Susceptible cv. **‘Atomic Red**’ and Brasillia Embrapa
and resistant cv. **Deep Purple**
Cut and peel: **Propeel, UpperCut, Triton**
Cello carrots: **Maverick, Cellobunch, Envy, Bolero, Nairobi, Navedo, Brillyance**

Long term: Contribute to the USDA breeding program to improve genetic stocks for carrot production in California
Also assess leaf blights, forking (Pythium root dieback) and bolting

Several *Pythium* species cause cavity spot, including *P. violae* and *P. sulcatum.*

Both *P. sulcatum* and *P. violae* were found in California in 1991 and 2012.

Pythium sulcatum is the main species in Canada and Washington State

Recent results from Ontario, based on isolations and sequencing in 2022:

P. sulcatum	**68 %**
P. violae	**23**
P. intermedium	3
P. sylvaticum	3

P. ultimum, P. irregulare, P. rostatfingens ~ 1%

California: Vivoda et al. 1991, Lu et al. 2012

Methods- 2013- 2023

Seeding

- 60 carrot lines, including cultivars
- Direct seeded ~ 70 seeds/m, with a push V-belt seeder on to raised beds
    - early June
- Soil 60-78% organic matter, pH 5.7- 6.5
- 4 reps/ line, each rep was 5m (2013) or 6 m = 20 ft (2014 on) in length
- No soil fungicides were applied. Standard herbicides and insecticides were applied to the plots

- .

Other diseases of carrots

Alternaria Leaf Blight

Forking may be the result of Pythium root dieback or other factors

Methods

Harvest

- 50 carrots/rep harvested late Oct. each year and placed in cold storage until assessment.
- A separate sample (50) is assessed for forking

Assessment

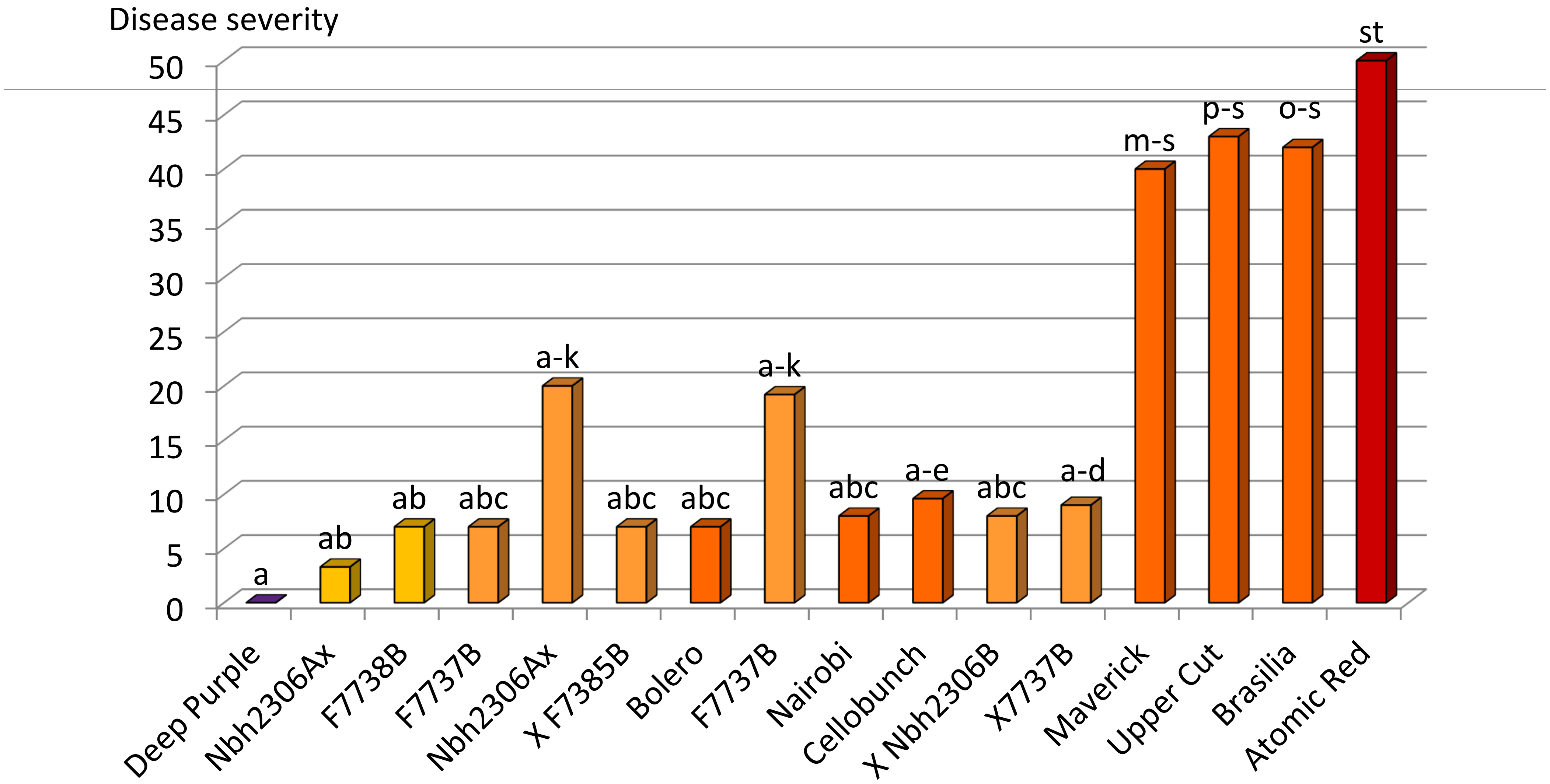
- Carrots were washed and assessed for cavity spot incidence (%) and severity based on the length of the largest lesion per carrot (1= <1 mm, 2= 1-2 mm, 3= 2.1- 5 mm, 4= 5-10 mm, 5= >10 mm)
- A disease severity index (DSI) was calculated
- Carrots were also assessed for carrot leaf blights (Alternaria and Cercospora) and bolting in the field.
- Leaf blight assessment: 0 =no disease, 5 = foliage mostly dead. 2 (some lesions on leaves, none on petiole) and below is good

Notes on 2023 trial

- Plant stand not as good as some years for some lines
- Higher cavity spot:
  - incidence **92%,** (53% in 2022)
  - severity **50%** (23% in 2022)
- Irrigated in August because of low rainfall
- Carrot leaf blights moderate to high (max 3.9 on a 0-5 scale)
- Carrot forking 0 –7%

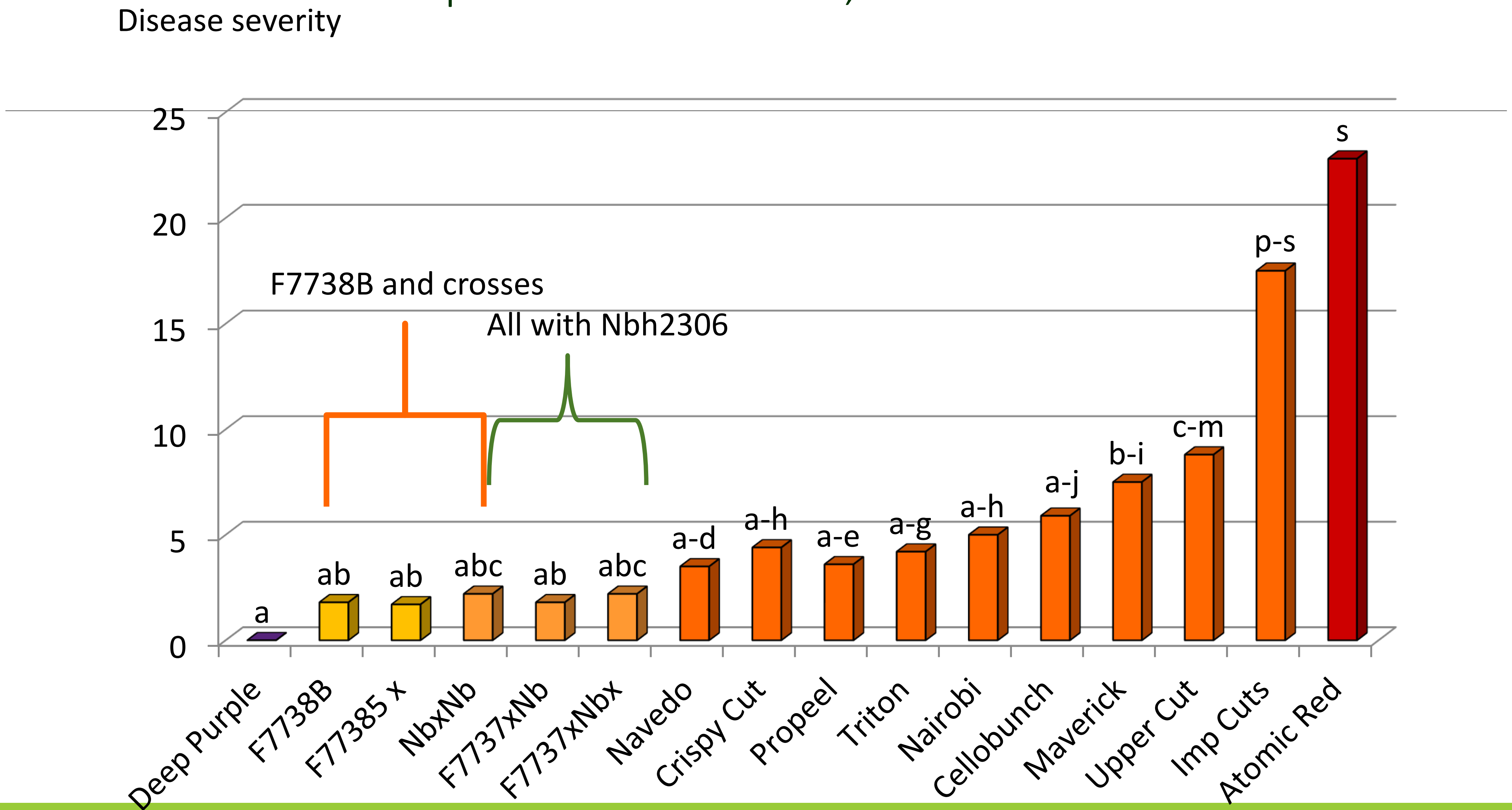
Very little bolting in 2021, 2022 and 2023

Severity of cavity spot on representative carrot lines grown at the Muck Crops Research Station, 2023



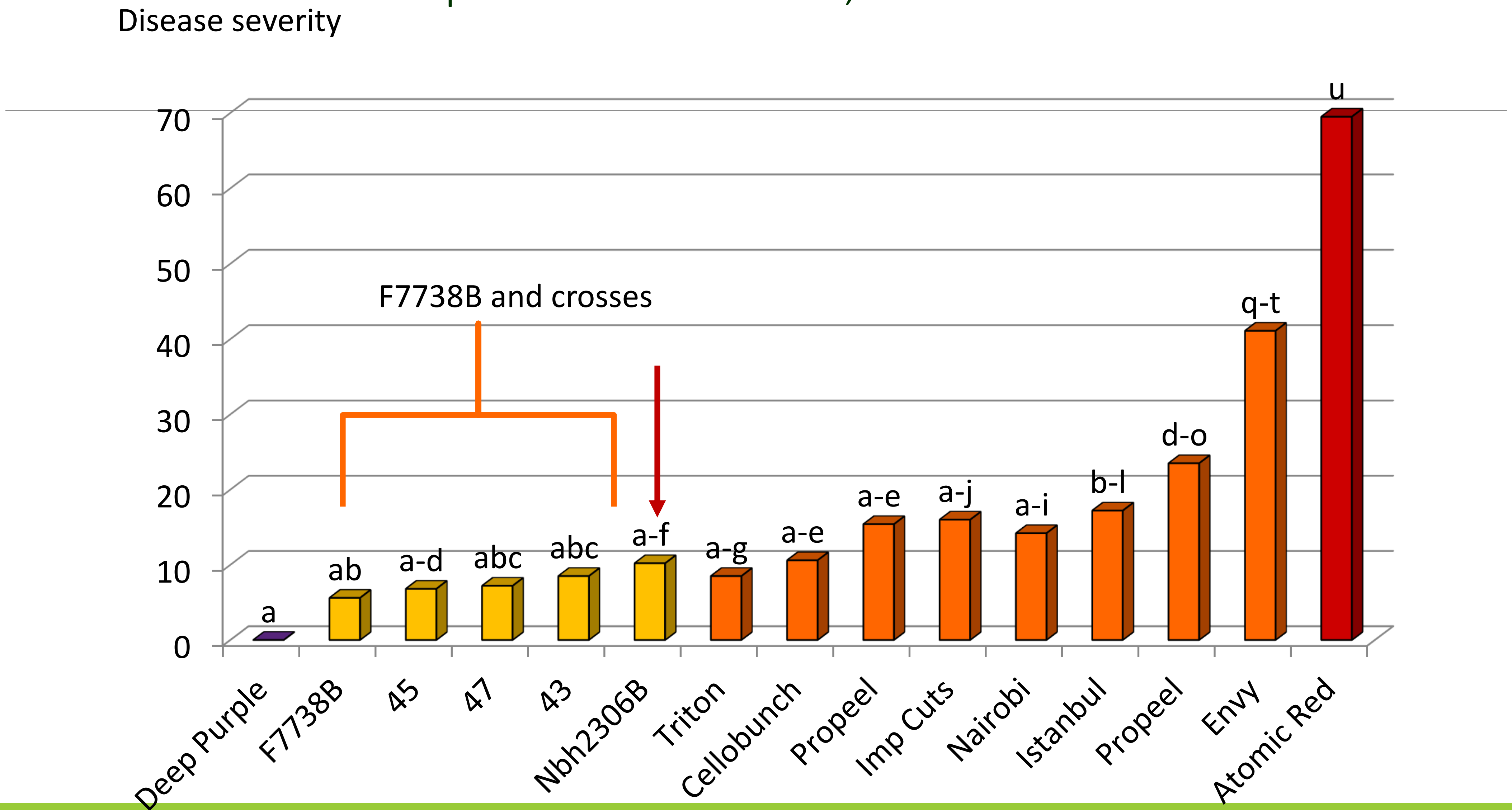
Percent disease ranged from 0 to 92, Disease severity from 0 to 50

Severity of cavity spot on representative carrot lines grown at the Muck Crops Research Station, 2022



Percent disease ranged from 0 to 91, Disease severity from 0 to 70

Severity of cavity spot on representative carrot lines grown at the Muck Crops Research Station, 2021



Percent disease ranged from 0 to 91, Disease severity from 0 to 70

Nbh2306A x U7393: Incidence 12% **Severity 3.3** %

Nematode resistant cross

F7738B Incidence- 17%, Severity 7%

Deep Purple

No cavity spot

Atomic Red from 2022

Incidence – 91, Severity 70


U8277 Incidence 91%
Severity 63%
4033CC

Carrots with low cavity spot 2023

Line	Cavity spot (%)	Severity (0-100)	Forking (%)	Leaf blight (0-5)
Deep Purple	0 a	0 a	7	1.8
Nbh2306AxU7393	12 ab	**3.3 ab**	3	2.8
F7738B	17 abc	**6.8 ab**	3	2.8
F7737B	18 a-d	**6.7 abc**	1	**0.8**
Nbh2306AxU7393	19 a-d	**19.5 a-k**	4	2.5
Atomic Red	91.7 u	49.7 st	3	3.0

Forking ranged from 0- 7%. Leaf blight ranged from 1.3 to 3.5.

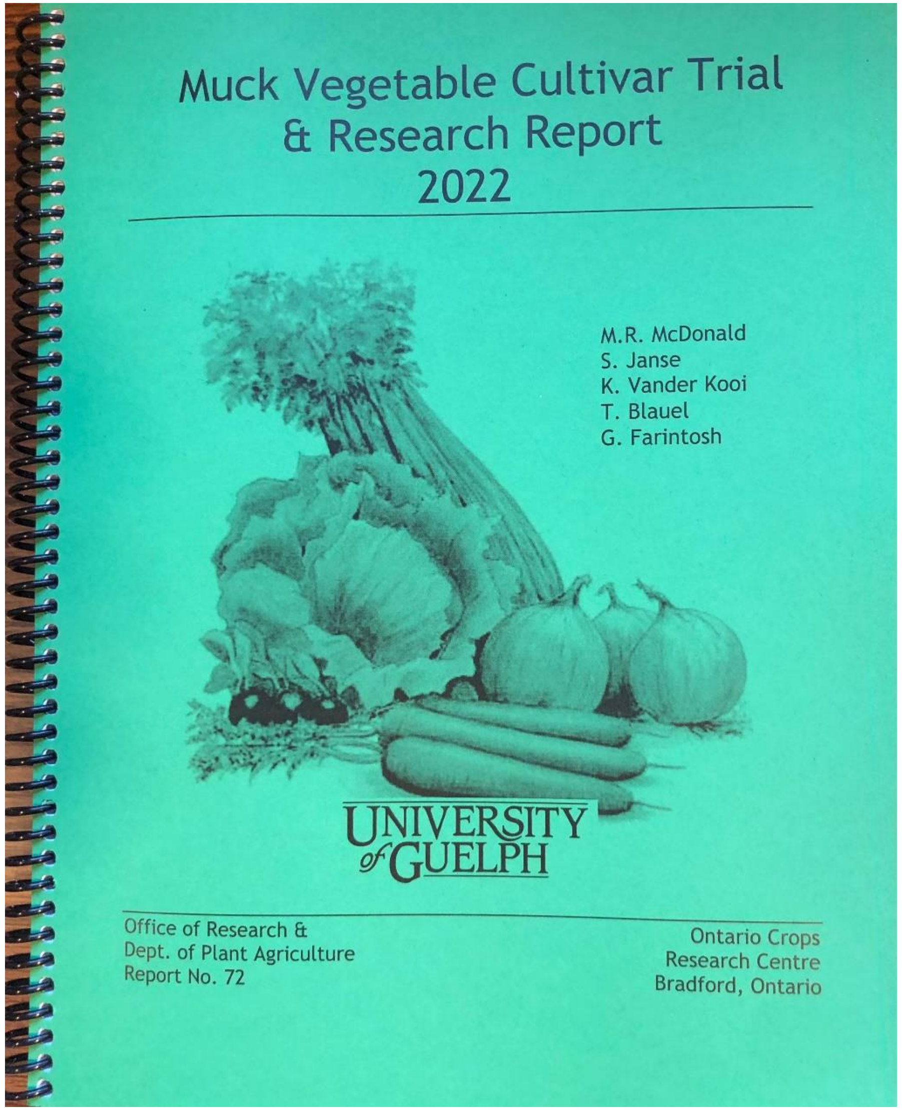
Carrots with low cavity spot 2022

Line	Cavity spot (%)	Severity (0-100)	Forking (%)	Leaf blight (0-5)
Deep Purple	0 a	0 a	14	1.0
F7738B 3 way	4.5 ab	**1.8 ab**	3.5	2.0
F7738BxF7738B	6.0 abc	**1.7 ab**	2.5	3.8
F7738BxNbh2306	7.0 a-d	**2.2 abc**	6.0	**0.8**
L9786B	8.2 a-e	**2.2 abc**	3.6	3.6
Atomic Red	53.3 u	22.8 s	6.5	2.4

Forking ranged from 0- 15%. Bolting ranged from 0 – 1.4, but most were 0).

Summary

- Higher disease pressure in 2023 than in 2022. Similar to 2021
- Several orange lines had low cavity spot and some are crosses with nematode resistant lines.
- One of the parental lines with low cavity spot also had low leaf blight.
- Atomic Red and some orange carrots were very susceptible (Brasilia Embrapa, Maverick, UpperCut)
- Information contributes to Phil Simon’s breeding for cavity spot resistance



All research trials are summarized in the Annual Report

Download at the web site:

https://bradford-crops.uoguelph.ca/

Or search: Ontario Crops Research Centre – Bradford

2023 report will be posted in early April

Research team 2023

Acknowledgements

Funding provided by the California Fresh Carrot Advisory Board

Additional funding by the Ontario Agri-Food Innovation Alliance and the Fresh Vegetable Growers of Ontario

Pythium isolated from different sizes of lesions collected from several fields with different carrot cultivars, Holland Marsh, 2022

Number of isolates of *Pythium* species in each field							
Field	B-SL2	E-SL5	S-SH3	C-SL3	F-SL6	W-MCRS	Q-MCRS
Cultivar	**SV2384DL**	**SV2384DL**	**Cellobunch**	**Cellobunch**	**Navedo**	**Envy**	**Envy**
Mefenoxam	**no**	**no**	**yes**	**no**	**yes**	**yes**	**yes**
Pythium species							
P. sulcatum	**49**	**56**	**73**	**42**	**69**	**103**	**143**
P. violae	**29**	**30**	**21**	**24**	**18**	**16**	**15**
P. irregulare	**1**	**4**	**1**	**1**	**1**	**0**	**1**
P. intermedium	**3**	**0**	**2**	**5**	**12**	**0**	**2**
P. ultimum	**1**	**0**	**0**	**3**	**1**	**1**	**1**
P. sylvaticum	**2**	**2**	**2**	**2**	**6**	**4**	**4**
P. rostratifingens	**0**	**0**	**0**	**0**	**0**	**3**	**0**
Total isolates /field	**85**	**92**	**99**	**77**	**107**	**127**	**166**
Total lesions /field	**20**	**10**	**30**	**20**	**30**	**30**	**35**
Overall isolates	753						
Overall lesions	175						

Isolation *Pythium* from lesions to identify the pathogens

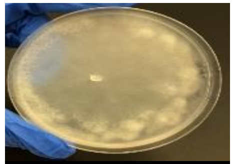

Collection of lesion


Lesion on Jeffer and Martin`s media (1986)

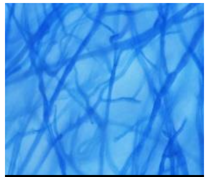

Hyphae growing out of lesion

- Different sizes of lesion were collected
- 6-8 hyphal tips growing at different rates from each lesion were sub-cultured

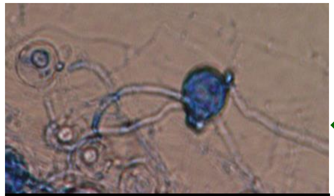
Purification on water agar (2%) medium


Corn meal agar

Group isolates based on colony morphological characteristics on corn meal agar


Aseptate hyphae (600X)


Oat-meal agar


Reproductive structures Van der Plaats-Niterink, 1981

Sanger sequencing of representative isolates ITS, COX-II and NADH to confirm the *Pythium* species


Storage

Carrots with low cavity spot 2021

Line	Cavity spot (%)	Severity (0-100)	Forking (%)	Leaf blight (0-5)
Deep Purple	0 a	0 a	8	3.0
F7738B	15 ab	**6 ab**	2	4.0
F7738B 3 way x	21 abc	**7 ab**	1	2.8
F7738B 3 way x	22 abc	**7 abc**	4	2.1
Nbh2306B	33 b-g	**10 a-f**	3	1.6
Atomic Red	90 g	70 u	9	2.4

Forking ranged from 0- 15%. Bolting ranged from 0 – 1.4, but most were 0).

Carrot Breeding to Develop and Introduce Improved Cultivars for California Production

Phil Simon *(USDA-ARS, Univ. of Wisconsin),*
Jas Sidhu *(UC, Coop. Extension, Farm & Home),*
Phil Roberts *(Univ. of California - Riverside),*
Mary Ruth McDonald *(Univ. of Guelph),*
Irwin Goldman *(Univ. of Wisconsin),*
and Industry Cooperators

Scope of USDA Cooperative Carrot Breeding 2023-24

- Field trials
  - In DREC, El Centro and in the Central Valley (Jas Sidhu et al.)
    - General breeding
  - In Coachella field, Riverside greenhouse (Phil Roberts et al.)
    - Nematode resistance evaluation and selection for genetic resistance
  - In Guelph, Canada (Mary Ruth McDonald et al.) and Central Val., (Jas Sidhu et al.)
    - Cavity spot resistance evaluation and crosses being made
  - Alternaria leaf blight resistance testing in Hancock, WI (Irwin Goldman et al.), Central Valley (Jas Sidhu et al.) and Canada (Mary Ruth McDonald et al.)
- Selected carrots sent from field/greenhouse locations to Madison for lab evaluation and seed production
- Selected nematode resistant carrots sent from Dr. Roberts program
- Data on cavity spot resistant carrots sent from Dr. McDonald's; data and roots from Dr. Sidhu's programs

Additional activities as we breed new traits into fresh market carrots

- As we breed new carrots with disease and pest resistance, we also breed for good flavor (sweet, mild, not turpentiney), dark color, and uniform appearance
  - Lab evaluation for quality traits – pigments, sugars, flavor
  - Orange carrots are an important dietary source of vitamin A
  - Purple, yellow, and red carrot pigments also have nutritional value
- To speed up the breeding process we develop DNA markers to track important genes
  - Molecular markers for nematode resistance
  - Important for our partners in the seed industry

Gene Sources in the USDA Carrot Breeding Program

Time to breed in a new trait

Wild carrot 10-25 yrs.

Land races from Uzbekistan, Turkey, etc. 8-15 yrs.

Heirloom varieties -White Belgian, Chantenay, etc. 4-6 yrs.

Today's carrot cultivars

Gene sources are rare for most traits – Many carrots get evaluated to find new sources

UC DREC and UW Hancock trials

- Hybrid trial (253 entries) with Jas Sidhu was planted at the Desert Research Extension Center in Holtville/El Centro for 2024
- Hybrid trial (125 entries) in Hancock, WI for 2023
- Of top-rated entries at DREC,

  9 of the top USDA cello hybrids had nematode resistant parentage and 3 of the top USDA cut & peel hybrids had nematode resistant parentage

Nematode Field Trials - 2022

- In cooperation with Phil Roberts on trial plots in Coachella
- Harvested in August
  - 580 entries
  - *M. incognita*
  - Identify new sources of resistance, confirm earlier sources, combine multiple sources
  - Field day to demonstrate resistance levels

Performance of *Mj-1* Nematode Resistance Stocks ("Nb")

- Advances in the level of nematode resistance from 'Brasilia 1252' (*Mj-1*). Both *M. javanica & M. incognita*
- Resistance levels holding up for both nematodes
- USDA inbreds with resistance used as parents in cello trial and released to seed industry
  - Primarily Br 1252 derivatives but new inbreds also include Homs
  - Nbh 2306 and Nb 3271 being released to seed industry and researchers
- 'Cape Market' is a new source of resistance being evaluated
- More cut and peel inbreds with nematode resistance being used in USDA experimental hybrids

Industry Testing of Nematode Resistant Carrots

- Seed of nematode resistant breeding stocks was released in 2014 to the seed industry for testing and their use to incorporate nematode resistance into commercial breeding lines
- Seed companies submitted entries into the field trials
- Strong resistance (score of 0 or 1) for several entries from seed companies

Progress in Combining Nematode Resistance Sources - 2023

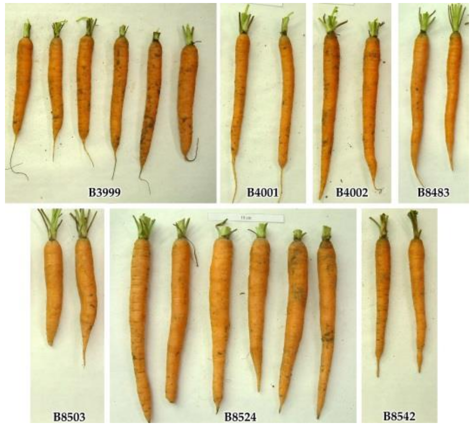
	MJ	1091	WR	HM	PD	SFF	NF	CM
MJ	--	*** 0-5	*** 1-3	*** 0-2	*** 0-5	*** 0-1.5	*** 0-3	** 1-2.5
1091		--		*** 0-3	** 2-4	*** 0-2	* 1-4	
WR			--	*** 0-2	*** 3.5-4	** 2-3	* 1-3	
HM				--	*** 0-2.5	*** 0-2	** 0-2	** 1-2.5
PD					--	* 1-3	** 2-3	* 1.5-3
SFF						--	*** 0-1.5	*** 1-2.5
NF							--	
Susc. Long	*** 0-1	*** 0.5-2	*** 1.5-3	*** 0-1	*** 0-2	*** 0-1	** 1-3	*** 1-2.5
Susc. Flavor	*** 0-1	*** 0-2	*** 2-3	*** 0-1.5	*** 0-1	*** 0-1	** 1.5-3	** 0-3.5
Susc. Other	*** 0-1			*** 0-1	** 2-4	*** 0-1		** 1.5-3

Yellow highlight - Recent advances

Green highlights – Best candidates for upcoming efforts

Progress in Incorporating Nematode Resistance into California Carrots

Resistant & susceptible 'Brasilia'



Inbreds from orig. Br 1252 cross (L) and cello (R)

Inbred (F4) from crosses w/ C&P

Exp. Hybrids w/ C&P resistant parents

Progress in Advancing Cavity Spot Resistant Carrots

- Trials by Mary Ruth McDonald to identify and advance new resistance sources. Trialing by Jas Sidhu to confirm resistance & horticultural quality in California
  - Resistance in orange USDA breeding stocks F7737 & F7738
- Seed production intercrossing resistance into Calif. inbreds
- Similar resistance trends in 2021, 2022, & 2023 all locations
  - F7737 and F7738 parentage in hybrids improved resistance
  - Both lines being released to the seed industry and researchers
  - Nbh2306 also a source of cavity spot resistance, and also strong root-knot nematode resistance. Being released
- Pyramiding/combining multiple sources of resistance

Alternaria leaf blight resistance breeding

- Resistance scored in 112 breeding populations as part of CFCAB project as well as ~650 USDA breeding stocks in Wisconsin fields in 2023
- Disease ratings also collected on cavity spot trial entries by Mary Ruth McDonald in Canada and on Alternaria trials by Jas Sidhu in California
- Fairly consistent disease resistance rankings in Wisconsin and California
- Intercrossing among resistant sources is underway

Carrot Seed Production in Greenhouse and Field

Coming up

- Cooperative efforts for California market carrot breeding
  - New combinations of nematode cavity spot and Alternaria resistance genes
  - Evaluate additional carrot germplasm for cavity spot resistance and advance crosses made including data and selected roots from Drs. McDonald and Sidhu
  - Germplasm releases - long, good flavor, nematode resistant selections
  - Alternaria resistance re-evaluated in CA and WI, and include all entries also scored in Canada
  - More detailed genetic maps for all traits
  - More efficient breeding approaches

Thanks much to the California Fresh Carrot Advisory Board and to You for joining us!

Up Next: Phillip Roberts

DISEASE & WEED MANAGEMENT IN CARROT: BAND STEAM

Steve Fennimore

University of California, Davis

California Fresh Carrot Advisory Board 3.20.24

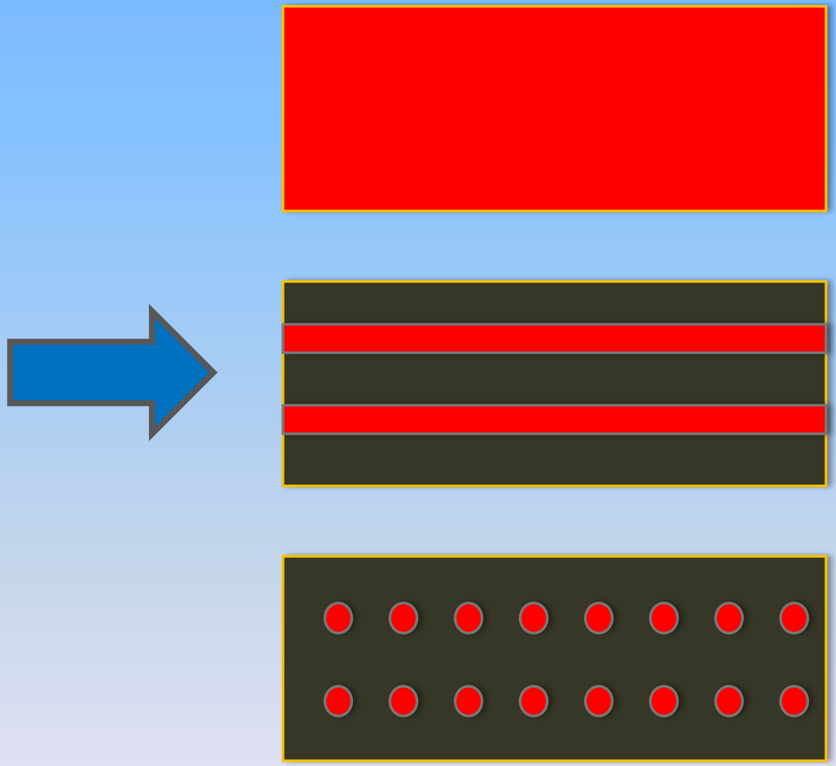
2022 OBJECTIVES

- **Evaluate soil disinfestation with steam in carrot for control of soilborne diseases and weeds.**
- **Determine the ideal band width and depth for steam application in carrot**

DEFINITION OF SOIL DISINFESTATION

- **Reduction of the pest community in the soil to a level that will permit profitable crop production.**
- **A “kill step” used to reduce soil pest infestations**

STEAM PATTERNS



Broadcast

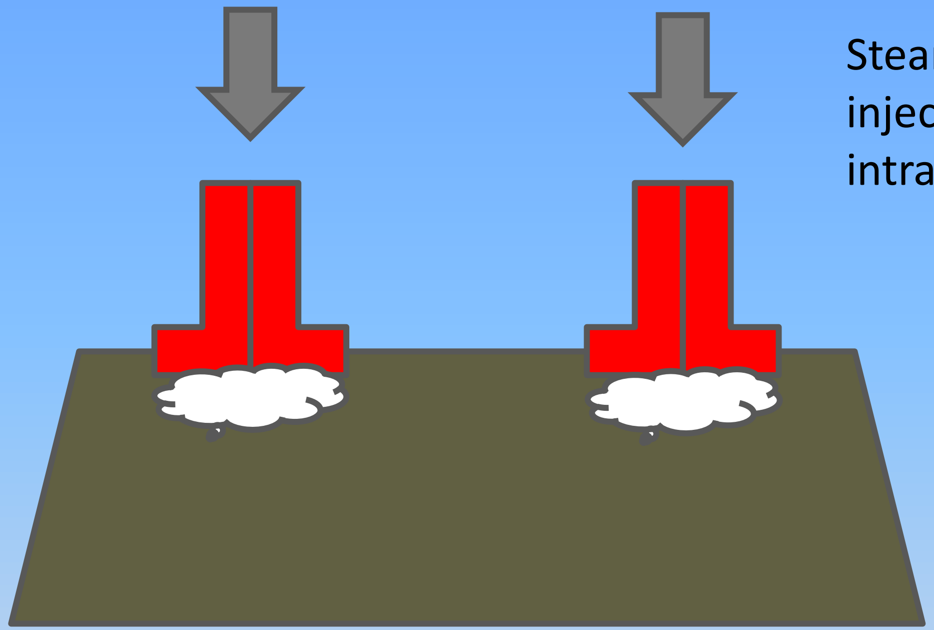
Band

Spot

HOW SOIL STEAMING WORKS

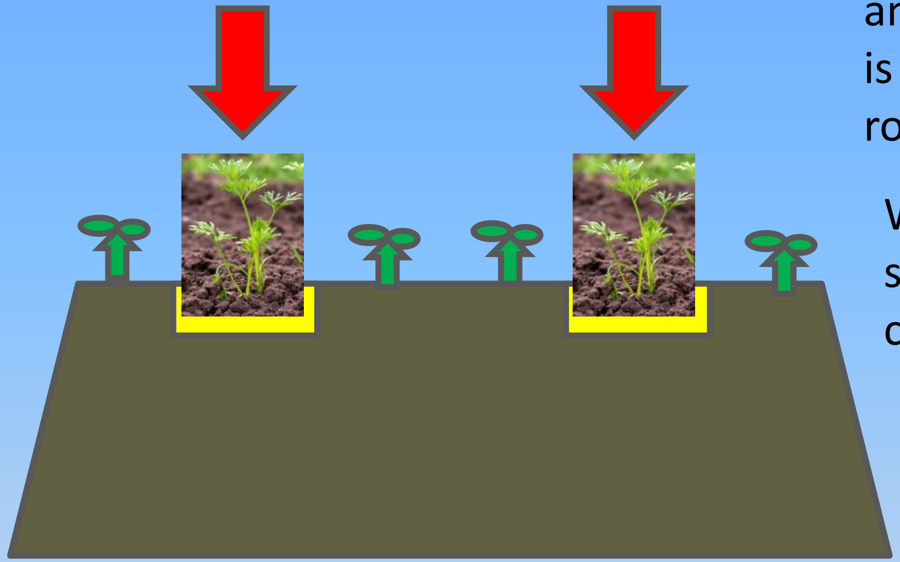
1. Inject steam into the soil to raise soil temperature to 158°F for 20 minutes
2. Steam transfers heat from heat source to target soil particles
3. When steam comes in contact with cold soil particle the steam molecules condense releasing heat to the soil particle
4. Steam kills the pathogens in an around the soil particle
5. Steam also kills weed seeds and nutsedge tubers

BANDS DISINFESTED WITH STEAM



Steam is injected into intra row soil

SEED CARROT INTO STEAMED BAND



Weed emergence and disease inoculum is reduced in intra-row

Weeds outside seedline can be cultivated out.

CARROT GROWN IN STEAM TREATED BANDS

2022 Trials

-Trial 1: May 4th 2022 (carrot)

Done with a prototype field steam applicator equipped with a bed shaper with shanks injected steam in a band from Yuma, Arizona

-2 inches deep by 4 inches wide

-40 inch beds

Trial 2: September 1 & 2, 2022 (Carrot)

Done with the same steam applicator as above

3.5 and 5.5 inches wide by 2, 4 & 6 inches deep

****All Treatments were replicated 4 times and arranged in a randomized complete block design****

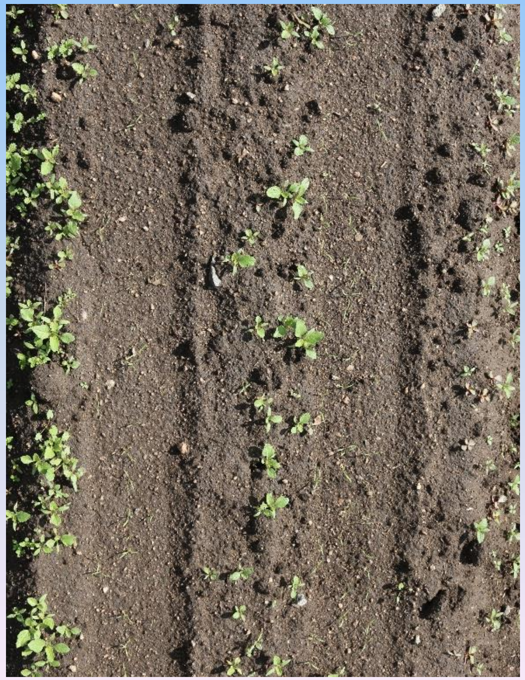
WEED CONTROL BY SPECIES

Purslane 99%

Shepherd’s-purse, nettleaf goosefoot 88%

Burning nettle, henbit, pigweed 100%

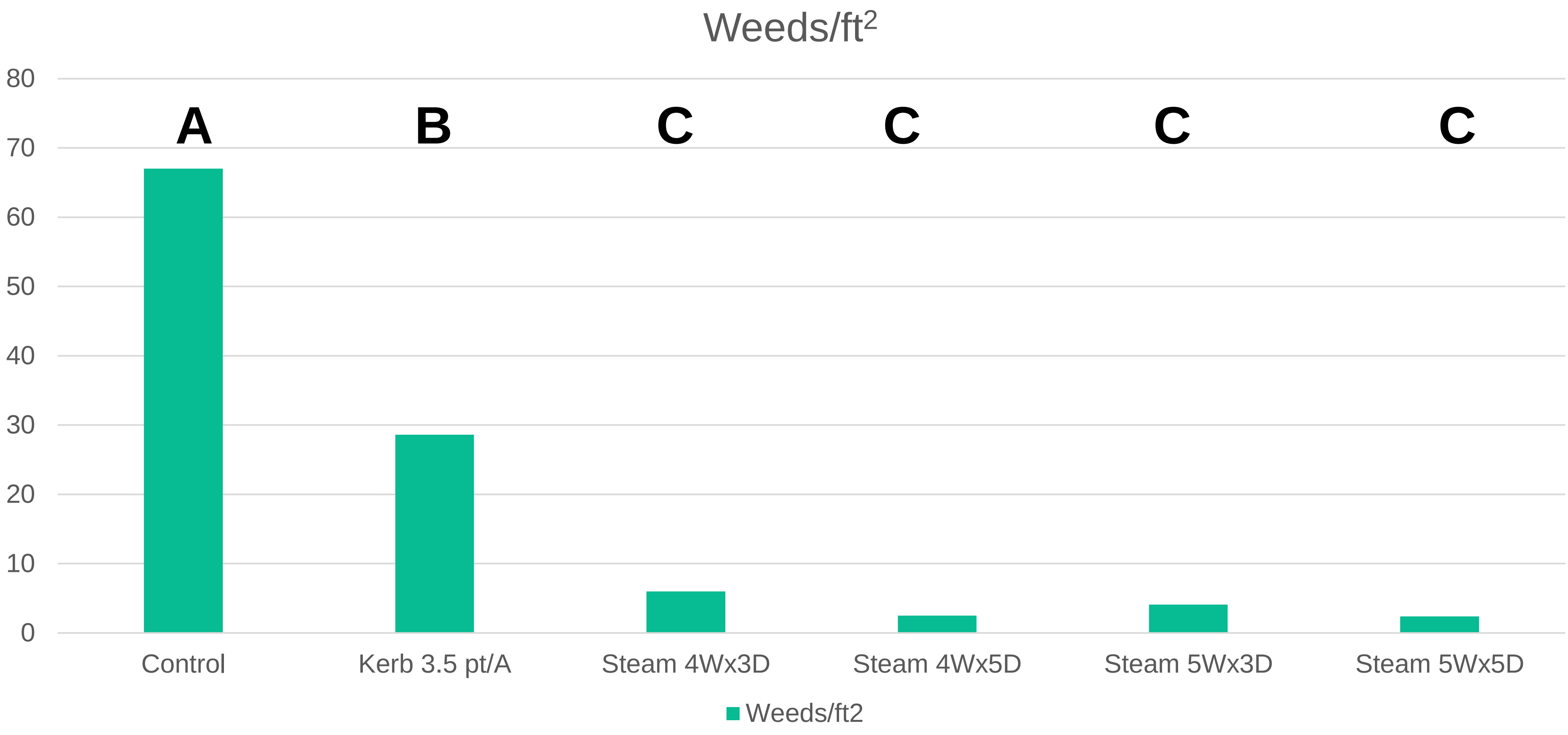
Little mallow 42%



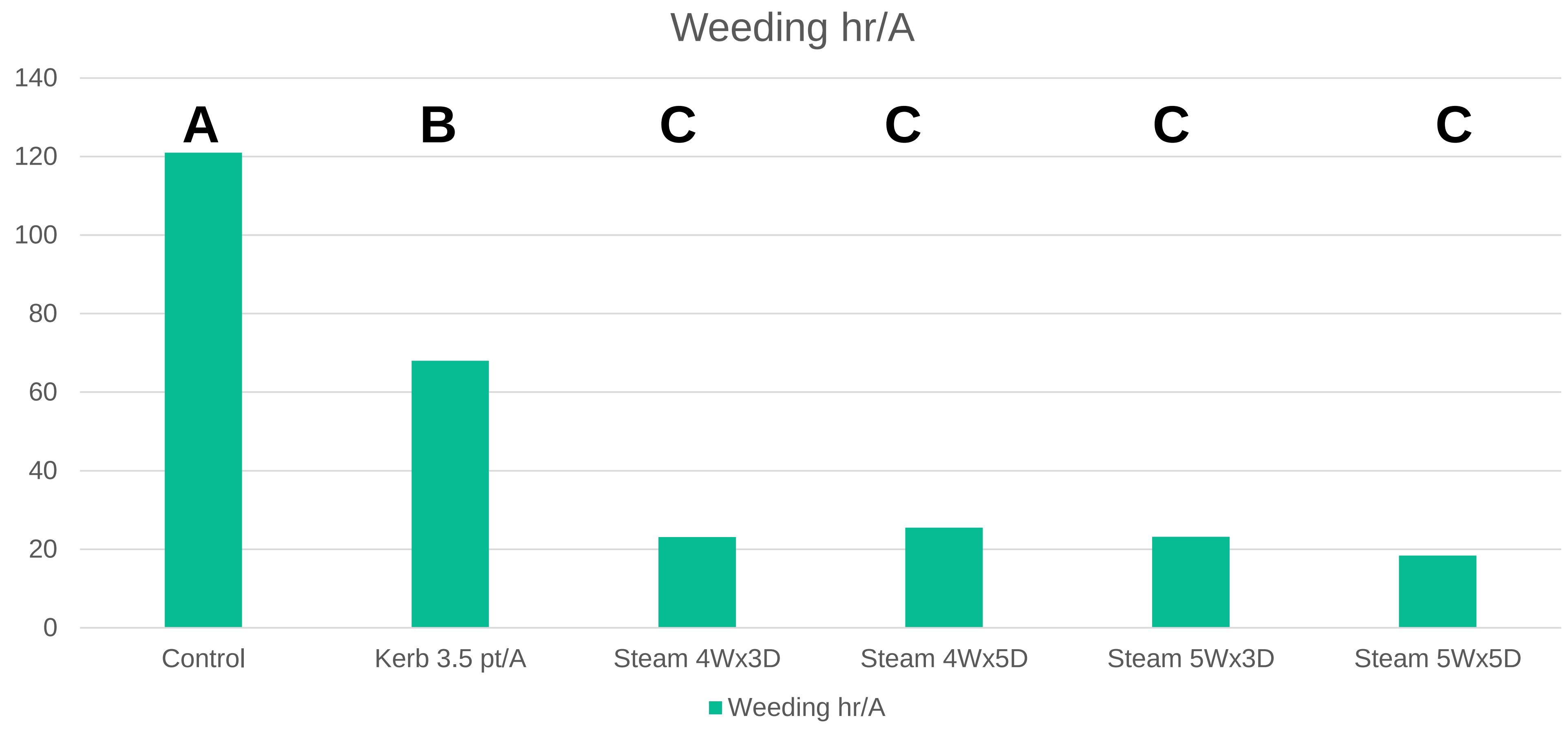
DATA COLLECTED & DETAILS

1. Weed densities
2. Hand weeding time
3. Pythium control
4. Crop yield
5. Treatments were steam vs. no steam
6. Treatments were replicated 4 times & arranged in randomized complete block design

Total number of weeds in the seedline band – the “expensive” weeds



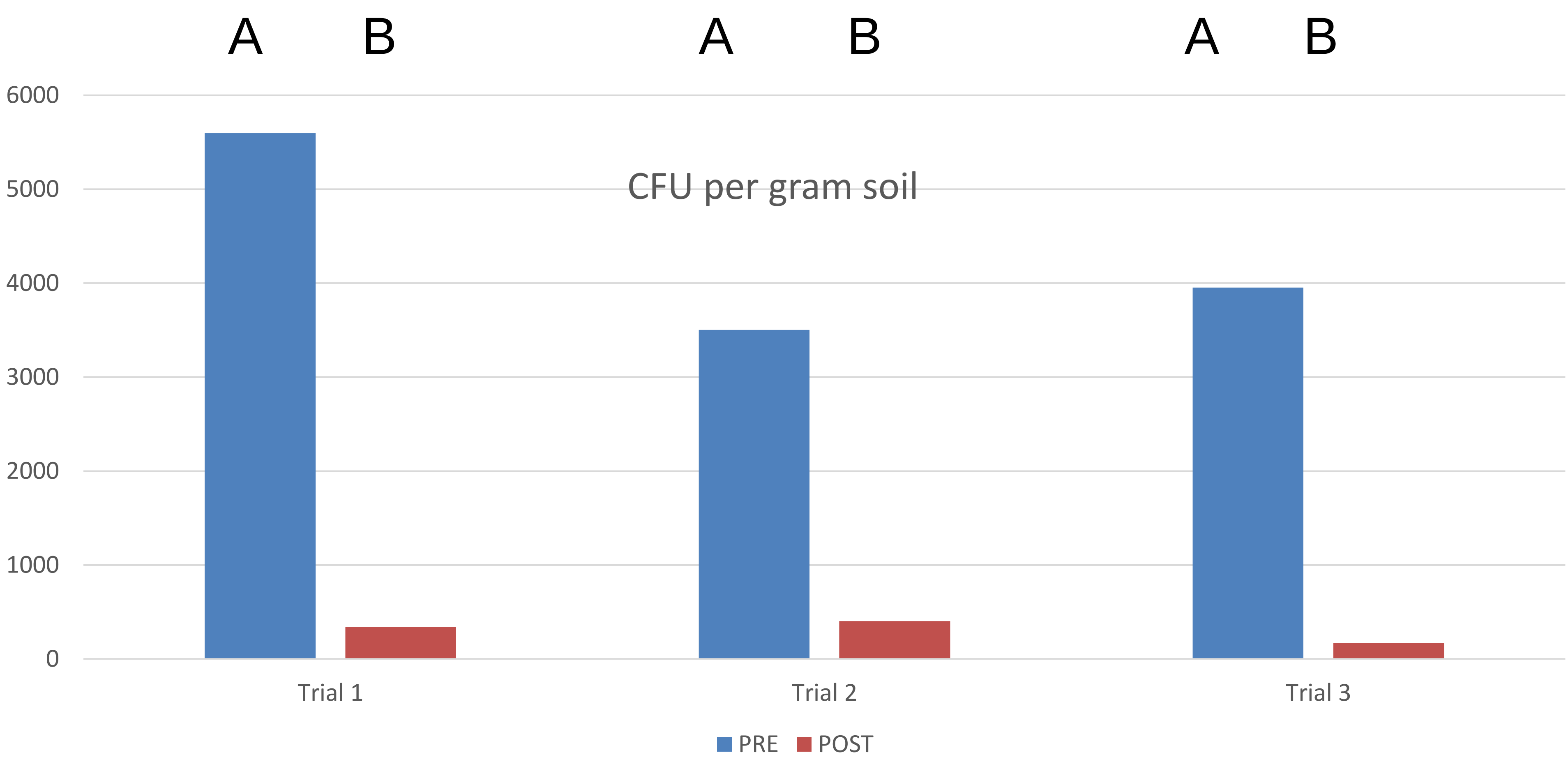
Hand weeding times



Pythium ultimum control before & after steaming

Treatment	Before	After
	CFU/g soil	
4w 3d	8.5	1.4
5w 3d	6.7	1.3
4w 5d	10.2	0
5w 5d	12.8	0
control	8.2	5.7

Soledad Fusarium spp.



Influence of steam on soil microbial community

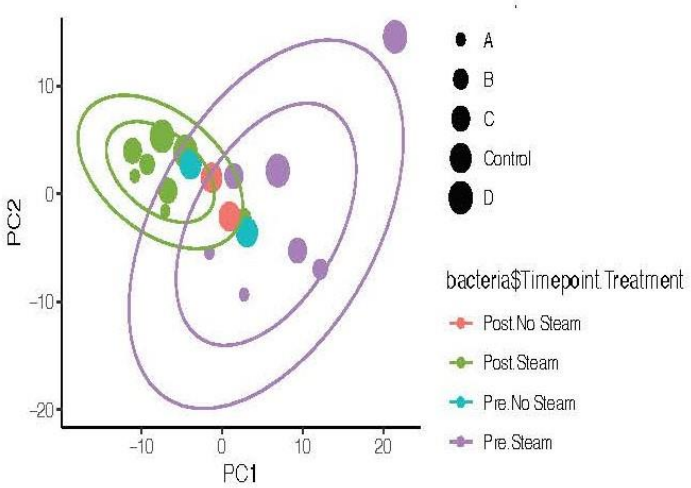


Figure 1: PCA plot for Treatment for all samples

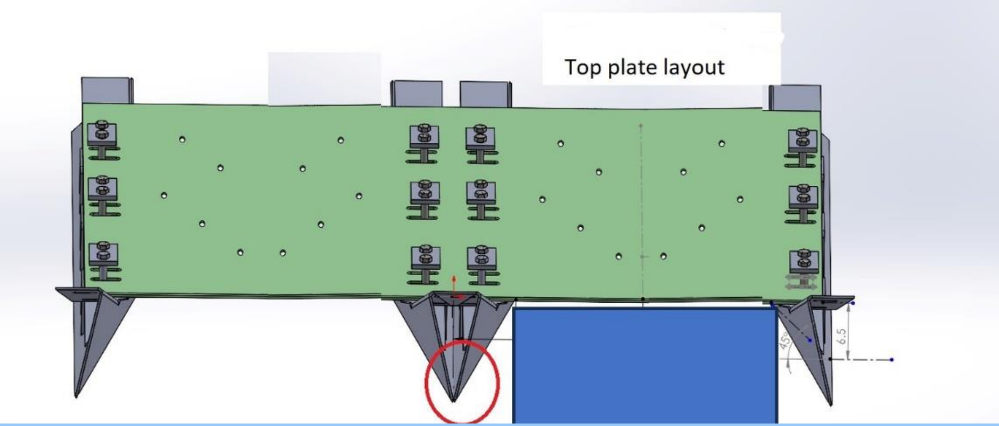
Firmicutes are promoted.
Nitrospirota were not affected.

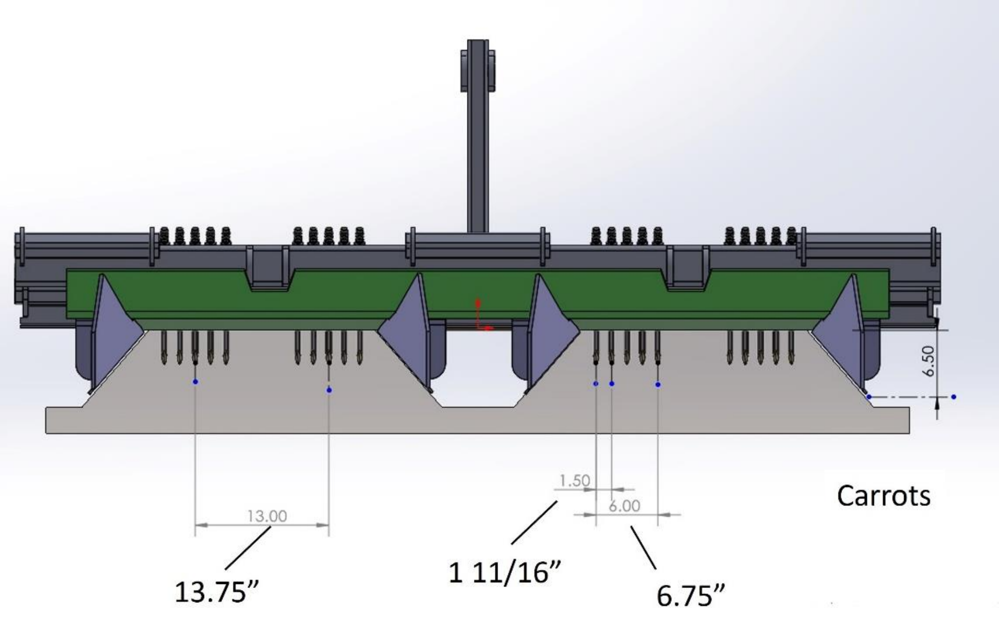

PROPANE
FLAMMABLE
PROPANE
FLAMMABLE

OBJECTIVES 2024

- Fabricate the top plates and shoulder panels for injectors
- Test commercial scale steam applicator in Kern County carrots

TOP & FRONT VIEW OF PLATES FOR BAND STEAM APPLICATION IN CARROTS





Jeremiah K.S. Dung | Associate Professor
Oregon State University | Department of Botany & Plant Pathology
Central Oregon Agricultural Research and Extension Center, Madras, OR

EPIDEMIOLOGY OF BACTERIAL BLIGHT IN CARROT SEED CROPS

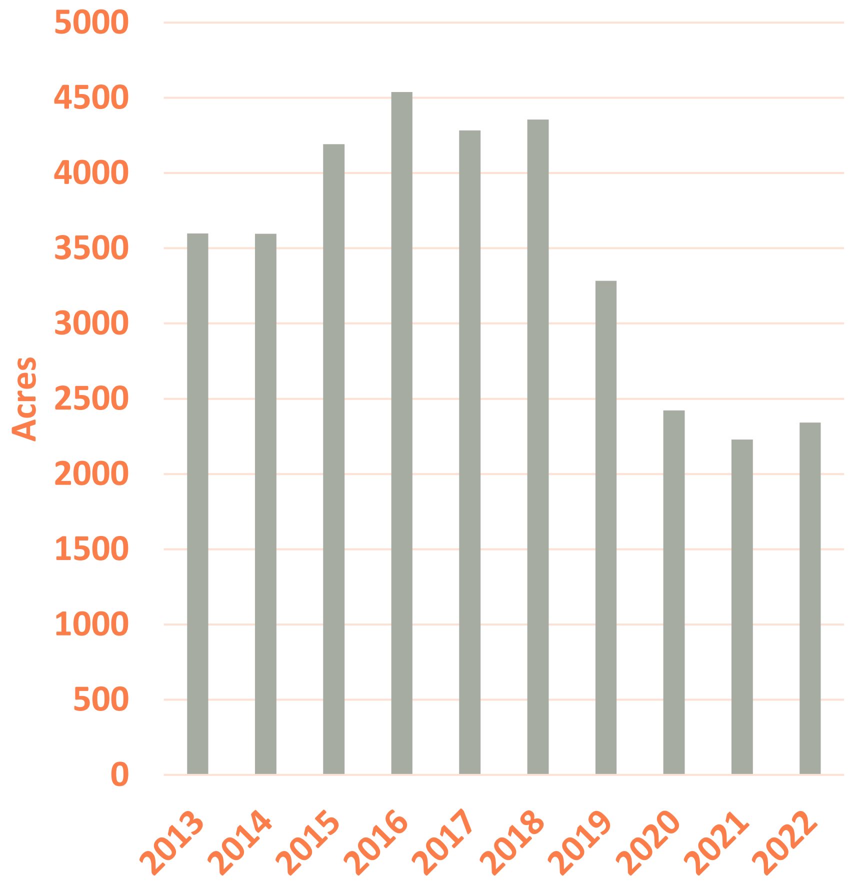
2024 Carrot Research Symposium
March 20, 2024

United States Department of Agriculture Specialty Crops Research Initiative (grant no. 2020-51181-32154)

Oregon State University

Carrot Seed Production in Central Oregon

- Drip-irrigated
- Bee-pollinated
- Steckling-to-seed production: roots (stecklings) are transplanted in spring and harvested in fall of the same year
- Seed-to-seed production: planted in August and harvested in September of the following year
  - Overlapping production cycles



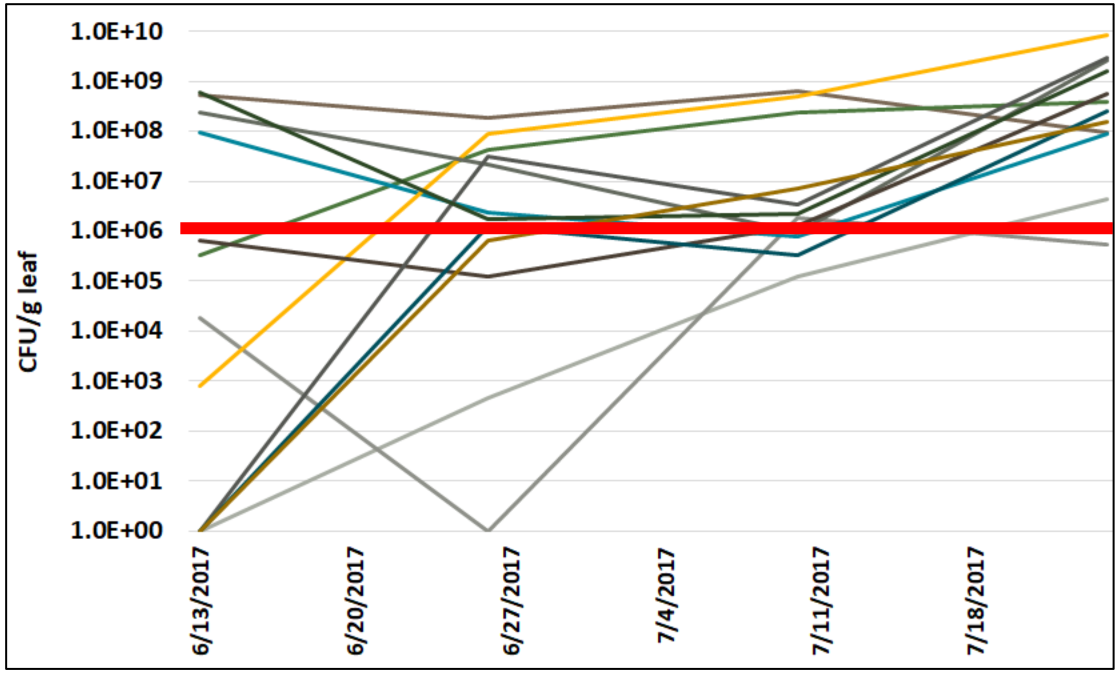
Source: North Unit Irrigation District Crop Report

Bacterial Blight of Carrot

- Caused by *Xanthomonas hortorum* pv. *carotae* (*Xhc*)
- First reported in CA (1931)
  - AZ, NM, MI, FL, NY, WI, ID, OR, WA
- Infects leaves, petioles, umbels, seed
- Yellow, angular spots that expand into irregular, brown, water-soaked lesions surrounded by a yellow halo

Xanthomonas in Carrot Seed Production

- Seedborne, airborne
- Survives and reproduces epiphytically
- Symptoms are associated with large populations ($\geq 10^6$ CFU/g leaf tissue)
- Seed-transmitted at 10^4 CFU/g seed



Impacts of *Xanthomonas* on Carrot Seed Production

- For seed growers:
  - Costs associated with control (copper bactericides)
  - Reduced seed yield due to blighted umbels
  - Reduced seed germination
  - Sustainability of production
- For seed companies:
  - Healthy, disease-free seed is a goal
  - Expensive and difficult hot-water/chemical treatments
  - Rejection of seed in export markets

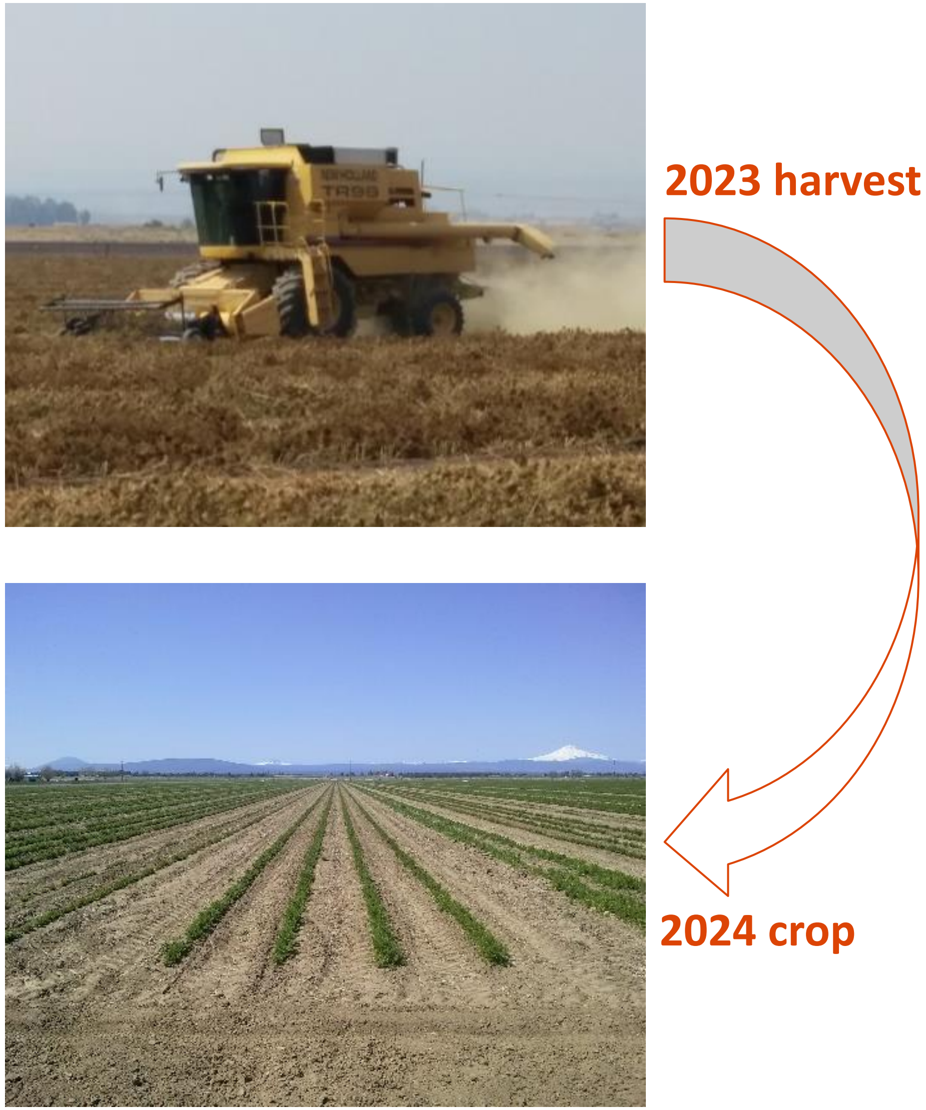


Management of *Xanthomonas* in Carrot Seed Production

- Exclusion of the pathogen
  - Pathogen-free seed/stecklings
  - 2- to 3-year rotation: spatial & temporal isolation (reducing the 'green bridge')
- Reduce pathogen populations in fields
  - Incorporate infested residues
  - Avoid overhead irrigation
  - Foliar bactericide applications: coppers + mancozeb
- Post-harvest
  - Hot water seed treatment: 122°F for 30 min
  - Chemical seed treatment

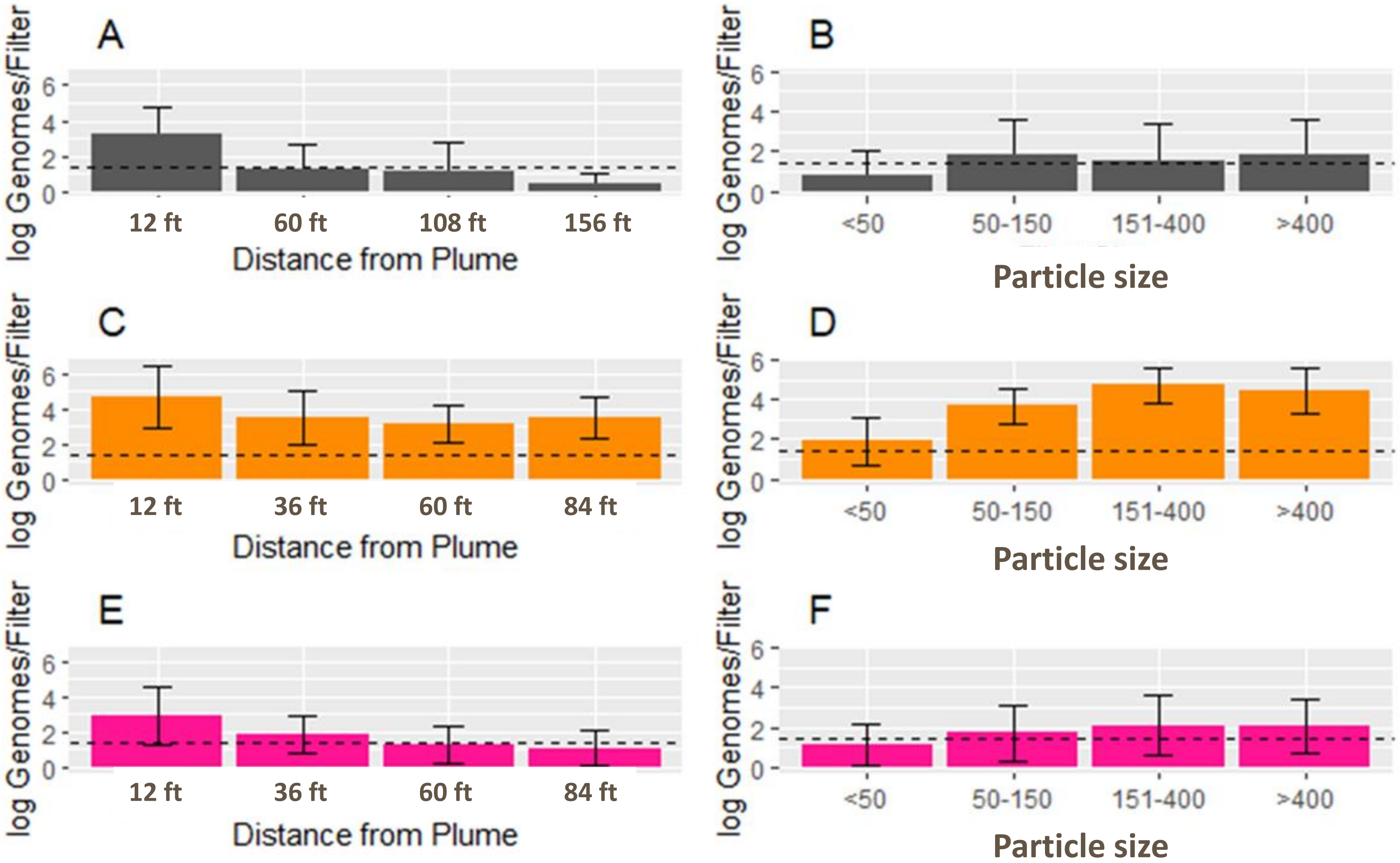
The “Green Bridge” Effect

- Large epiphytic populations can occur on carrot plants
- 13-month production cycle results in overlapping carrot seed cropping seasons
- “Green bridge” effect
- Airborne *Xanthomonas* detected up to 1 mile from crops being threshed



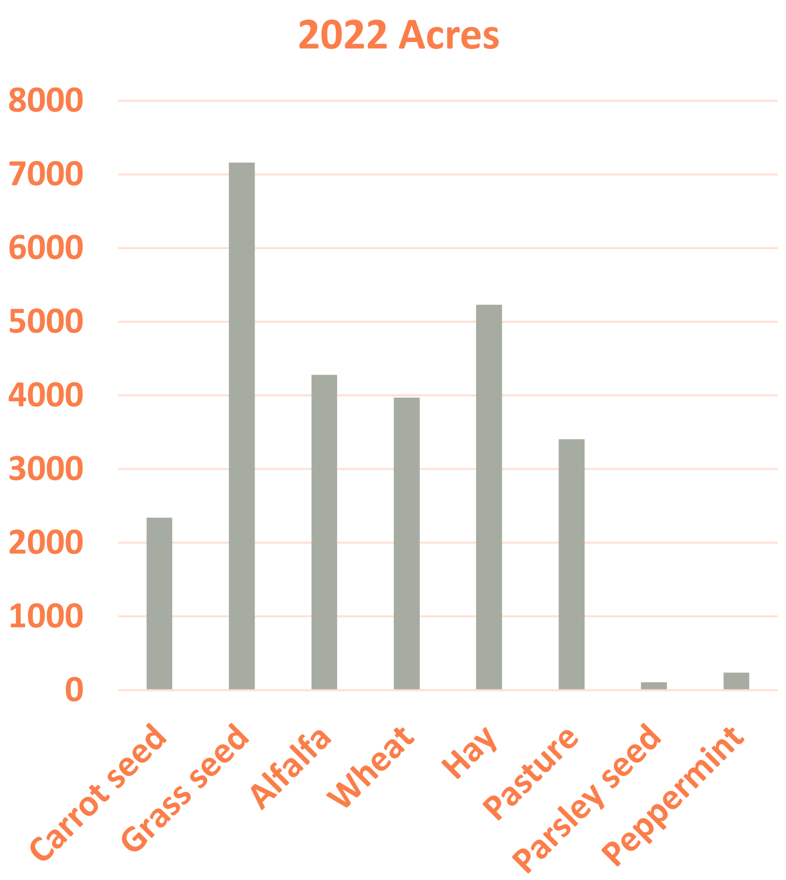
Aerial Dispersal of *Xhc* in Carrot Seed Production Systems

Aerial Dispersal of *Xhc* in Carrot Seed Production Systems



Non-Carrot Crops as Potential Green Bridges for *Xhc*

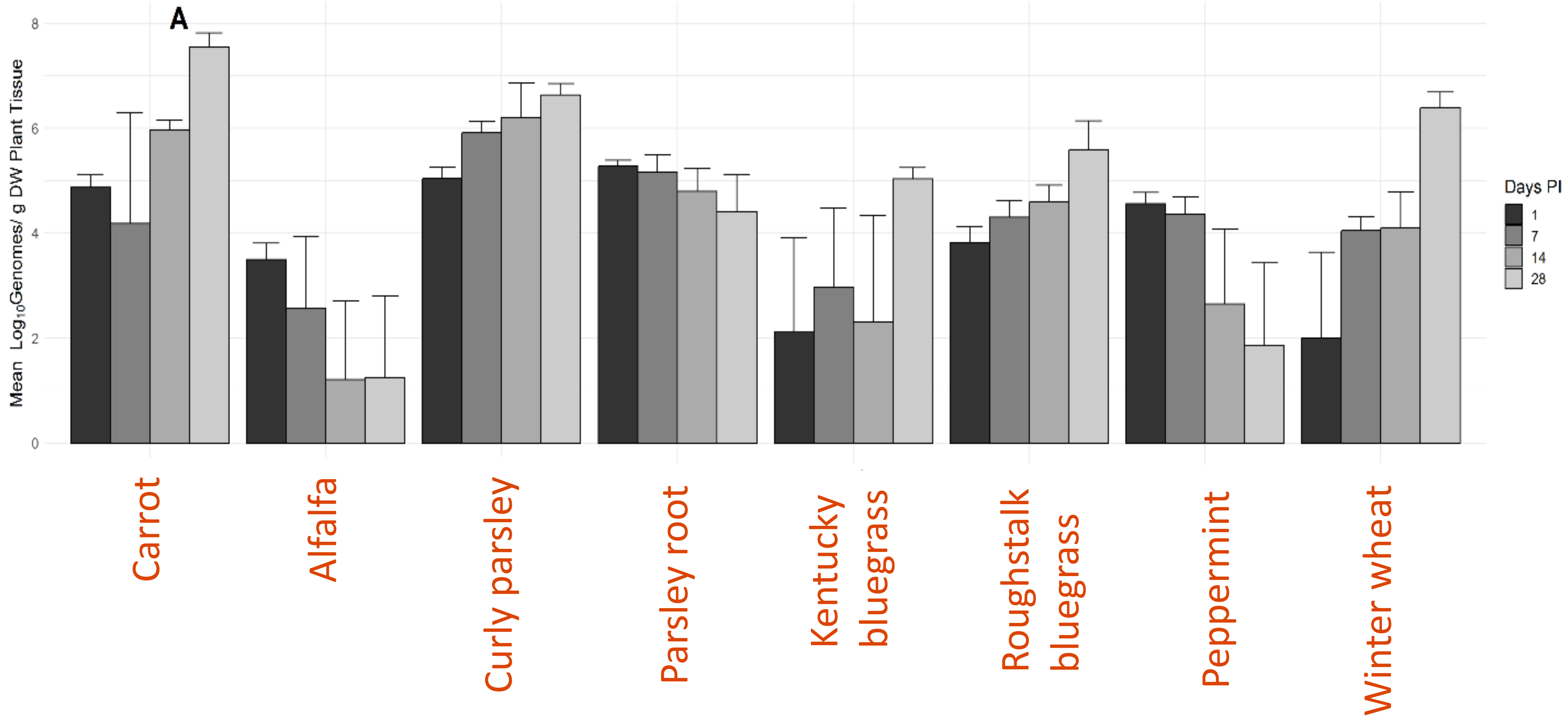
- *Xanthomonas* spp. are known to occur as epiphytes on non-hosts
- Previous sampling demonstrated that *Xhc* was detectable on weeds and non-carrot crops in central Oregon
- Transient or resident populations?
- Potential inoculum reservoirs?



Field Sampling of Non-Carrot Crops

Farm	Crop	Mean *Xhc* genomes/g dry weight plant tissue	Positive Samples (out of 5)
A	Carrot seed	5.01×10^4	3
	Parsley root seed	4.02×10^4	4
	Alfalfa (on field margin)	9.19×10^3	2
	Alfalfa (within carrot row)	5.58×10^4	3
B	Carrot seed	1.77×10^7	4
	Parsley root seed	2.80×10^5	4
	Kentucky bluegrass seed	2.98×10^4	3
C	Carrot seed	4.65×10^9	5
	Parsley seed	3.35×10^7	5
	Forage Rye	1.28×10^5	5

Epiphytic Colonization of Non-Carrot Crops by *Xanthomonas* in the Greenhouse



Aerobiology and Epidemiology of *Xhc* in Carrot Seed Crops

- *Xhc* can be detected in airborne carrot seed crop debris generated during harvest
- The pathogen was detected up to 150 ft away from harvesting activities
- *Xhc* was detected in small (<50 µm) particles, which can potentially travel long distances
- Non-carrot crops can potentially harbor asymptomatic *Xhc* populations and serve as inoculum reservoirs in carrot seed production systems

Acknowledgements

Kate Baldino (M.S. student) Oregon State University

Matt Huckins (Ph.D. student) University of Utah

Grower-cooperators: Boyle Family Farms, Madras Farms, Macy Farms

Funding: United States Department of Agriculture Specialty Crops Research Initiative (grant no. 2020-51181-32154)

Oregon State University

THE UNIVERSITY OF UTAH

USDA Agricultural Research Service

Up Next: Kenneth Miller

Managing Nitrogen and Irrigation for Sustainable Carrot Production

Ken Miller, Soil Scientist/Agronomist
2024 Carrot Symposium
3/20/2024

THE SOUTHERN SAN JOAQUIN VALLEY
MANAGEMENT PRACTICES EVALUATION PROGRAM

FORMATION
ENVIRONMENTAL

Topics

1. Overview of the Central Valley ILRP Groundwater Protection Formula, Values, and proposed Targets

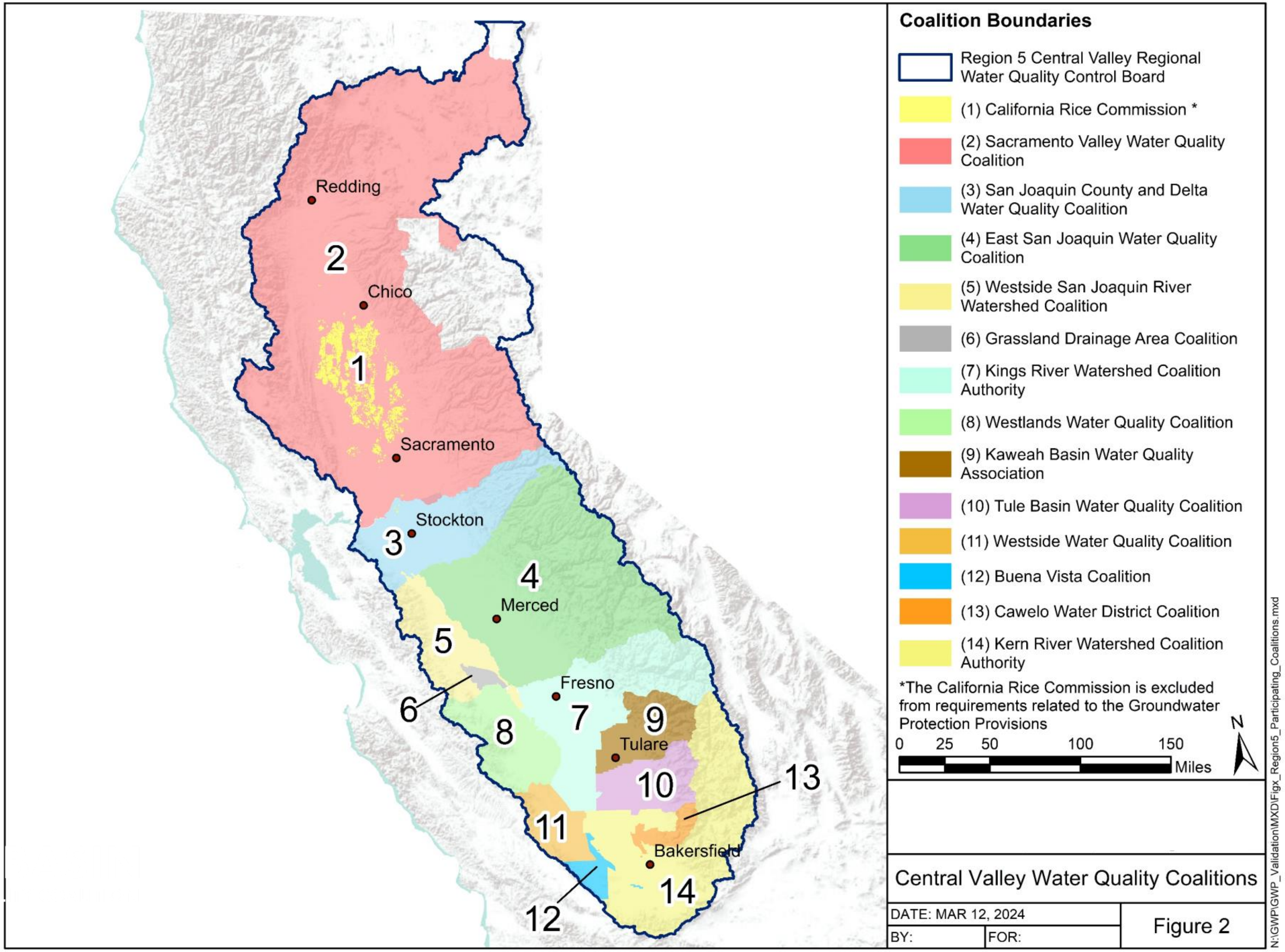
2. N Efficiency In Carrot Production

FORMATION ENVIRONMENTAL

Participating Coalitions

Sacramento Valley Water Quality Coalition

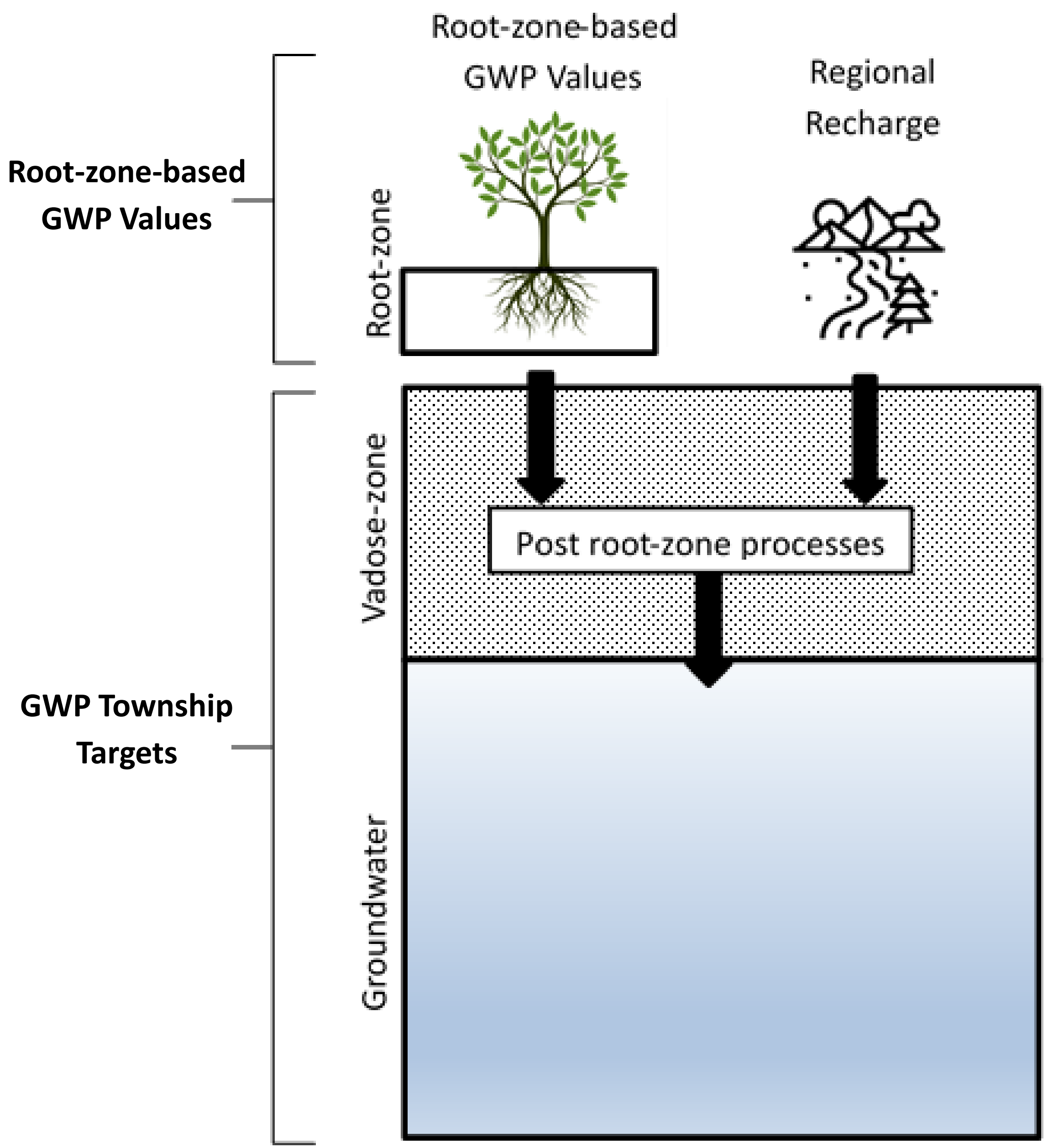
Grasslands Drainage Area



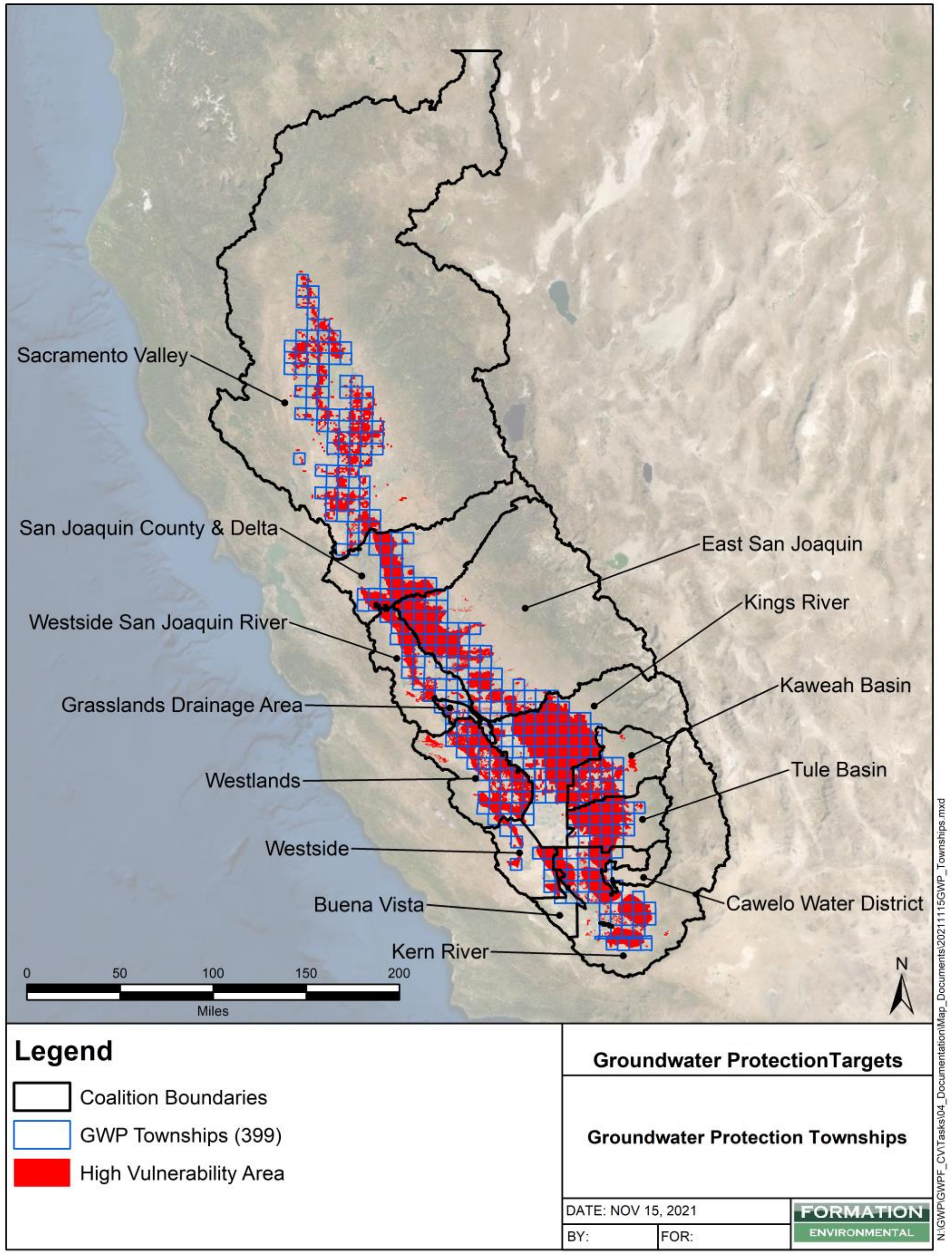
Groundwater Protection - GWP

- Implemented collectively by 13 coalitions

- The Order Requires:
  - **GWP Formula:** Data and Methods
    - Grower INMP data + CV-SWAT model
    - Approved Jan. 2021
  - **GWP Values:** Township Leaching Estimates
    - Conditionally approved Nov. 2021
  - **GWP Targets:** Township Targets to Achieve Compliance for irrigated agriculture
    - Approved June 2023
    - Revised/updated every 5 years



GWP Townships based upon high vulnerability areas



GWP Formula and Values

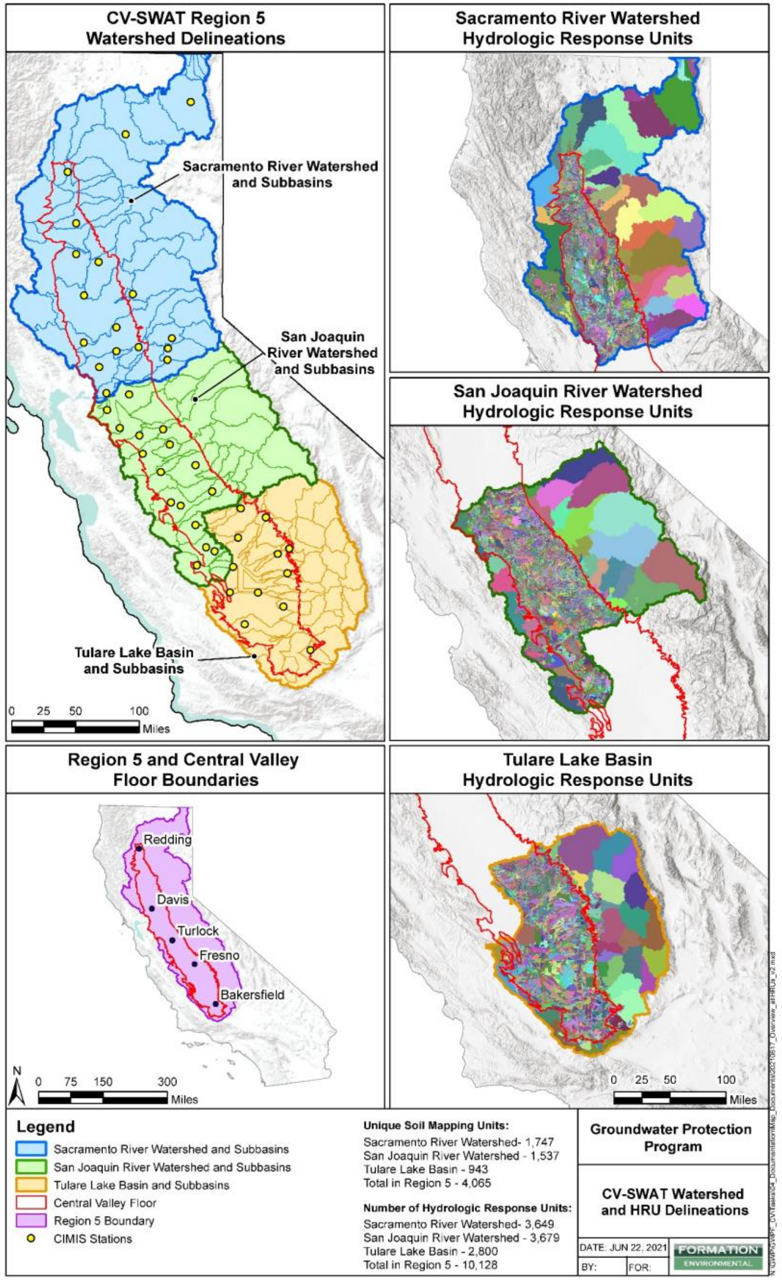
Root-zone assessment tool: The Central Valley SWAT Model (CV-SWAT)

- SWAT is scientifically accepted and robust
  - > 30 years of R&D by USDA-ARS
  - > 3,500 peer-reviewed articles
- Detailed, physically-based
  - Sub-field-scale model
  - Runs at a daily timestep
  - Climate, soil, crop, management
  - Water cycle, nitrogen cycle

SOIL & WATER ASSESSMENT TOOL

Root-zone assessment tool: The Central Valley SWAT Model (CV-SWAT)

- Adapted by coalitions for CV for ILRP program requirements
  - In collaboration with NRCS and UC
  - Funded in part by $2 million CIG, coalitions
- CV-SWAT includes:
  - Calibrated >50 crop models covering >98% of CV acreage (including carrots)
  - Reflective management practices based upon grower information, advisors/experts
- CV-SWAT automated based on grower reports to produce over 75,000 simulations (~550 unique carrot scenarios)



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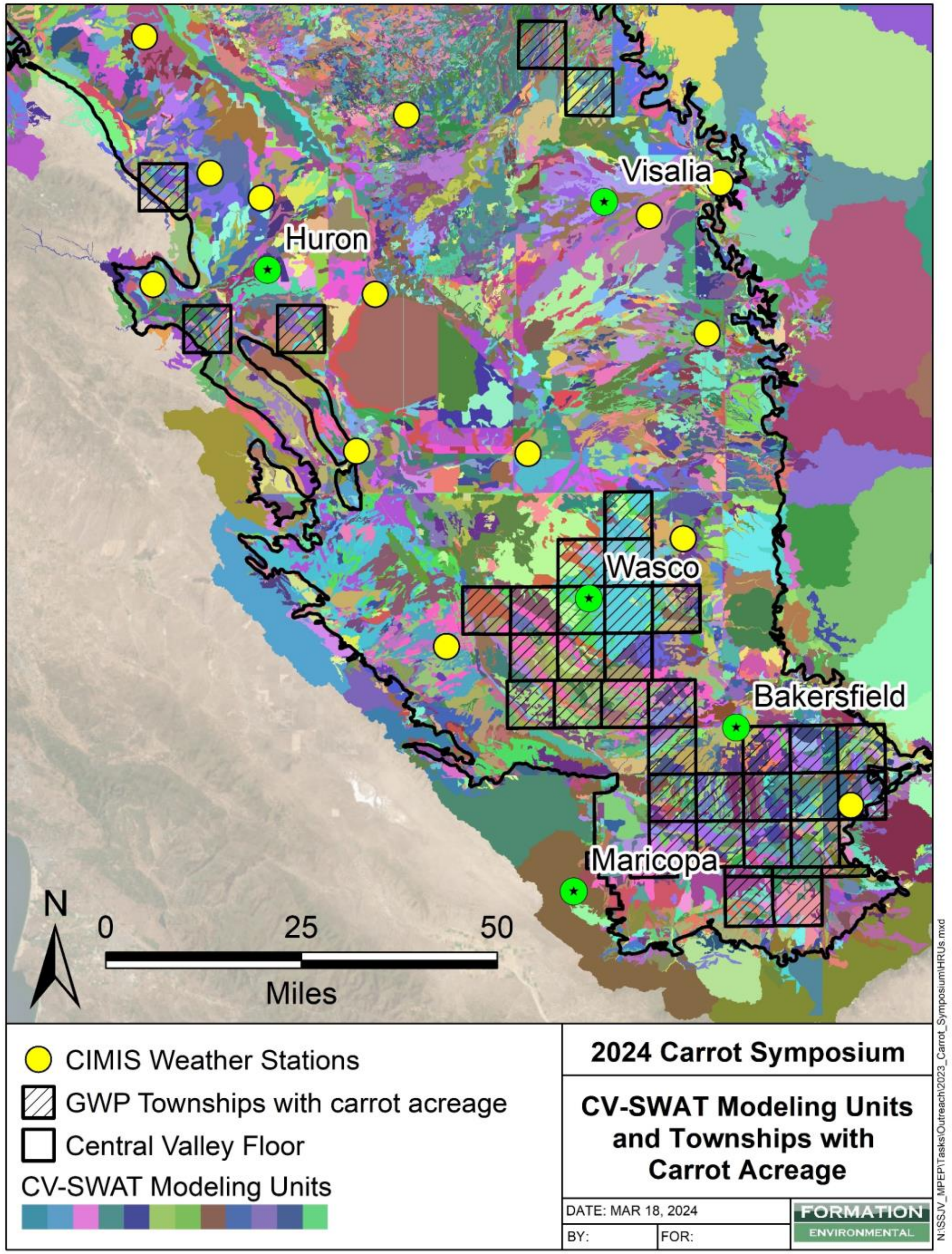

GWP Values:
Current state of agricultural industry at the bottom of the root zone

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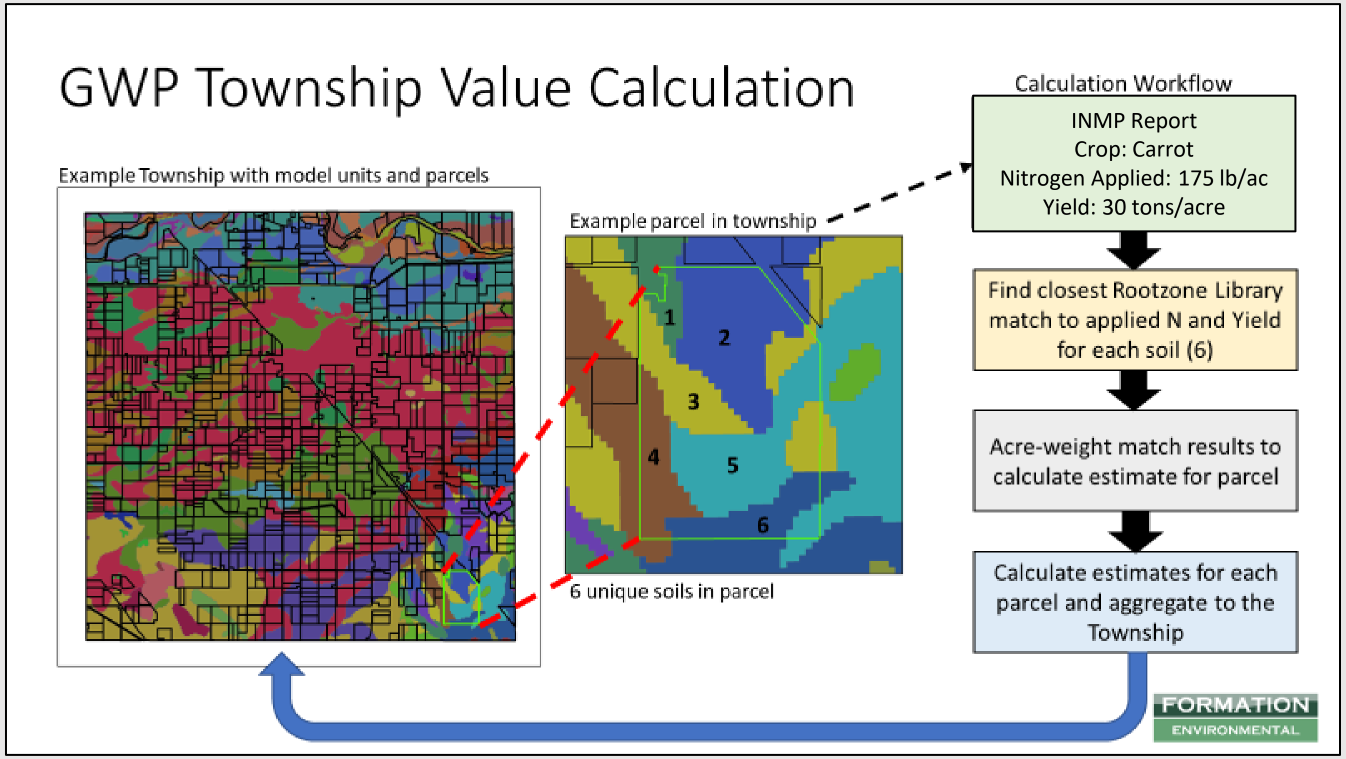
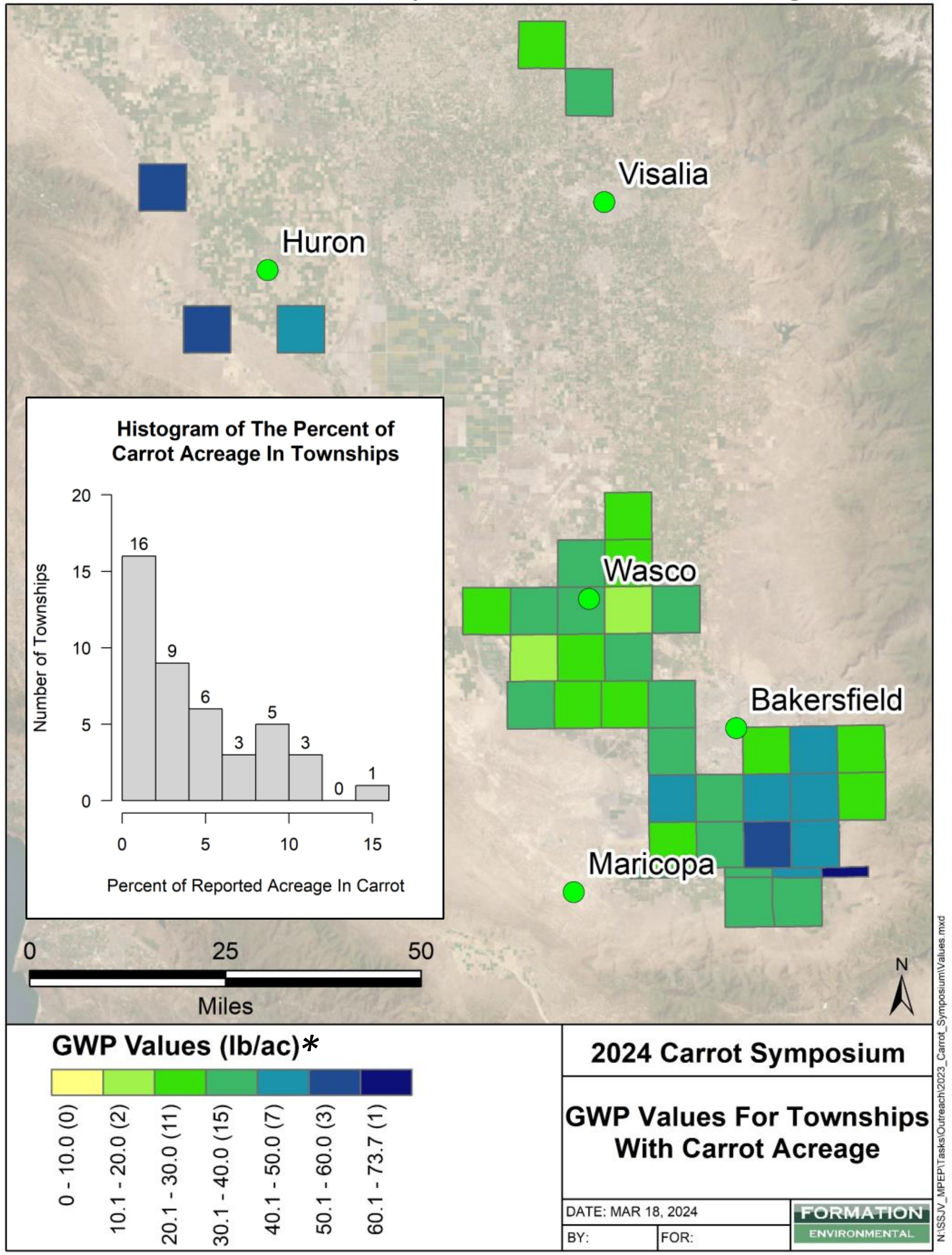


Focus on Townships with Carrot Acreage



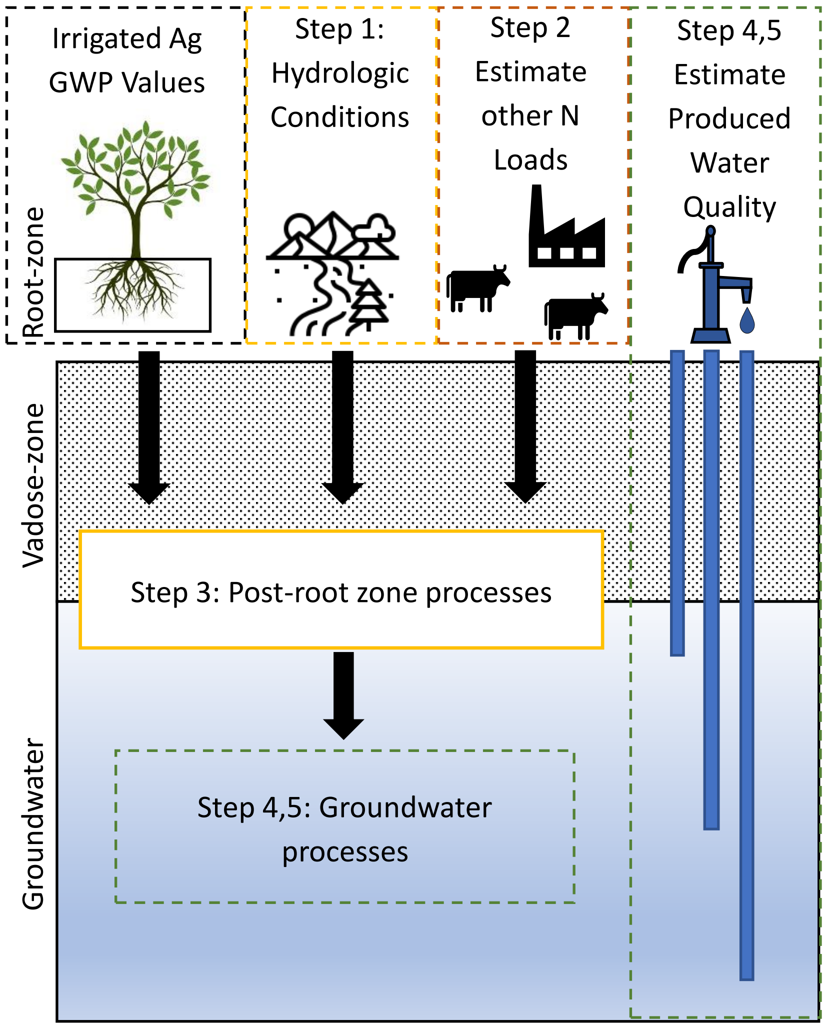
**GWP Values are based on all crops grown in the township, not only carrots*

GWP Targets

Assessment Framework to determine GWP Targets

Connect GWP Values to other key regional processes that impact water quality

1. Account for regional hydrology
    - Additional recharge sources
2. Estimate other N loads
    - Less robust than GWP Values
3. Consider post-root zone N attenuation
4. Consider groundwater processes
5. Estimate produced water quality under current GWP Values and GWP Targets
    - Non-Point Source Assessment Tool (NPSAT) from UC Davis



Coalitions Submittal for GWP Targets: Two-Step Approach

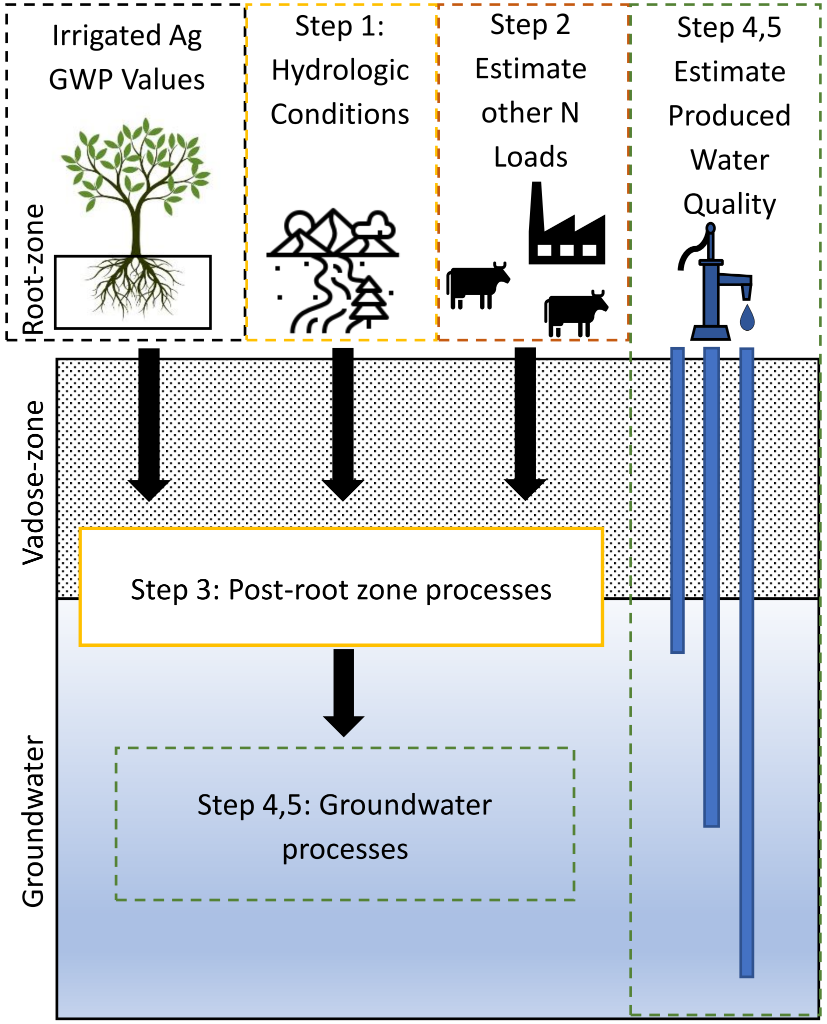
GWP Submissions:

1. Milestones as Interim Performance Goals (GWP Milestones)

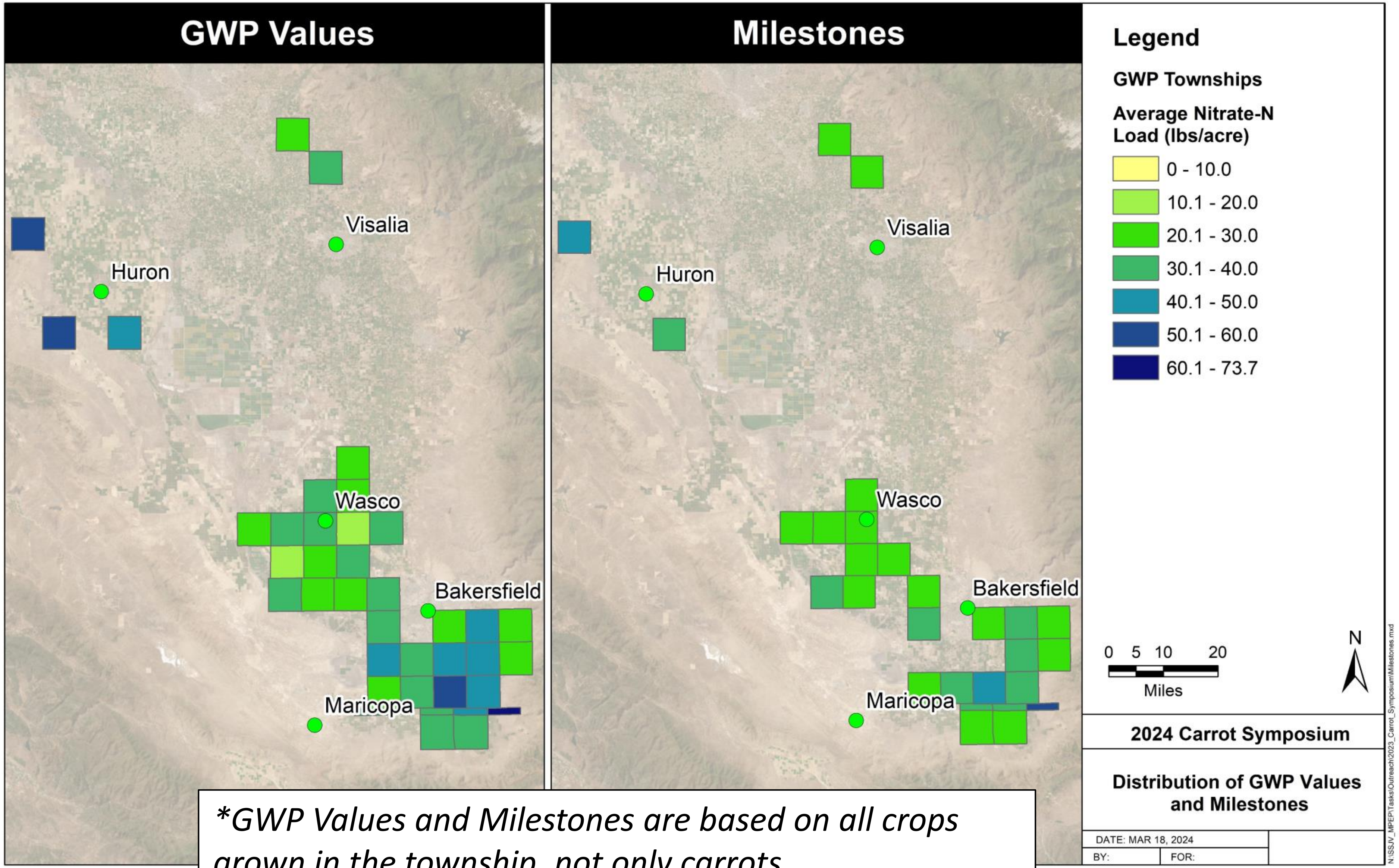
- Rootzone focused, minimize N losses through protective management practices

2. GWP Targets For Complying with Receiving Water Limitations (GWP Targets)

- Based upon assessment framework, NPSAT simulations

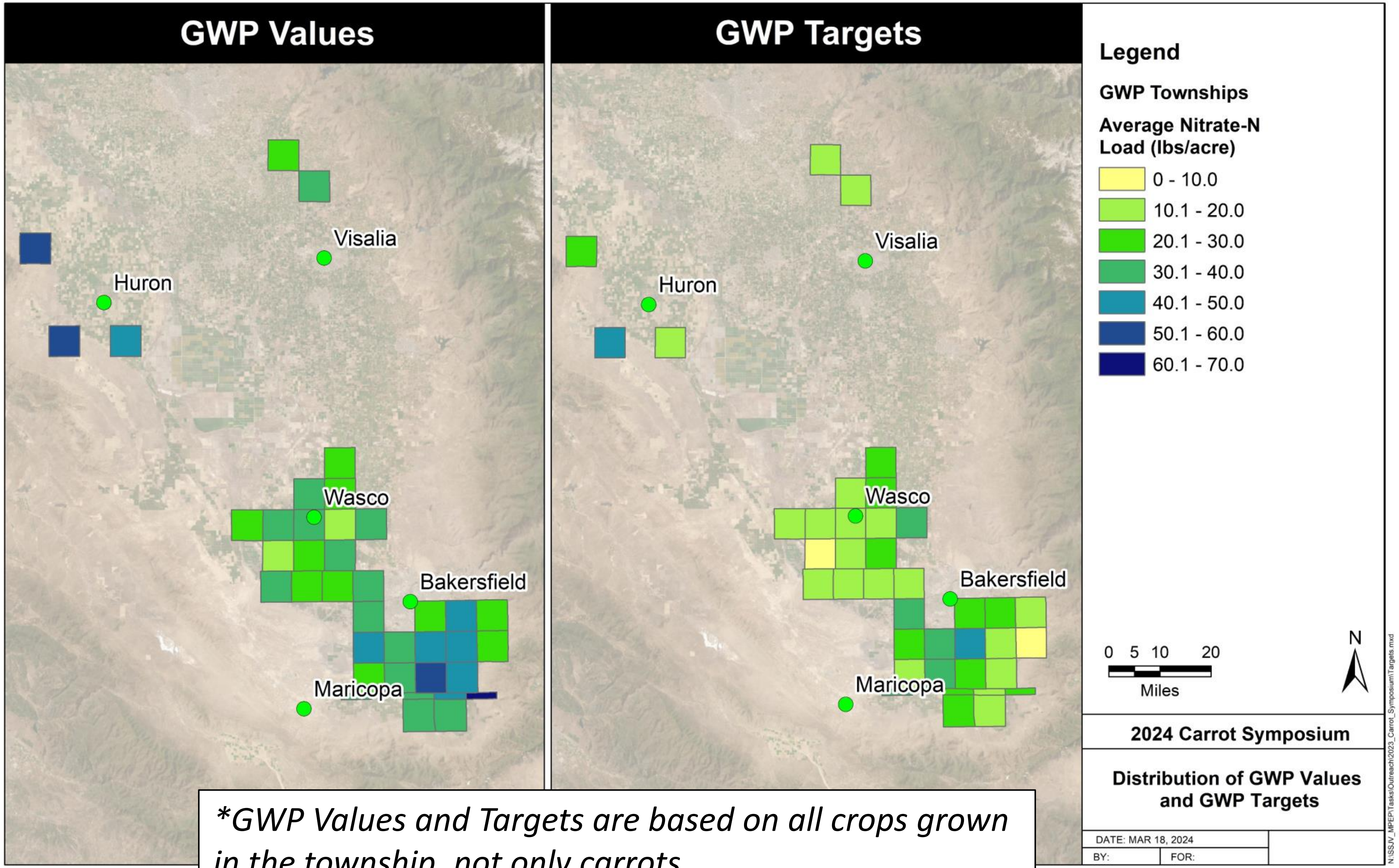


Milestones (Root-zone focused)



**GWP Values and Milestones are based on all crops grown in the township, not only carrots*

GWP Targets (Based up groundwater modeling)



**GWP Values and Targets are based on all crops grown in the township, not only carrots*

Putting Milestones & GWP Targets Into Context

- Interim GWP Milestones & GWP Targets are ***not*** enforceable metrics

- State Water Board may – in the future – consider what are appropriate enforceable metrics

- Coalitions are required to develop and implement Groundwater Quality Management Plans (GQMPs)
  - GQMPs must include schedules, milestones, performance goals
  - GWP Targets will be incorporated into GQMPs this year

- When incorporated into GQMPs, Coalitions will each individually identify their education & outreach plan to growers

Nitrogen Efficiency in Carrot Production

THE SOUTHERN SAN JOAQUIN VALLEY
MANAGEMENT PRACTICES EVALUATION PROGRAM

‘N balance’ as a metric of N use efficiency :

- N application = (fertilizer N + available N in organic amendments + NO_3-N in irrigation water)
- Each ton of carrots is assumed to remove 2.8 lb N
- ‘N balance’ is the difference between N applied and N removed with harvest (A - R)

In theory, the higher the N balance, the greater the risk to groundwater

STEP 4: INMP SUMMARY REPORT

Complete the table below for each field or management unit for this membership. ***All values should be on a per acre basis.***

Field or Management Unit	Crop	Crop Age	Total Irrigated Acres	Total N Applied Lbs/acre				Yield	Prod. Unit	Yield Info*
Refer to Parcel Inventory		Perennial only (years)	(acres)	N in Irrigation Water (lbs/acre)	Organic Amendments (lbs/acre)	Dry/Liquid Fertilizers (lbs/acre)	Foliar Fertilizers (lbs/acre)	Harvested Yield (lbs/acre or tons/acre)	(lbs or tons)	

Where does the N removal factor come from ?

Data sources and number of observations.

Source	Sites		Years sampled		Observations
	Location	n	Years	n	
Own analyses	California	14	2018	1	14
Own analyses	California	35	2019	1	35
Own analyses	California	5	2020	1	5
Own analyses	California	10	2021	1	10
Overall					**64**

Summary of carrot N removal data.

Source	Summary (lbs/ton of fresh weight)			CV (%)
	mean	SD	Range	
Own analyses 2018	2.78	0.51	2.01 - 4.11	18.4
Own analyses 2019	2.85	0.65	1.61 - 4.69	22.9
Own analyses 2020	2.97	0.81	1.98 - 4.08	27.4
Own analyses 2021	2.55	0.63	1.67 - 3.32	24.7
Overall	**2.80**	**0.63**	**1.61 - 4.69**	**22.7**

on average, a ton of carrots contains 2.80 lb N

Nitrogen concentrations in harvested plant parts – Update 03/2021

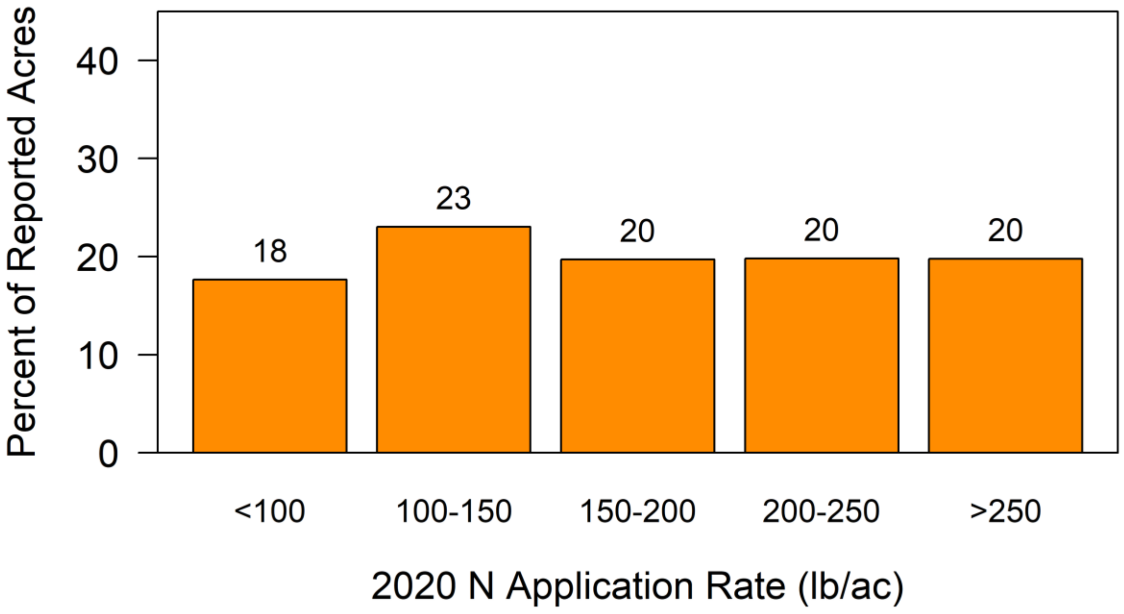
Includes updated values for

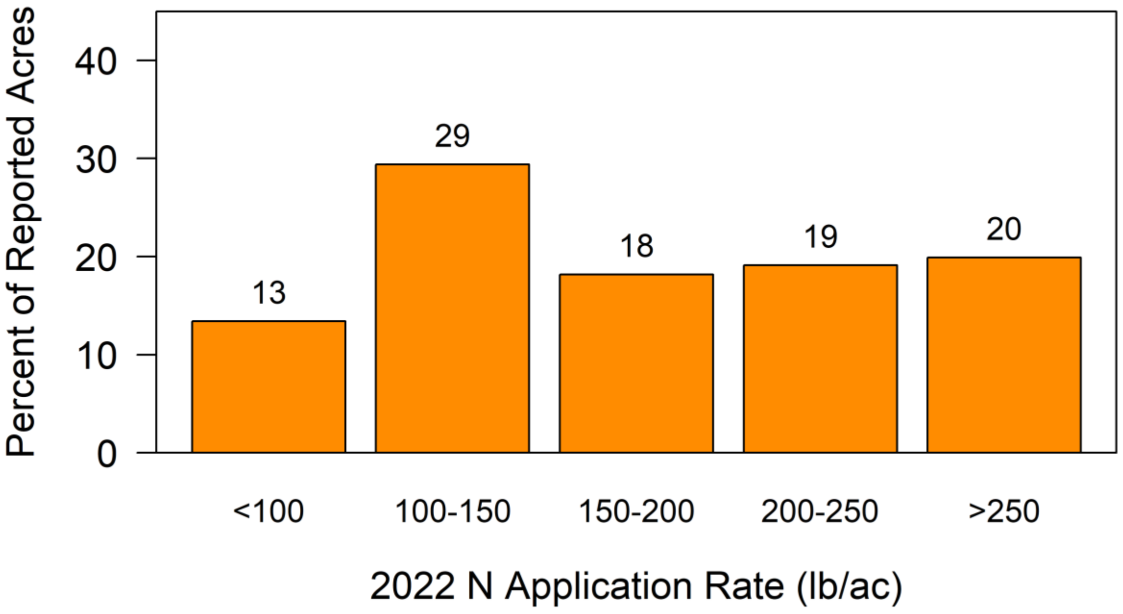
- **Carrots**
- **Corn for silage**
- **Cotton**
- **Peaches**
- **Pistachios**
- **Plums**
- **Pomegranates**
- **Tomatoes, processing**
- **Safflower**
- **Sunflower**
- **Walnuts**

Daniel Geisseler

March 30, 2021

2020 and 2022 grower-reported N application rates and carrot yields



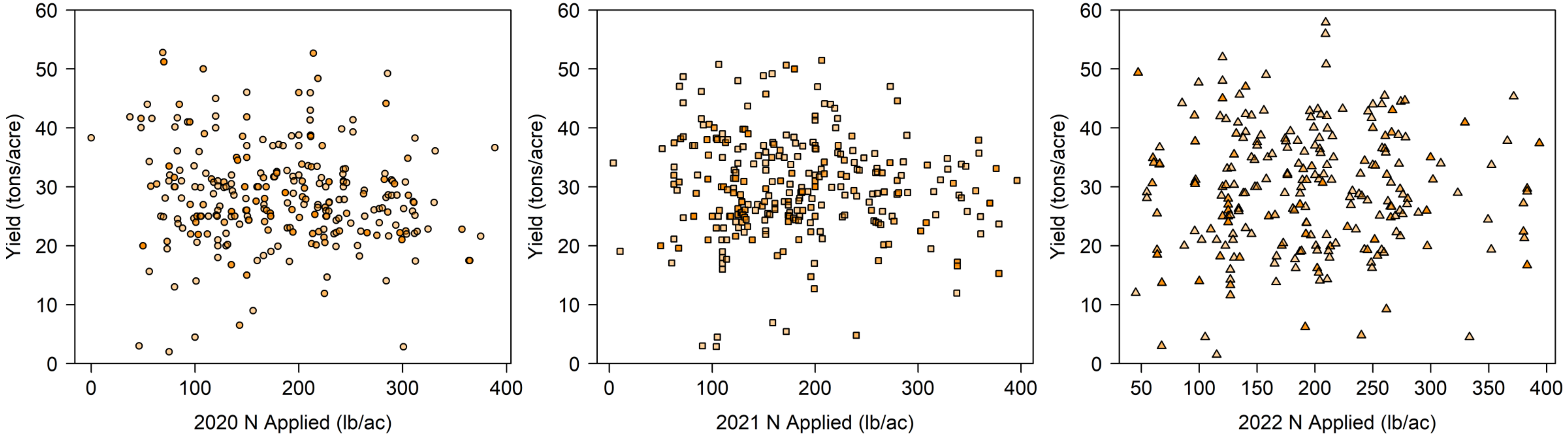


Acre-weighted means*:

Year	Ave N applied (lb/acre)	Ave yield (tons/acre)	lb N applied / ton carrots harvested
2020	179	29.0	6.2
2021	179	29.8	6.0
2022	182	29.3	6.2

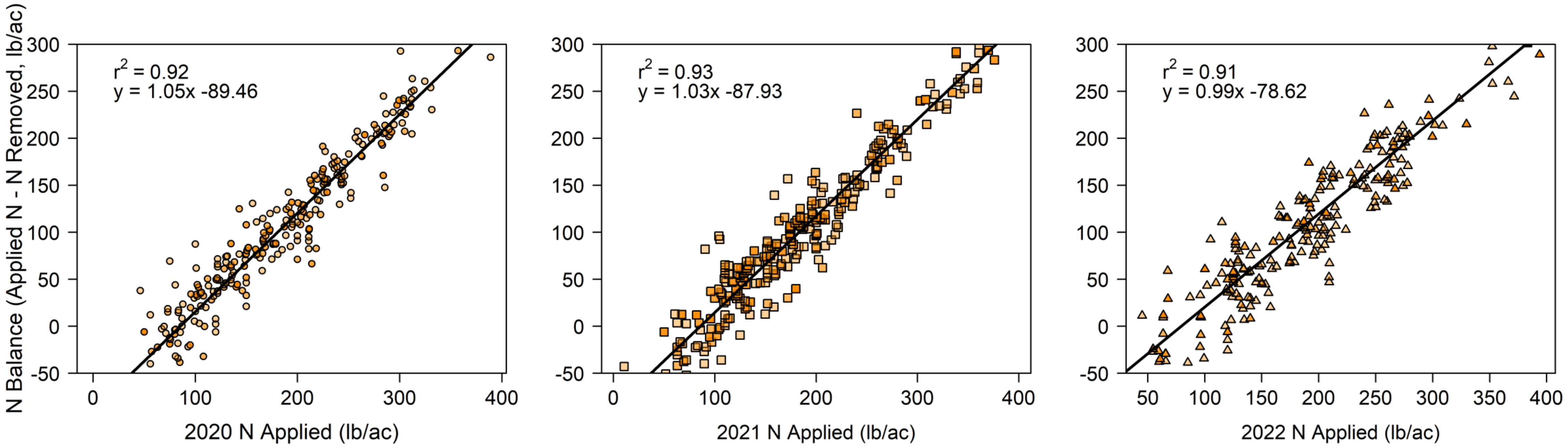
*conventional versus organic systems
- Yields within ~5%, on average
- N rates differ – *more on subsequent slides*

Carrot yield and N application rate appear unrelated…

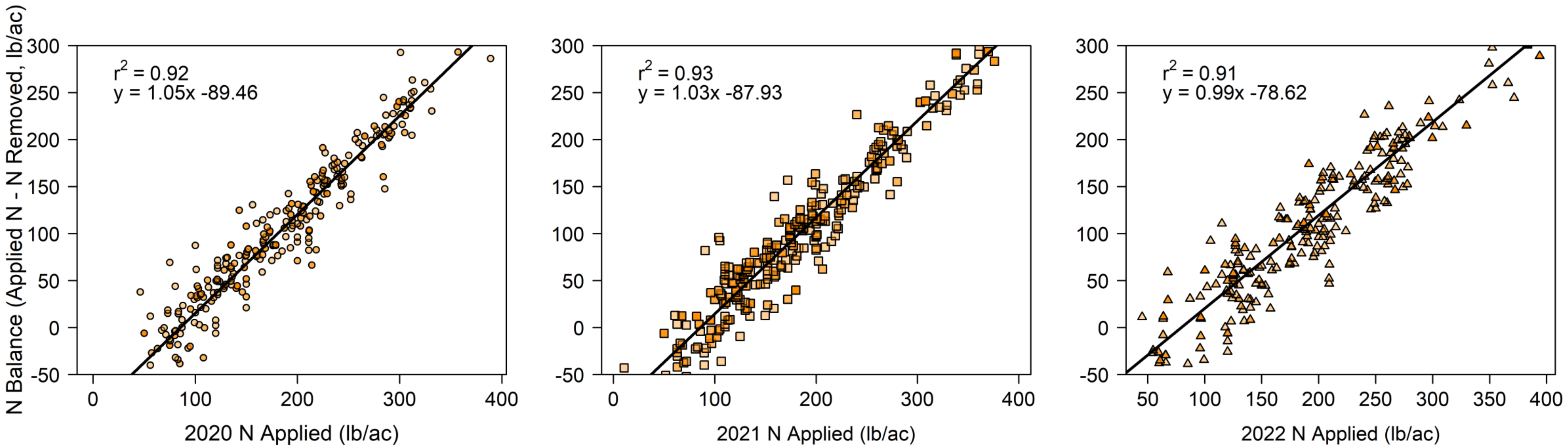


- **Lack of correlation between N rate and yield observed in other crops as well**

With no N rate vs. yield correlation, ‘N balance’ increases linearly with increasing N rate:



- **N balance for carrot ranks higher than most perennial crops, in the middle of the pack for annuals**



N balance does not directly equate to nitrate leached below the root zone (this is why CV-SWAT was used):

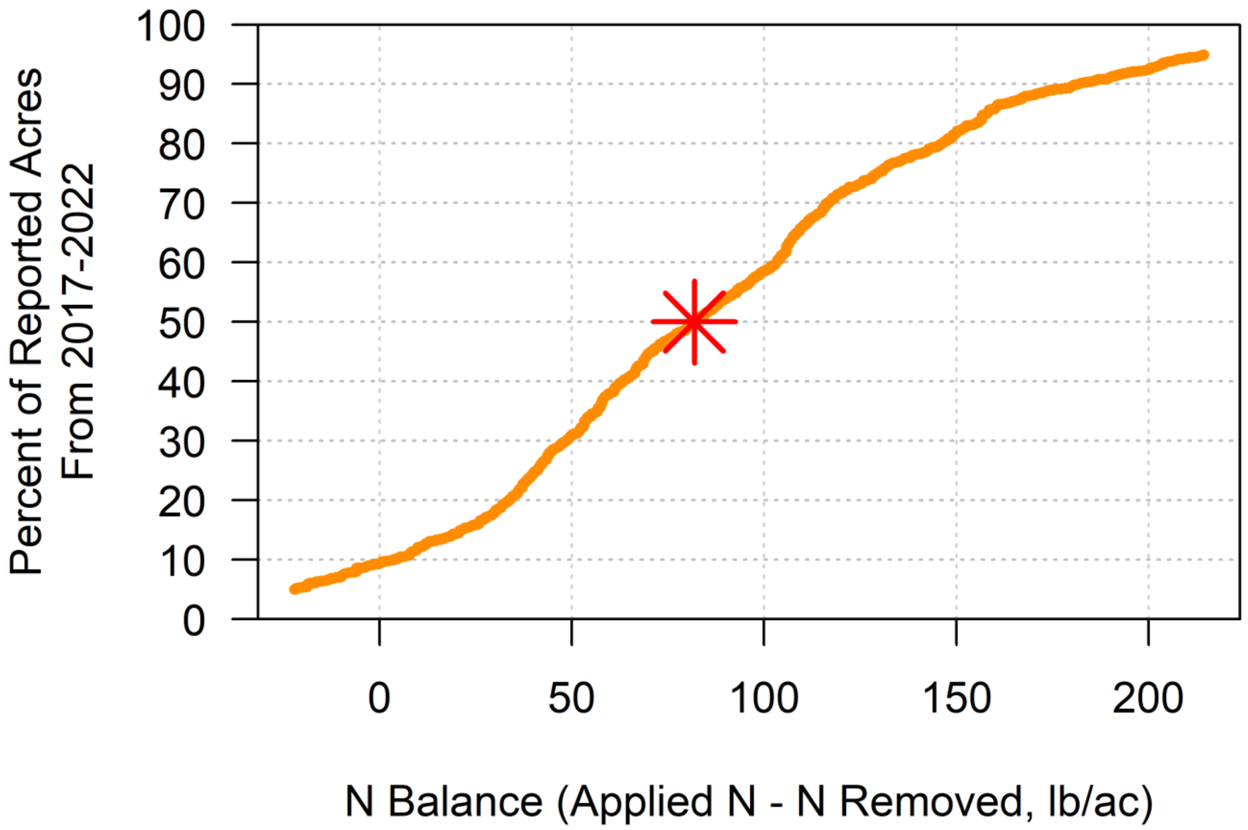
- **Other N pathways in the root zone (denitrification, volatilization, soil storage as organic N); however, the amount accounted for in these pathways is modest (typically < 10% of applied N)**

- **Rotational effects or cover cropping could be significant – must account for N “credits”**

- **Biological / chemical processes below the root zone may attenuate nitrate-N depending on subsurface conditions**

What is the way forward?

Grower-reported N application rates:

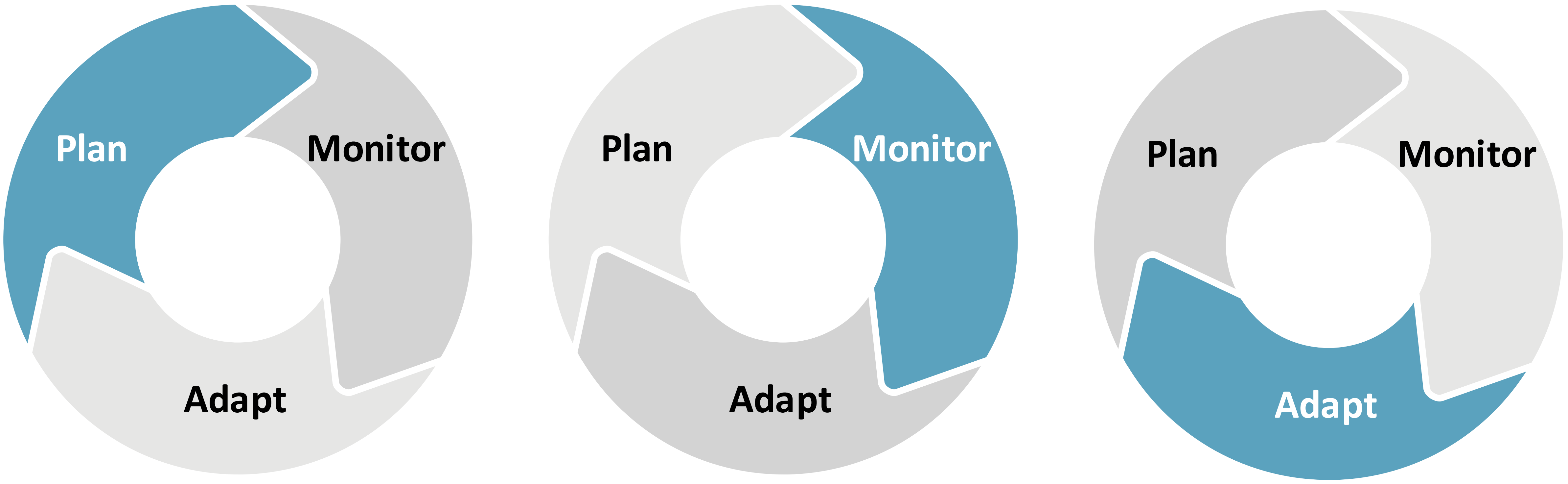


To lower the A-R N Balance either:

- *Reduce Fertilizer inputs*
- *Increase yields*
- *Both*

- **Median A-R is 82 lb N/acre (half of all acres achieve this level or less)**
- **75th percentile is 129 lb N/acre**
- **90th percentile is 182 lb N/acre**

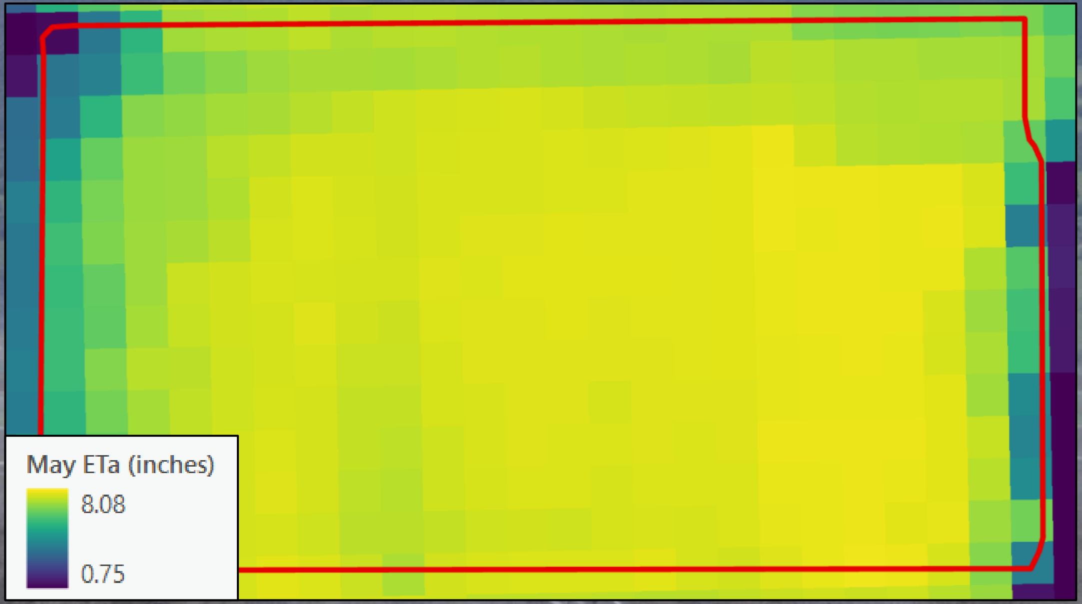
→ **Mostly from N rates > 200 lb/acre**


Plan
Monitor
Adapt
Plan
Monitor
Adapt
Plan
Monitor
Adapt

irrigation efficiency (IE) greatly affects nitrogen use efficiency (NUE).

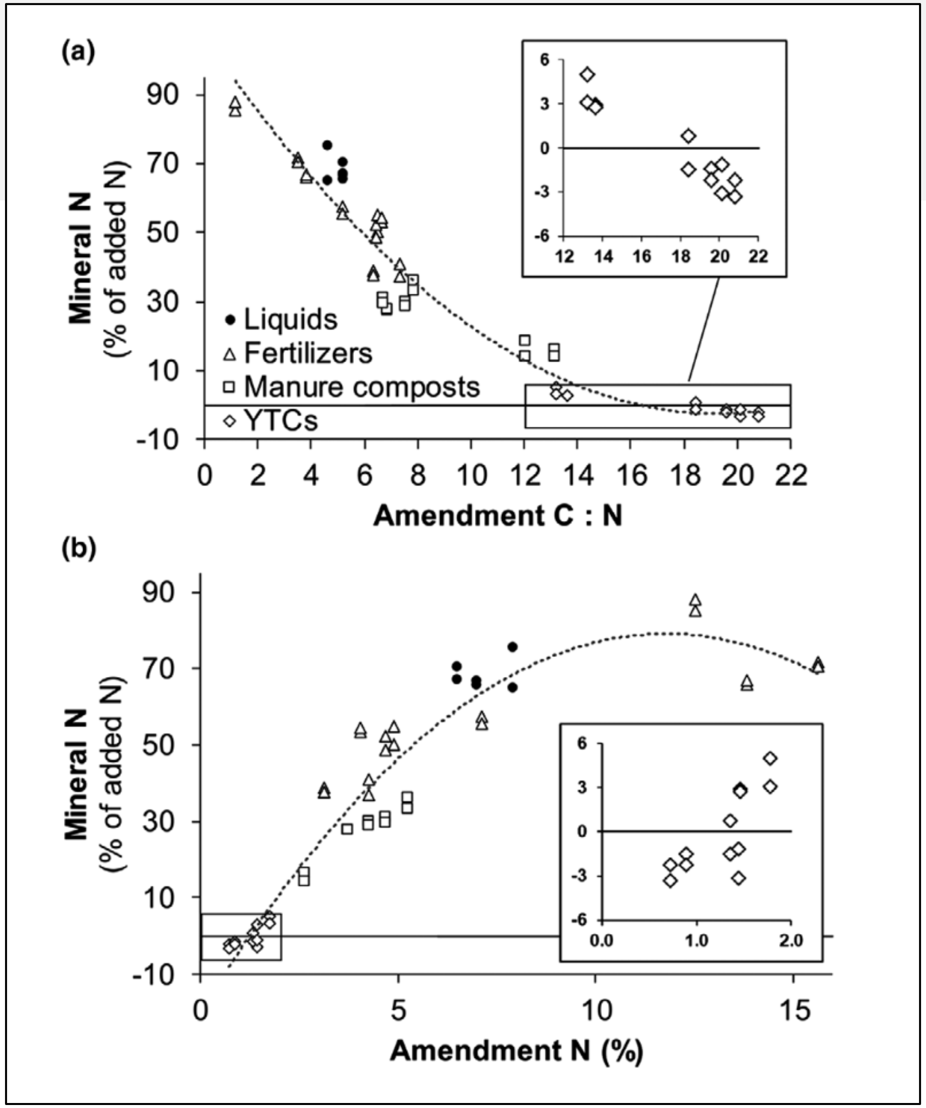
↑ IE = ↑ NUE

Example of in-field variability of ET



Considerations for organic systems

- Careful irrigation early in the season with nitrate concentrations tend to be high
- Estimating N released (mineralized) from soil amendments
  - Total amount and in-season timing relative to crop demand
    - Consider C:N ratio, %N, soil temperature
  - Soil sampling program
  - Calculator available here: http://geisseler.ucdavis.edu/Amendment_Calculator.html



Lazicki et al., 2020
https://acsess.onlinelibrary.wiley.com/doi/10.1002/jeq2.20030

How else to improve N efficiency?

- Trust that irrigation water NO_3-N is effective, and reduce fertilizer rates accordingly

Research Article

Field trials show the fertilizer value of nitrogen in irrigation water

by Michael Cahn, Richard Smith, Laura Murphy and Tim Hartz

Increased regulatory activity designed to protect groundwater from degradation by nitrate-nitrogen (NO_3-N) is focusing attention on the efficiency of agricultural use of nitrogen (N). One area drawing scrutiny is the way in which growers consider the NO_3-N concentration of irrigation water when determining N fertilizer rates. Four drip-irrigated field studies were conducted in the Salinas Valley evaluating the impact of irrigation water NO_3-N concentration and irrigation efficiency on the N uptake efficiency of lettuce and broccoli crops. Irrigation with water NO_3-N concentrations from 2 to 45 milligrams per liter were compared with periodic fertigation of N fertilizer. The effect of irrigation efficiency was determined by comparing an efficient (110% to 120% of crop evapotranspiration, ET_c) and an inefficient (160% to 200% of ET_c) irrigation treatment. Across these trials, NO_3-N from irrigation water was at least as efficiently used as fertilizer N; the uptake efficiency of irrigation water NO_3-N averaged approximately 80%, and it was not affected by NO_3-N concentration or irrigation efficiency.

California agriculture faces increasing regulatory pressure to improve nitrogen (N) management to protect groundwater quality. Groundwater in agricultural regions, such as the Salinas Valley and the Tulare Lake Basin, has been adversely impacted by agricultural practices, with nitrate-N (NO_3-N) in many wells exceeding the federal drinking water standard of 10 mg/L (Harter et al. 2012). The threat to groundwater is particularly acute in the Salinas Valley, where the intensive production of vegetable crops has resulted in an estimated net loading (fertilizer N application – N removal with crop harvest) of > 100 lb/ac (> 112 kg/ha) of N annually (Rosenstock et al. 2014).

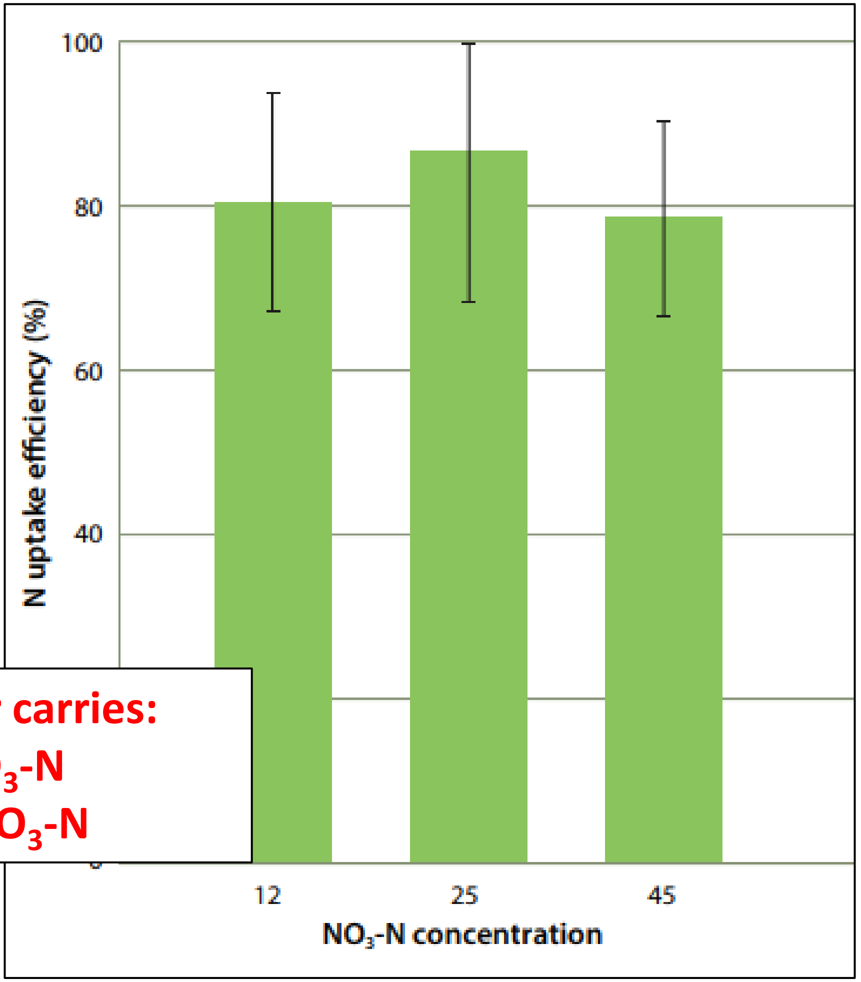
Levels of NO_3-N in irrigation wells in the Salinas Valley commonly range from 10 to 40 mg/L. Given the typical volume of irrigation water applied to vegetable fields, NO_3-N in irrigation water could represent a substantial fraction of crop N requirements, provided that crops can efficiently use this N source. Indeed, the concept of "pump and fertilize" (substituting irrigation water NO_3-N for fertilizer N) has been suggested as a remediation technique to improve groundwater quality in agricultural regions (Harter et al. 2012).

Cooperative Extension publications from around the country (Bauder et al. 2011; DeLaune and Trostle 2012; Hopkins et al. 2007) agree that the fertilizer value of irrigation water NO_3-N can be significant, but they differ as to what fraction of water NO_3-N should be credited against the fertilizer N recommendation. There is a paucity of field data documenting the efficiency of crop utilization of irrigation water N. Francis and Schepers (1994) documented that corn could use irrigation ... puter simulation, not on field trials.

With this near total lack of relevant field data, California growers have legitimate concerns about the degree to

Every acre-foot of water carries:

- 14 lb N @ 5 PPM NO_3-N
- 41 lb N @ 15 PPM NO_3-N



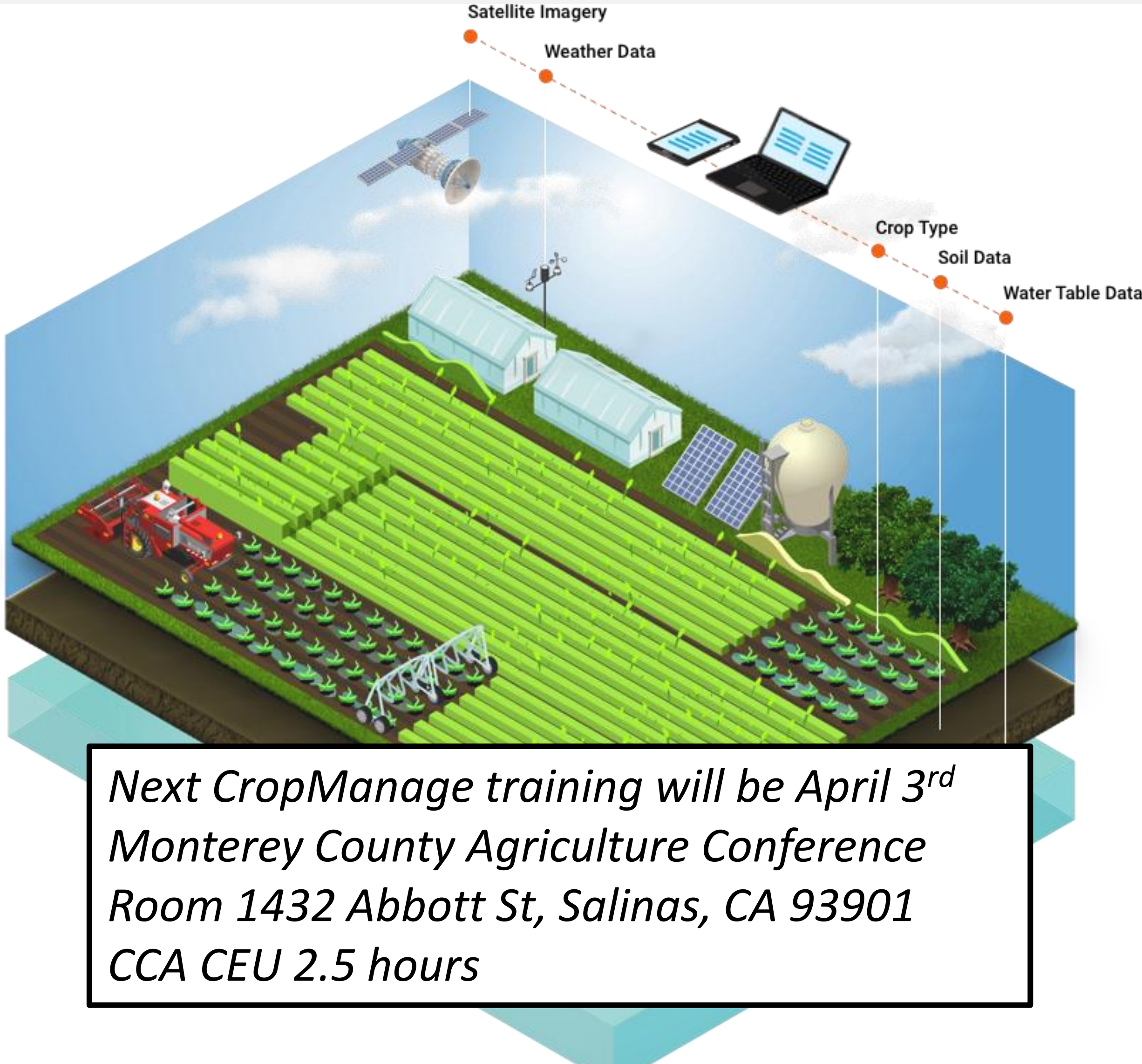
Cahn et al., 2017. California Agriculture 71:62-67.

N uptake efficiency of water NO_3-N, mean of 4 field trials

Consider utilizing decision support tools

- *Integrate soil, climate, crop, and management information to make informed in-season decisions about irrigation and fertilization*

- CropManage is one option – free from UC ANR
  - Easy to use and manage data
  - Can consider soil and tissue sample data, flow meters, soil moisture sensors
  - User information is anonymous
  - Has been shown to save 20-40% on water and N use in commercial settings compared to grower standard practices
  - UCCE advisors available for technical assistance, Kern County advisors will be evaluating in carrot

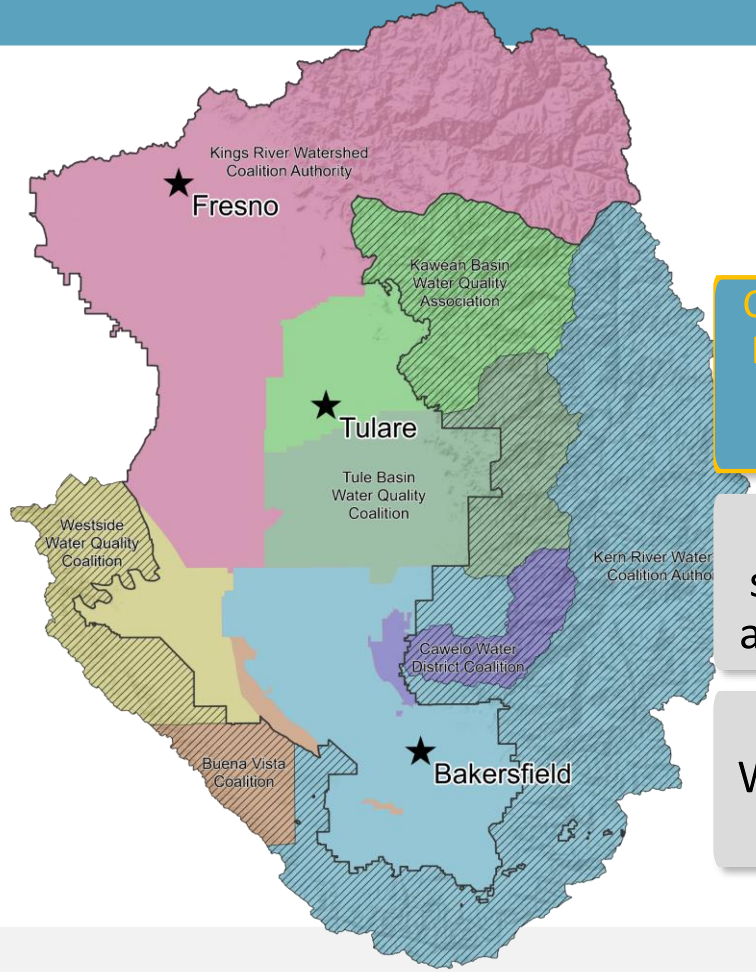


Next CropManage training will be April 3rd
Monterey County Agriculture Conference Room 1432 Abbott St, Salinas, CA 93901
CCA CEU 2.5 hours

INTEGRATED WATER & NITROGEN MANAGEMENT **TRAININGS**

Feb 2025 & 2026

THE SOUTHERN SAN JOAQUIN VALLEY
MANAGEMENT PRACTICES EVALUATION PROGRAM



Continuing Education Credits Available

A 3-part curriculum will be delivered in collaboration with UC experts

- Overview of the regulatory landscape and the connection between management and groundwater quality at the landscape scale.
- Irrigation efficiency and nutrient management content for nut and fruit trees, citrus, grapes, forage and grains, and row crops.
- Decision-support tool tutorials for CropManage.

Who should attend?

Growers, farm managers, other farm staff, crop advisors, consultants, and technical service providers are welcome.

Where?

Fresno, Tulare, Bakersfield

Online content delivered on agmpep.com

Funded by CDFA Water Efficiency Technical Assistance

In summary:

- The agricultural industry will be challenged to meet regulatory targets for groundwater quality protection
- N use efficiency in carrot production will have to improve over time