THE ALMOND CONFERENCE 2025

WELCOME!

CULTIVATING A HEALTHIER FUTURE

PRODUCTION RESEARCH UPDATES

Moderator

Sebastian Saa, ABC, Ag. Research

Speakers

Andreas Westphal, UC Riverside

Mohammad Yaghmour, UC ANR

Isaya Kisekka, UC Davis

Roger Duncan, UC ANR

Franz Niederholzer, UC ANR

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Hull Rot

MOHAMMAD YAGHMOUR
UCCE KERN COUNTY

DECEMBER 11, 2025

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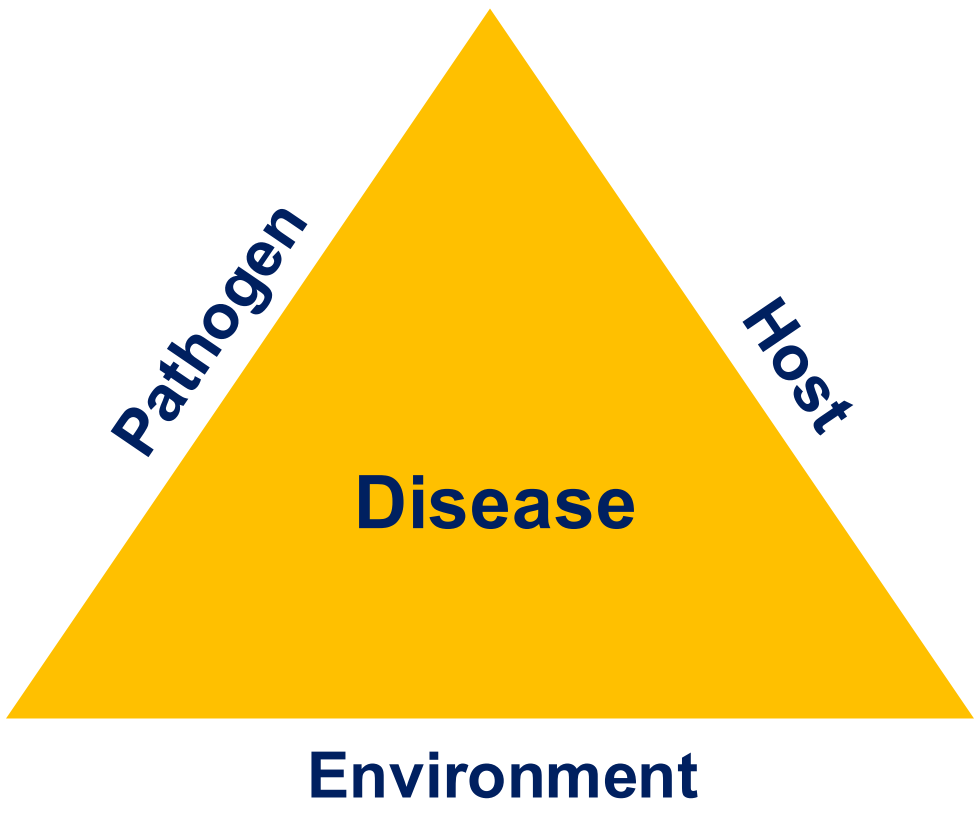
DISEASE TRIANGLE



SYMPTOMS OF HULL ROT

When the hull is infected and disease progress, leaves near the infected fruit starts to dry and shrivel.

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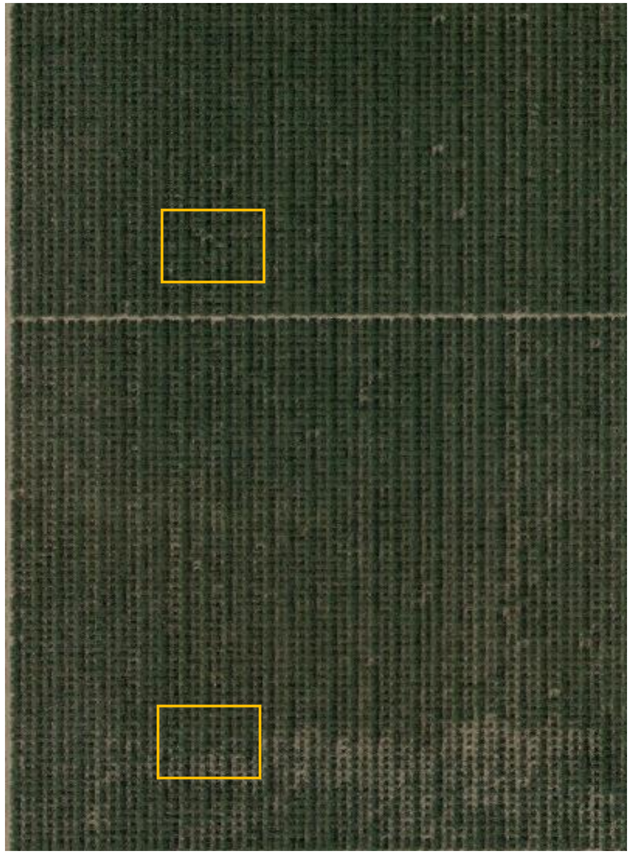
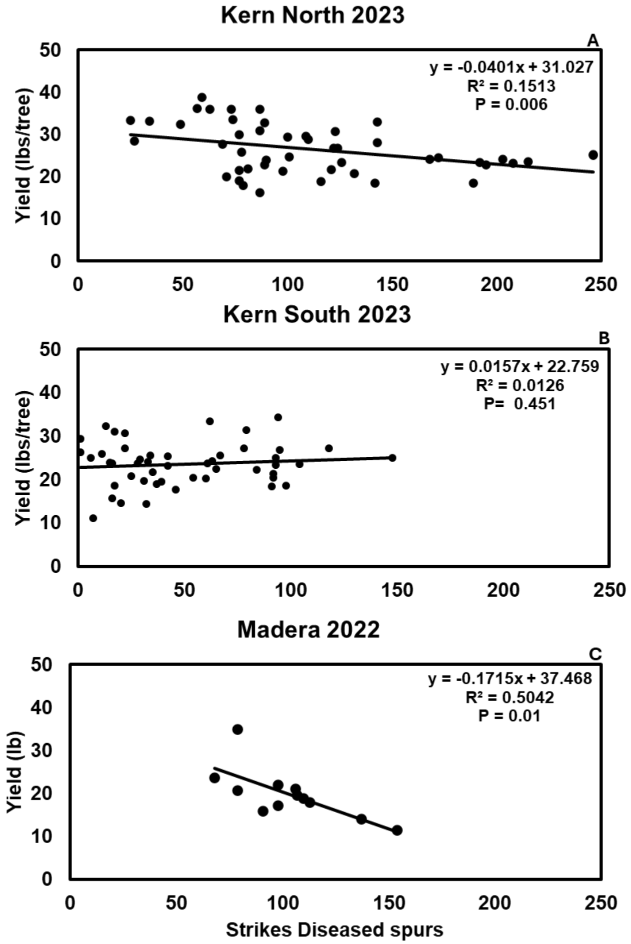
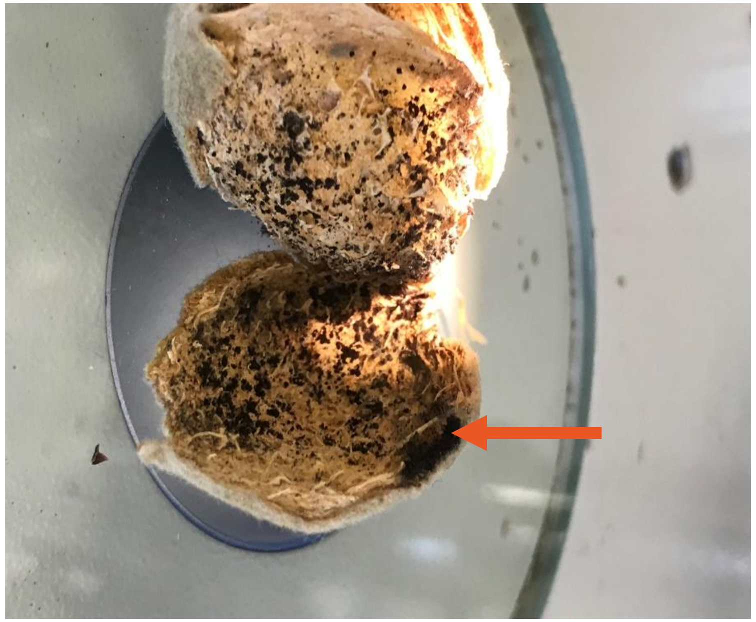
Effect of Hull Rot Incidence on Yield





SIGNS OF HULL ROT

Rhizopus stolonifer
Source of inoculum: soil



Aspergillus niger
Source of inoculum: soil

***Monilinia* spp.**
Sources of inoculum: Infected almond and stone fruit twigs, fruits, mummies, etc.

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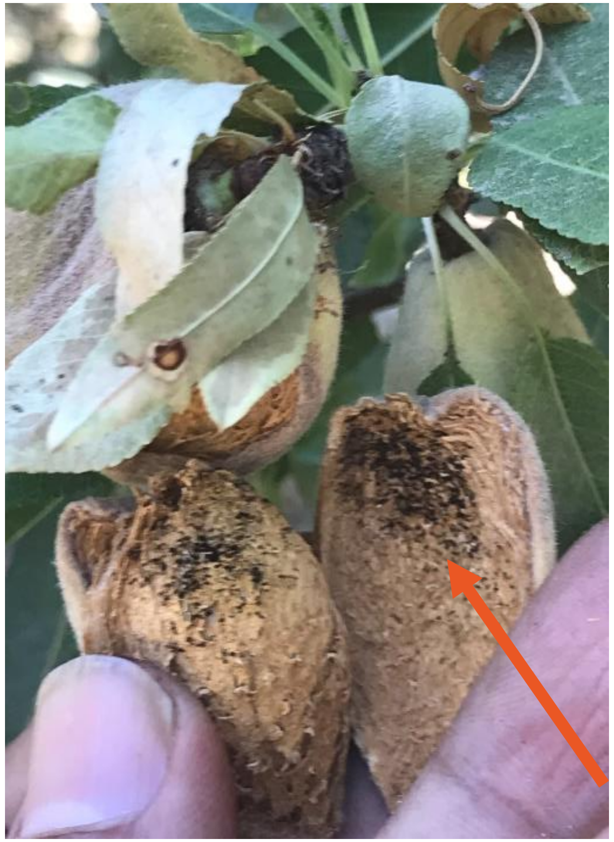
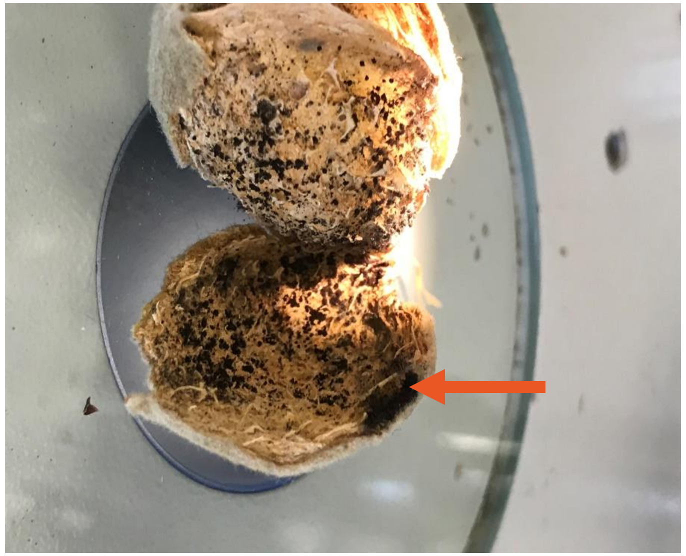
Aspergillus niger and Hull Rot

Since 2017, Hull Rot infections observed in almond orchards with flat jet-black spores identified as *Aspergillus niger*





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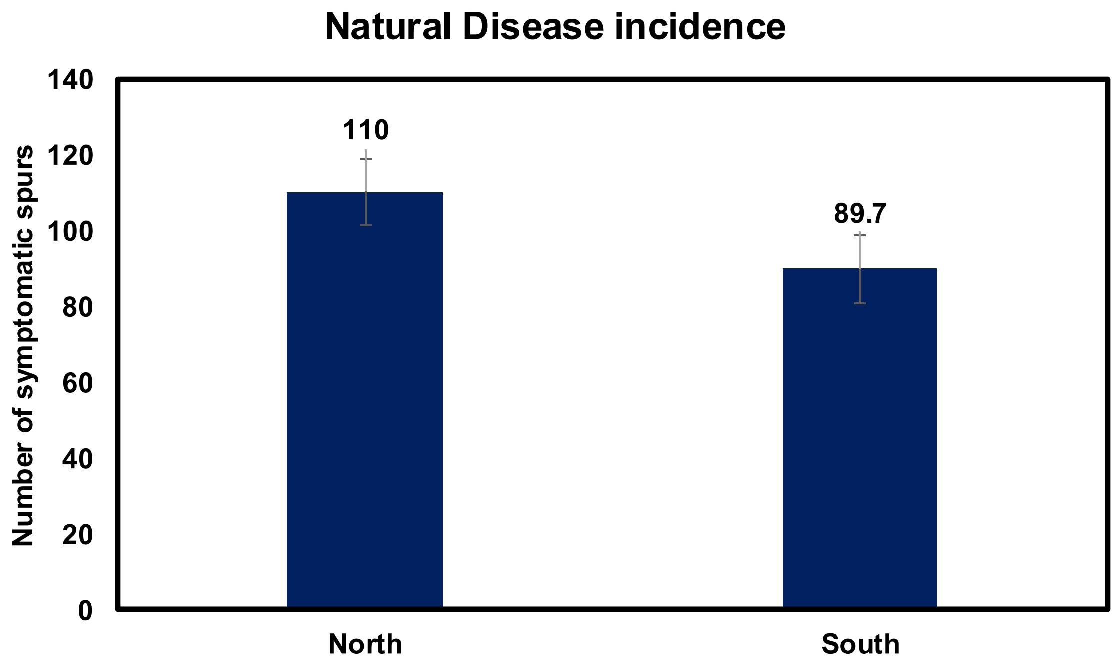
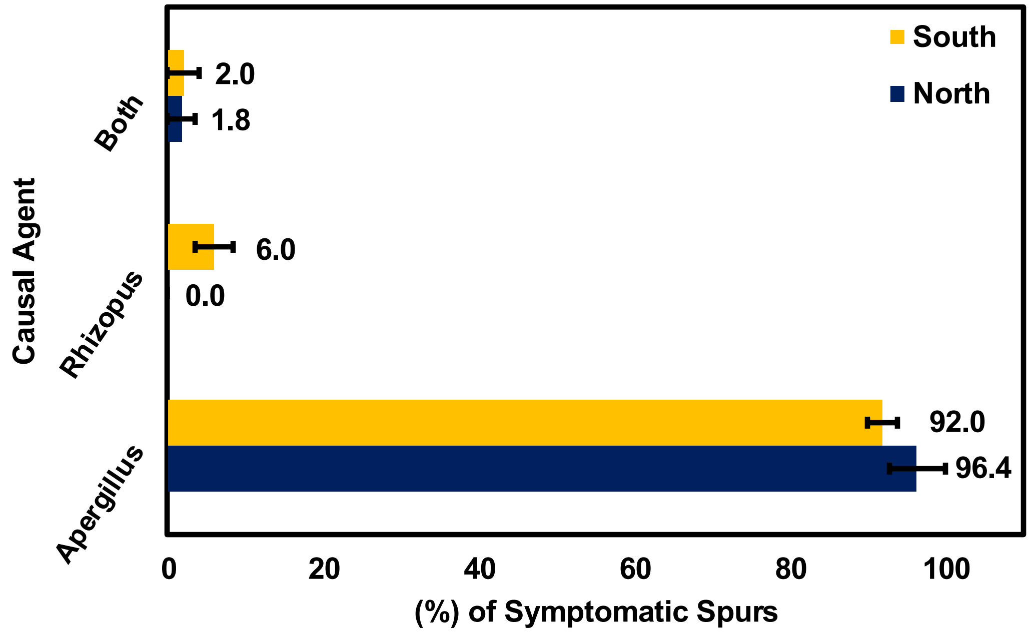
SYMPTOMS AND SIGNS OF HULL ROT

Aspergillus niger

Rhizopus stolonifer

NATURAL INCIDENCE OF HULL ROT 2021





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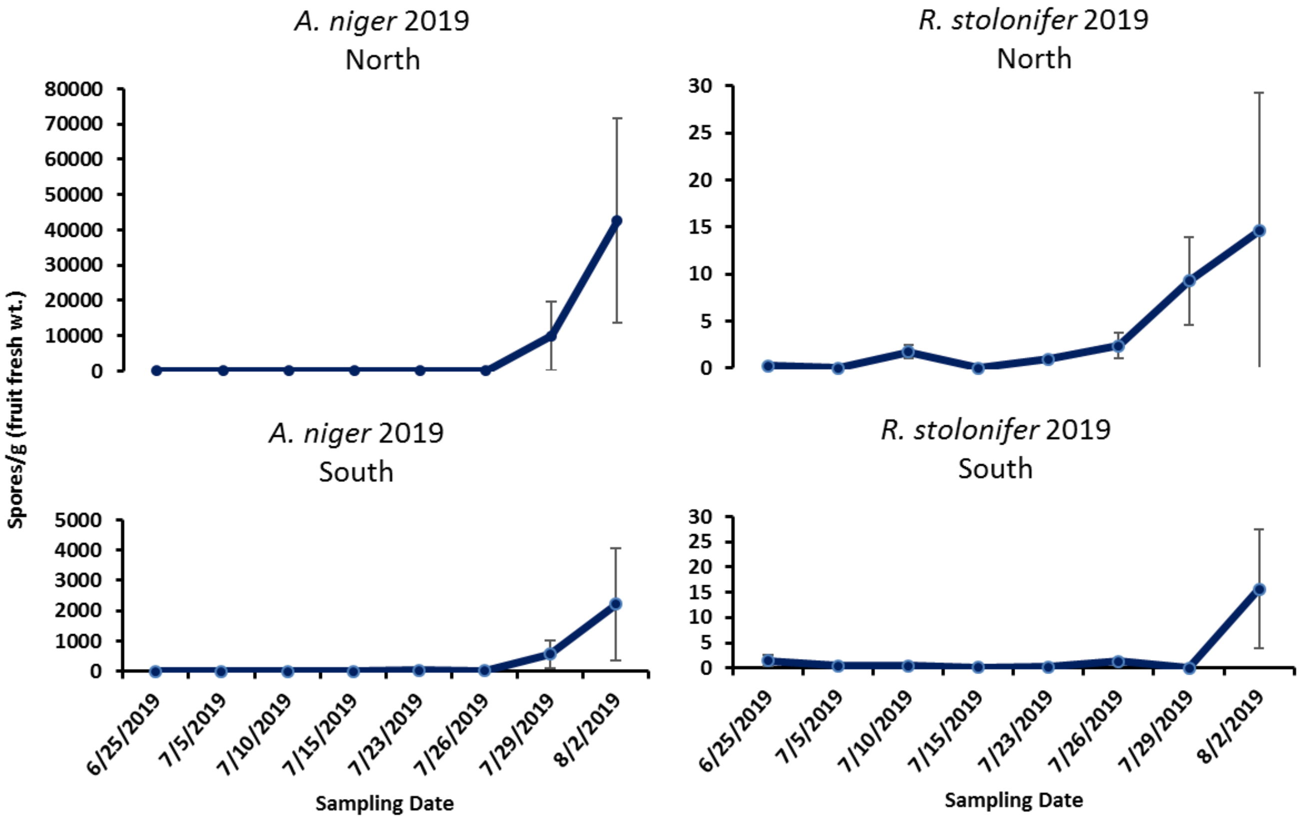
SOURCES OF INOCULUM



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FRUIT SUSCEPTIBILITY TO HULL ROT PATHOGEN *RHIZOPUS STOLONIFER*

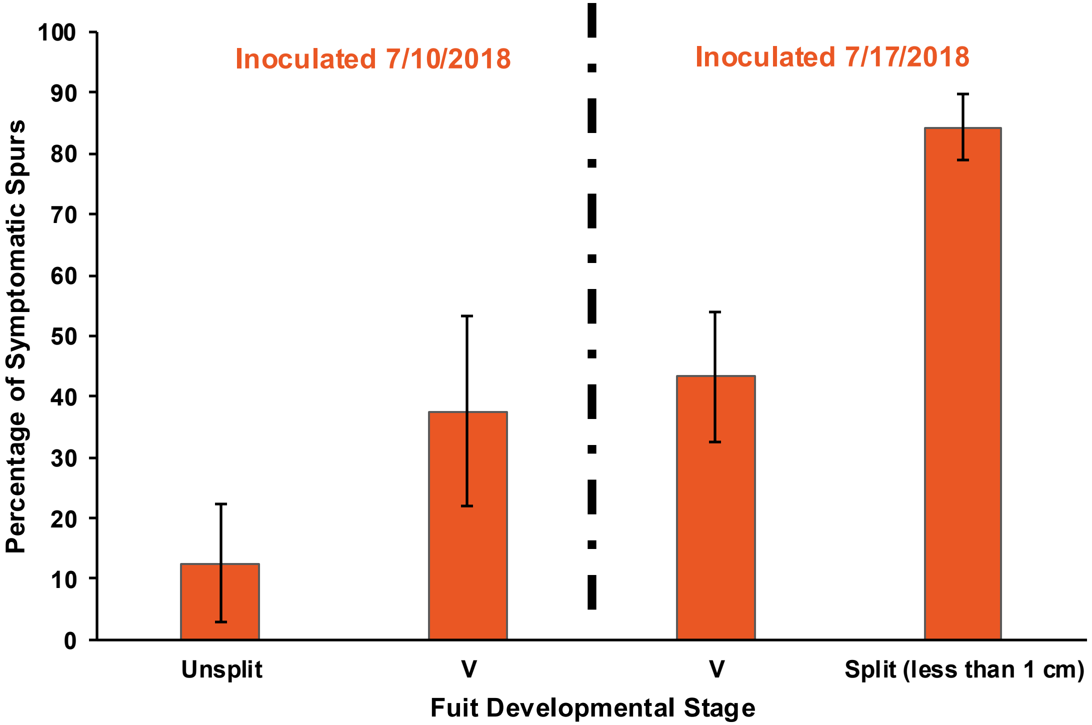
(b1) Initial separation-50% or more of a thin separation line visible

(b2) Deep V, is the most susceptible stage (source: Adaskaveg. 2010)

(b3) Deep V, split-a deep "V" in the suture, which is not yet visibly separated, but which can be squeezed open by pressing both ends of the hull

(c) Split, less than 3/8 inch

FRUIT SUSCEPTIBILITY AT DIFFERENT STAGES



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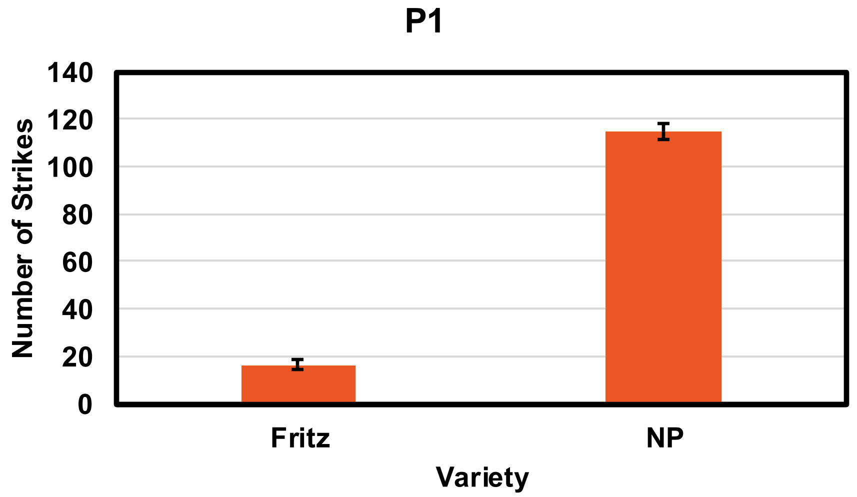
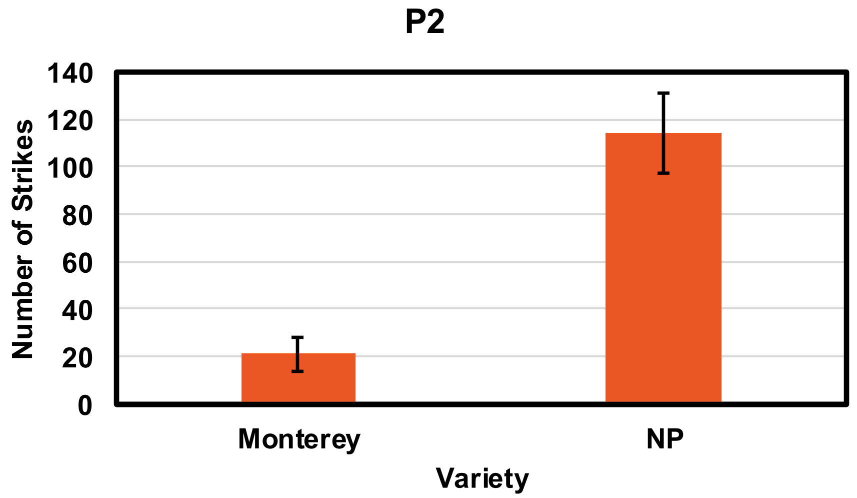
VARIETAL DIFFERENCES

Variety	Strikes / tree	Susceptibility
Nonpareil	>500	Very high
Butte	>200	High
Winters	>200	High
Price	100-200	Medium
Sonora	100-200	Medium
Aldrich	10-100	Low
Wood Colony	10-100	Low
Mission	10-100	Low
Ruby	10-100	Low
Livingston	10-100	Low
Padre	10-100	Low
Fritz	0-10	Very Low
Carmel	0-10	Very Low
Montrey	0-10	Very Low





Source: Doll and Holtz. 2013. Almond Hull Rot – Cultural and Chemical Management

STRATEGIES USED IN IPM

Avoidance

Exclusion:

- Quarantine
- Pathogen-Free planting material

Eradication

Protection:

Biological Control

Host Resistance

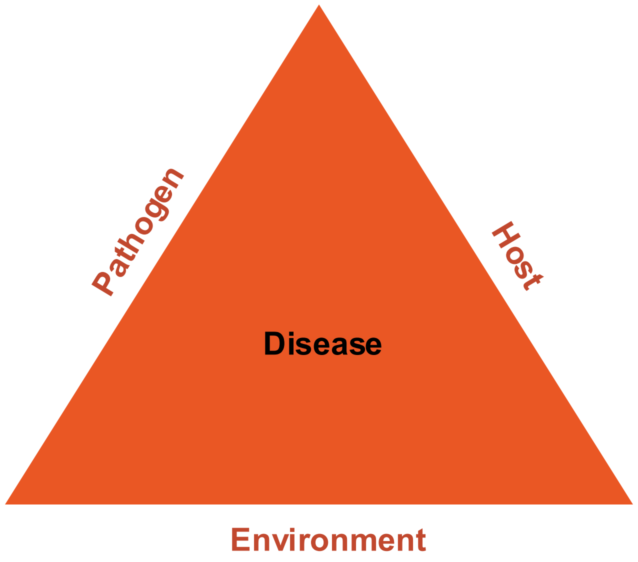
- Varietal susceptibility and resistance

Cultural practices

- Managing plant nutrition (e.g., nitrogen management for hull rot)
- Water management (Important in soil borne diseases, and hull rot)

Chemical control

- Fungicides, Fumigation, etc



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INTEGRATED HULL ROT MANAGEMENT

- Cultural
  - Irrigation management using strategic deficit irrigation (SDI)
  - Nitrogen management
  - Dust Management

- Chemical
  - Use of fungicides
  - Use of other chemical such as alkaline fertilizers

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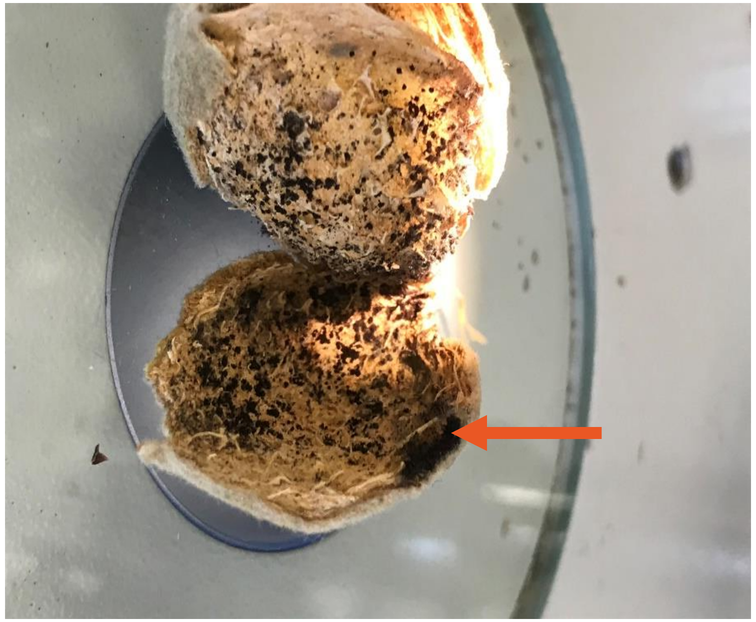
EFFECT OF FUNGICIDES ON HULL ROT



Timing of Chemical Control of Hull Rot

- Hull rot caused by *R. stolonifer* can be managed by a single application at hullsplit (1-5% hullsplit), timed with the NOW insecticide treatment.
- Hull rot caused by *Monilinia* spp. is best managed with fungicide applications 3 to 4 weeks before hull split (early June).

		Bloom			Spring[1]		Summer	
Disease	Dormant	Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	May	June/July
Alternaria	0	0	0	0	0	2	3	3
Anthracnose[2]	0	2	3	3	3	3	3	2
Bacterial spot	1	0	2	3	3	2	1	0
brown rot	0	2	3	1	0	0	0	0
Green fruit rot	0	0	3	2	0	0	0	0
Hull rot[7]	0	0	0	0	0	0	0	3
Leaf blight	0	0	3	2	1	0	0	0
Rust	0	0	0	0	0	3	3	1[6]
Scab[3]	2	0	0	2	3	3	1	0
Shot hole[4]	1[5]	1	2	3	3	2	0	0

[7] Make application at 1 to 5% hull split to manage hull rot caused by *Rhizopus stolonifer;* use earlier June timings for hull rot caused by *M. fructicola.* Apply a second application, mid-way through hull split especially if hull split is progressing slowly.

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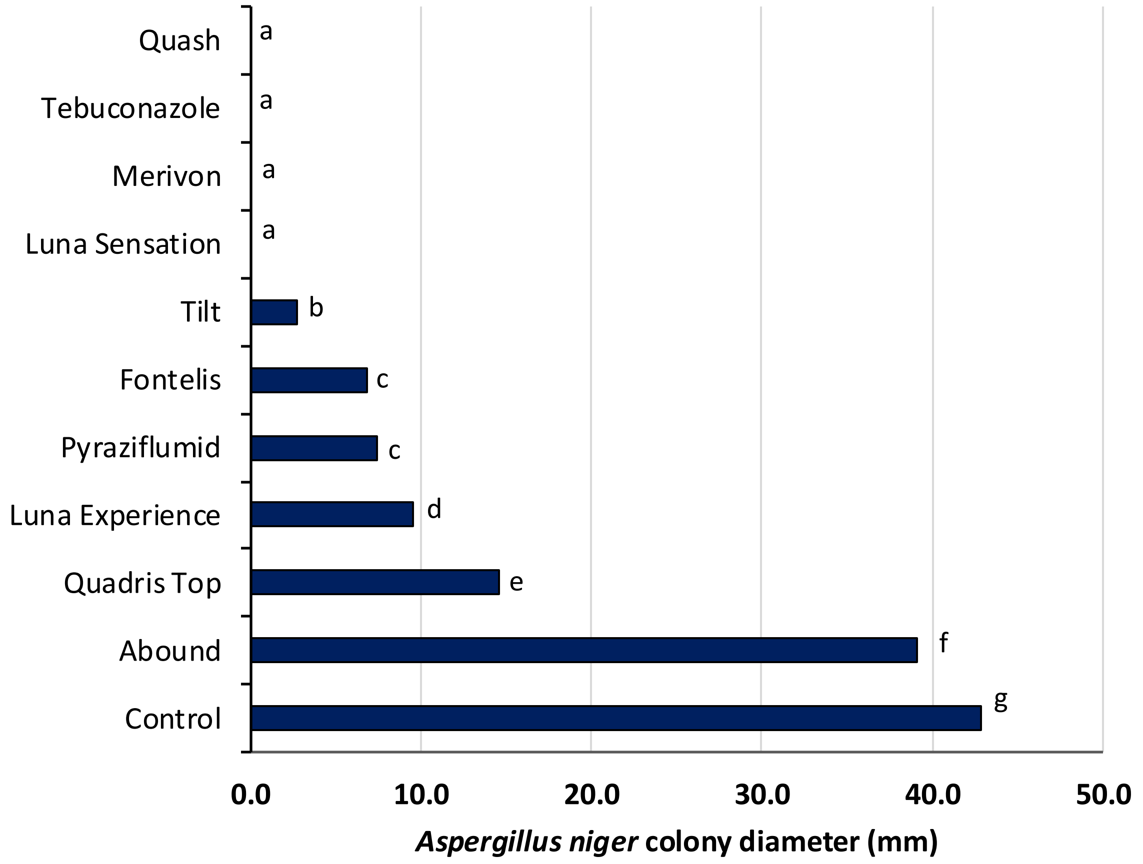
CHEMICAL CONTROL OF HULL ROT



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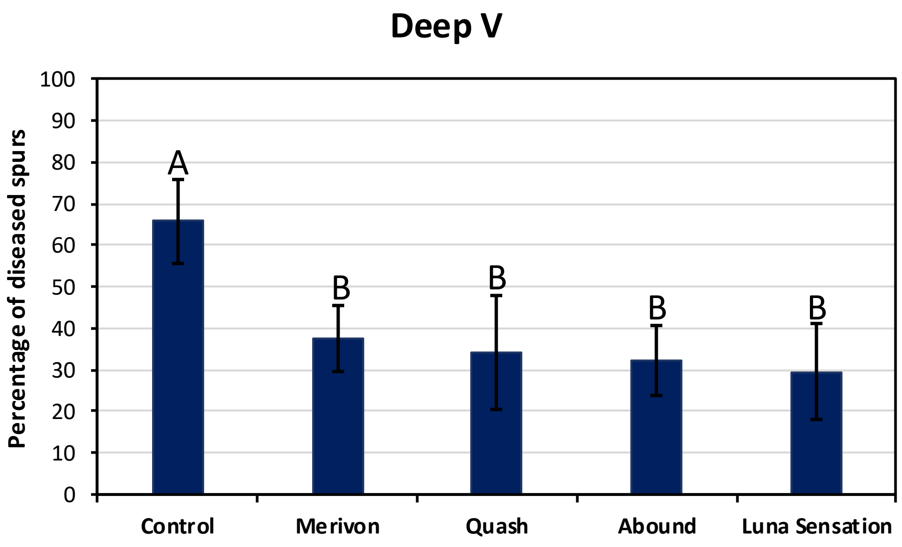
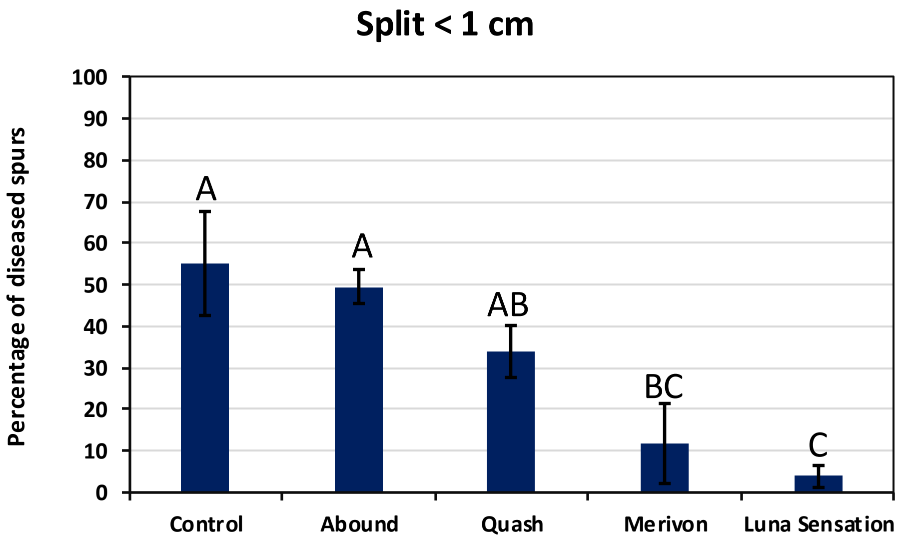
Aspergillus niger Management 2020





Hull Rot

- Identify the causal agent
- Irrigation management.
- Avoid excess nitrogen fertilizer.
- Dust Management
- Chemical control
  - Timing is important: *Rhizopus stolonifer* at hull split 1-5%. *Monilinia* spp. 3-4 weeks before hull split.

Thank You!

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UC CE

University *of* California
Agriculture and Natural Resources

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Data Driven Precision Irrigation Management for Almond Orchards

Isaya Kisekka

Professor

University of California, Davis

December 11, 2025

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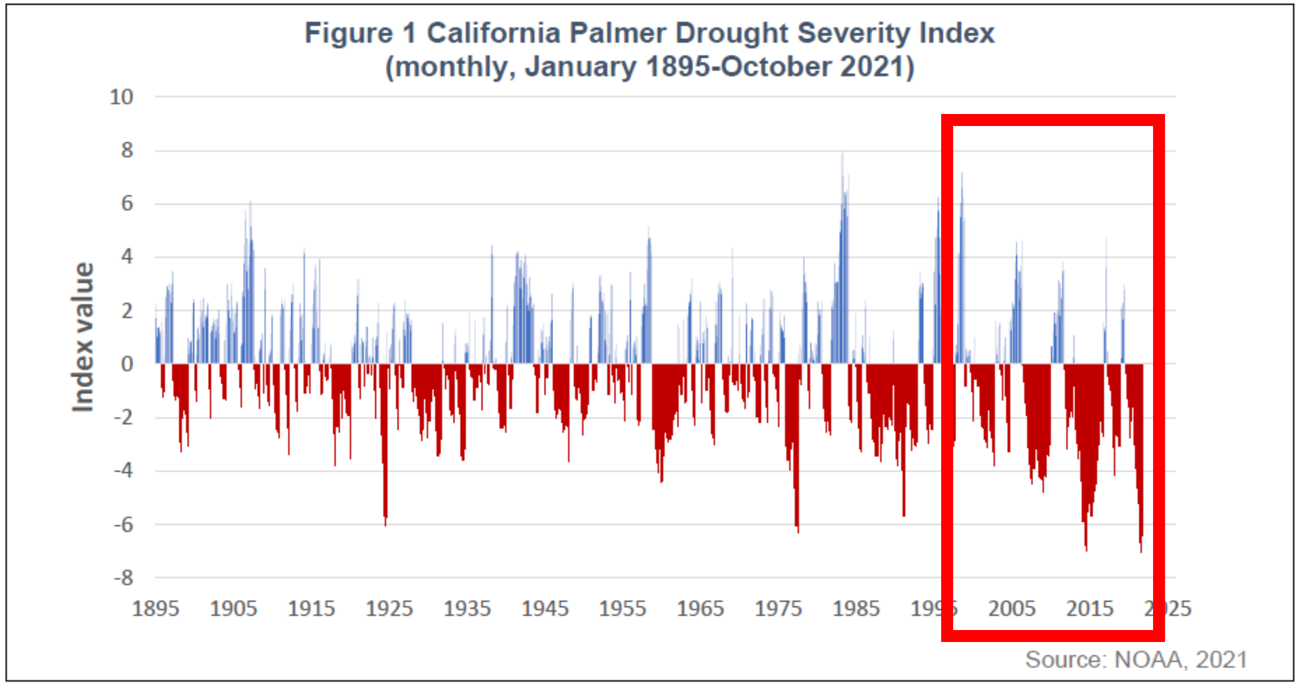
Why precision irrigation of almond orchards is needed

- Chronic water scarcity due to repeated drought cycles
- SGMA groundwater pumping limits
- Rising input costs, e.g., pumping/energy costs, labor, fertilizers, etc
- Almond price fluctuations



California's droughts have become more frequent, longer, and more severe

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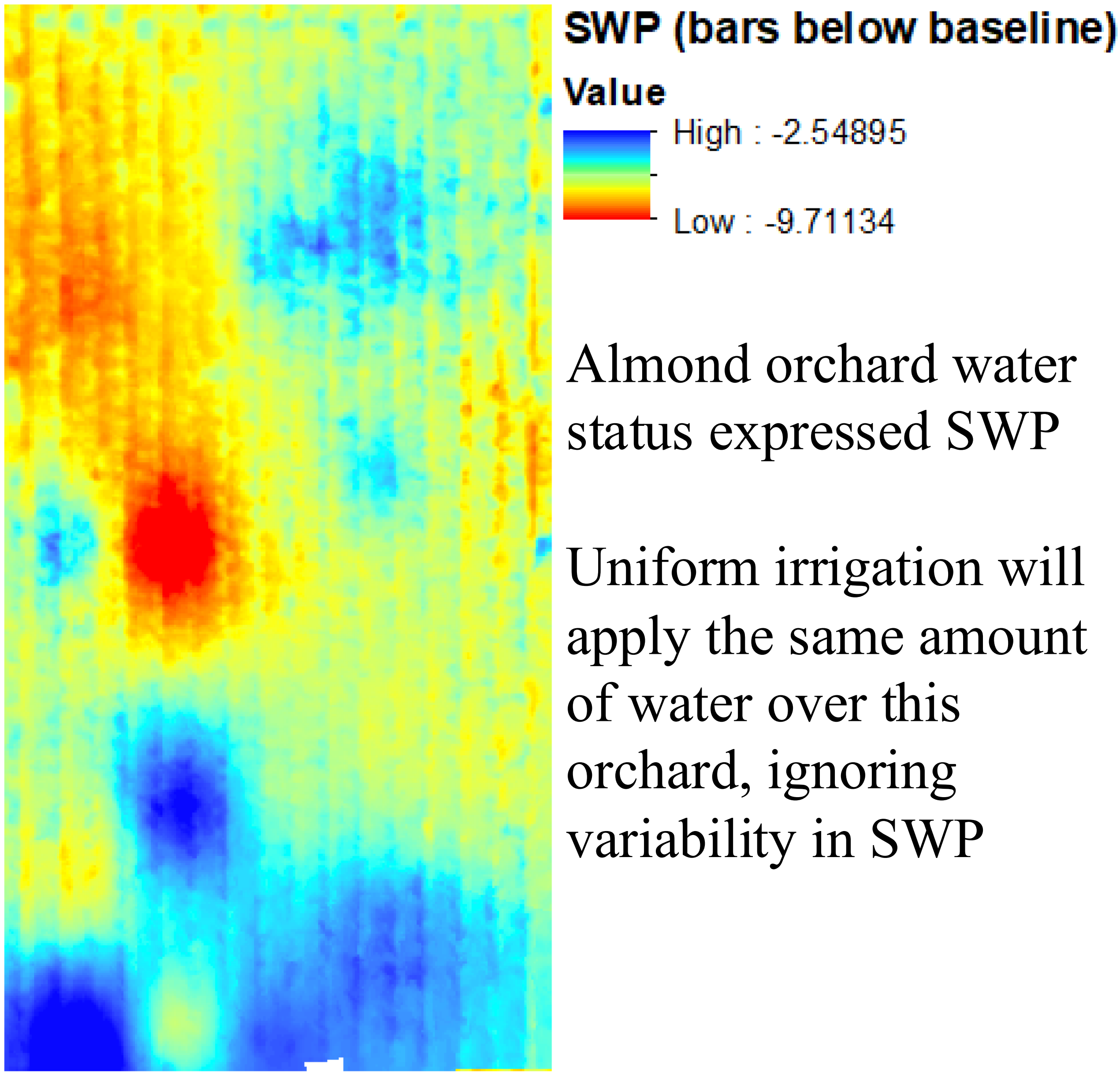
The uniform irrigation problem

- Ignores soil and tree vigor variability
- Over-irrigation in some zones
- Under-irrigation in others
- Exacerbates nut yield and quality variability



Almond orchard water status expressed SWP

Uniform irrigation will apply the same amount of water over this orchard, ignoring variability in SWP

What we did

- **Goal**: Created irrigation management zones that account for differences in infiltration, soil water storage, and tree vigor

- Evaluated two precision irrigation approaches: Almond Irrigation by Variety and Zone-based irrigation

- Spatial mapping, zone clustering, and zone-based irrigation

Precision irrigation: Almond irrigation by variety

Source: A. Pourreza

Precision irrigation: Almond irrigation by variety

Compared effects of:

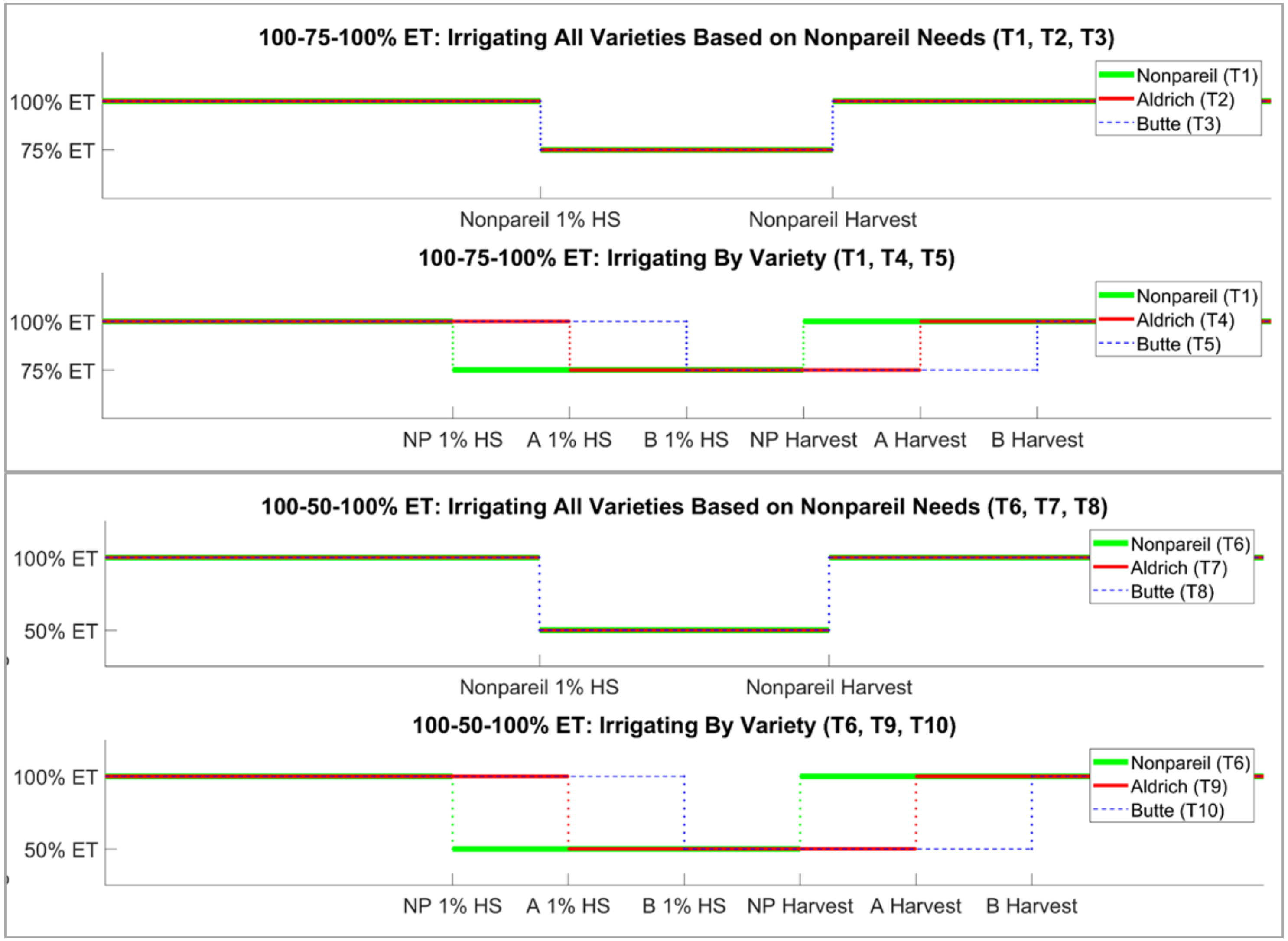
(1) Irrigating according to nonpareil hull-split timing

(2) Irrigating according to variety-specific hull-split timing

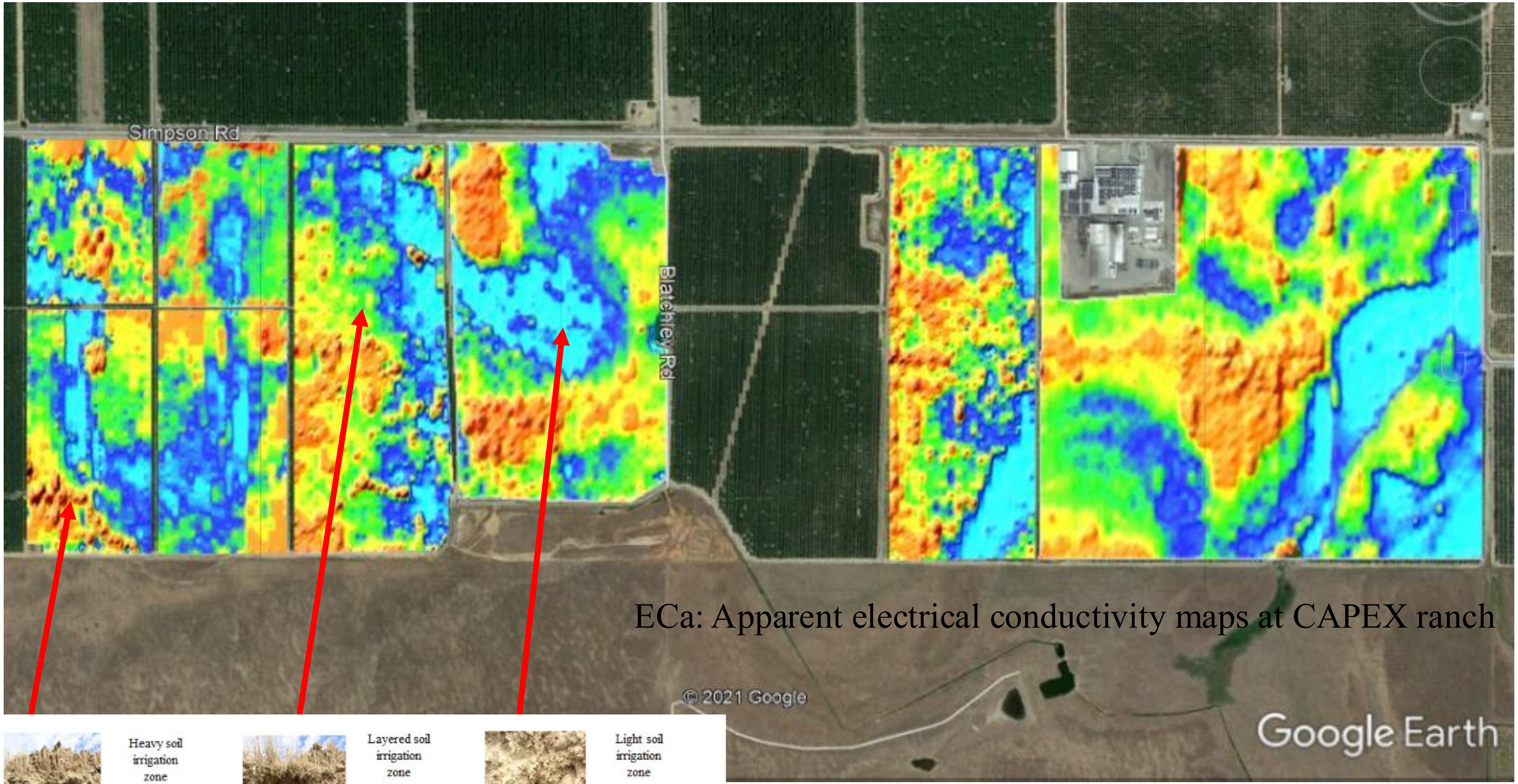
ELSEVIER
Agricultural Water Management
Volume 271, 1 September 2022, 107770

Variety specific irrigation of almonds during hull split, effects on yield and quality

Kelley Drechsler [a 1], Isaya Kisekka [a b]



Soil variability within an almond orchard near Corning, CA



Heavy soil irrigation zone

Layered soil irrigation zone

Light soil irrigation zone

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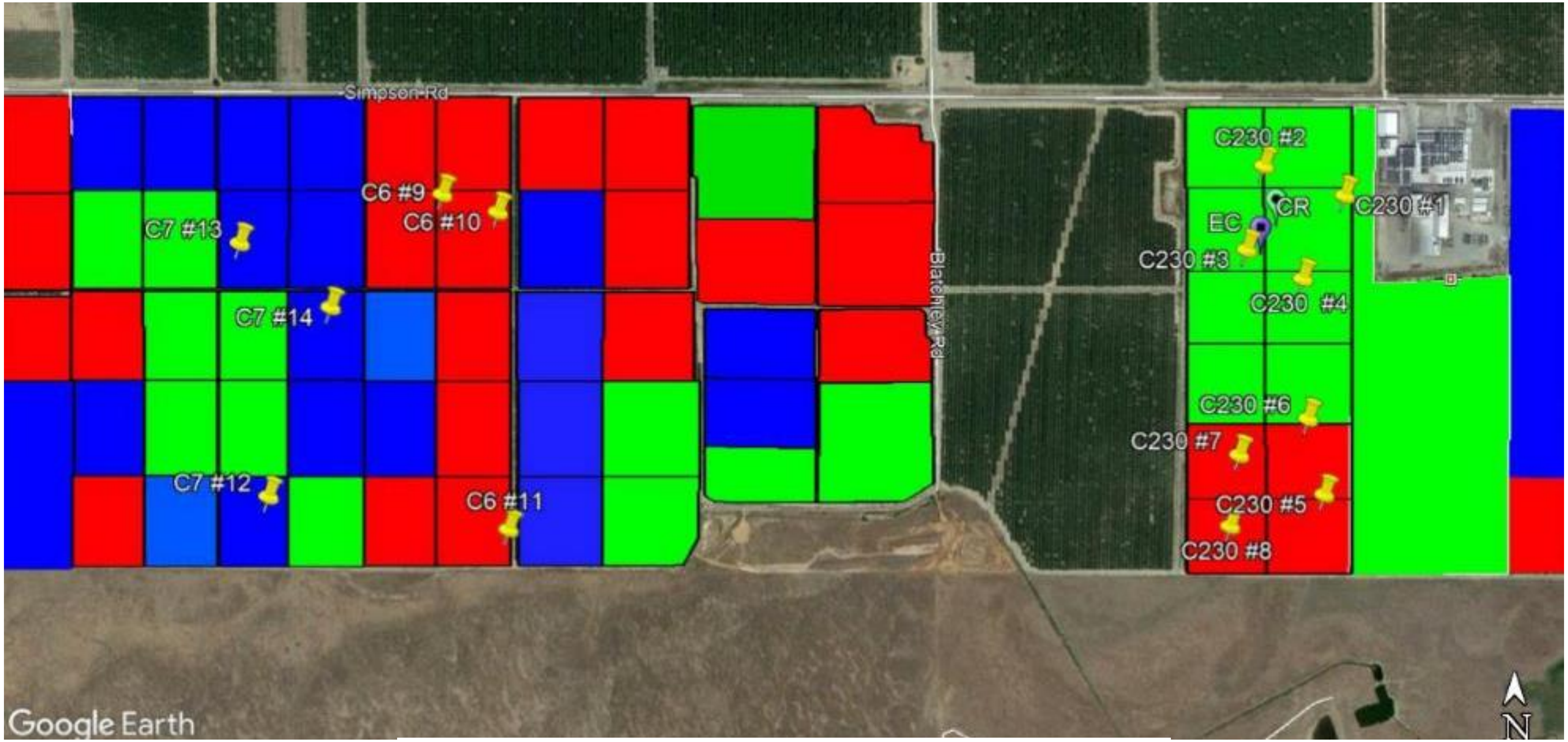
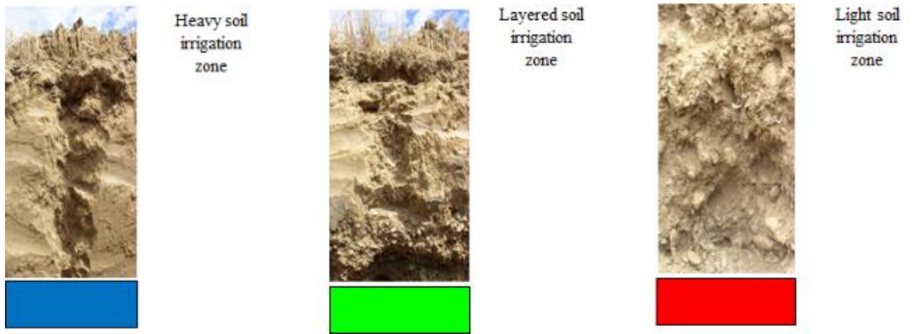
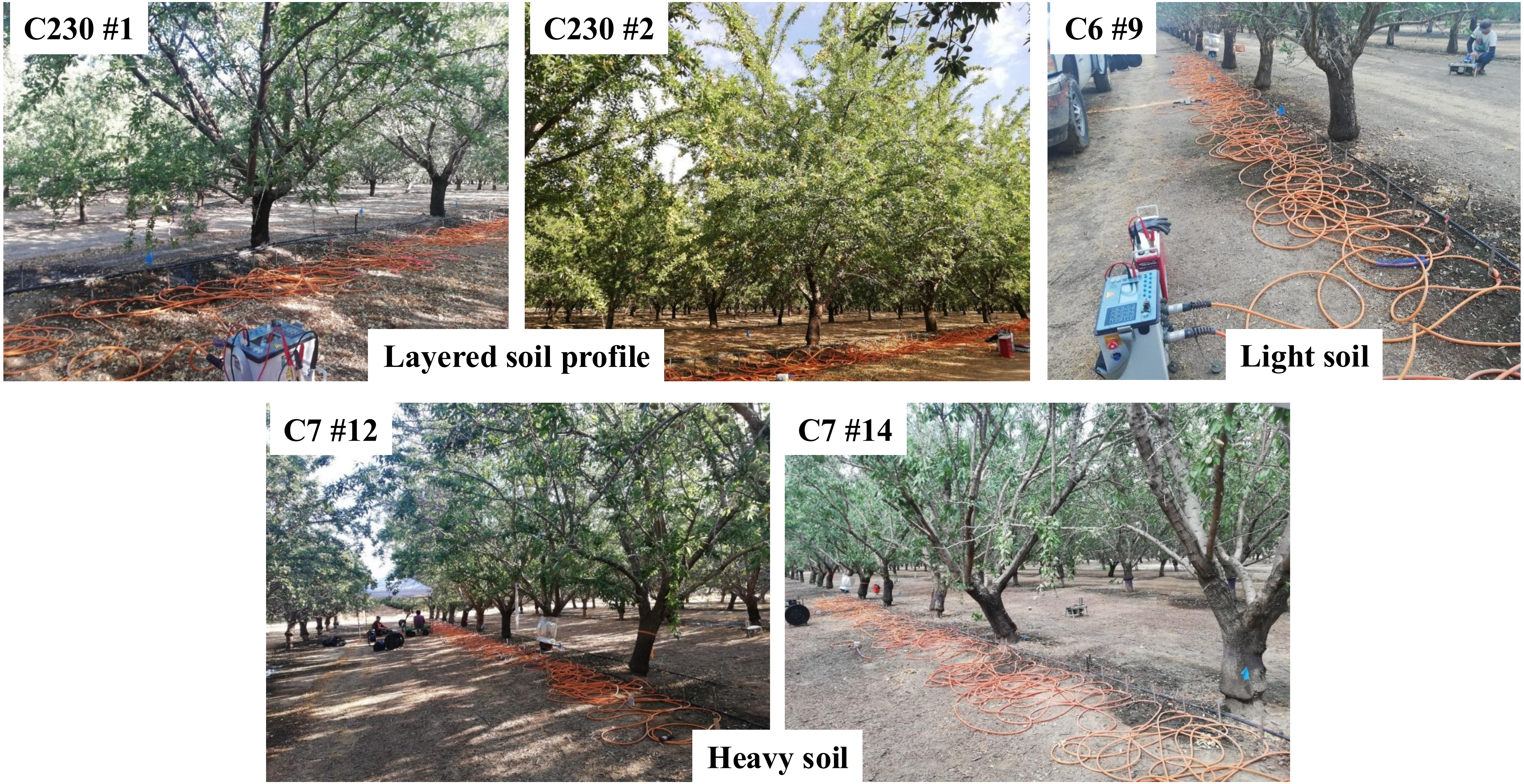
Precision irrigation based on management zones



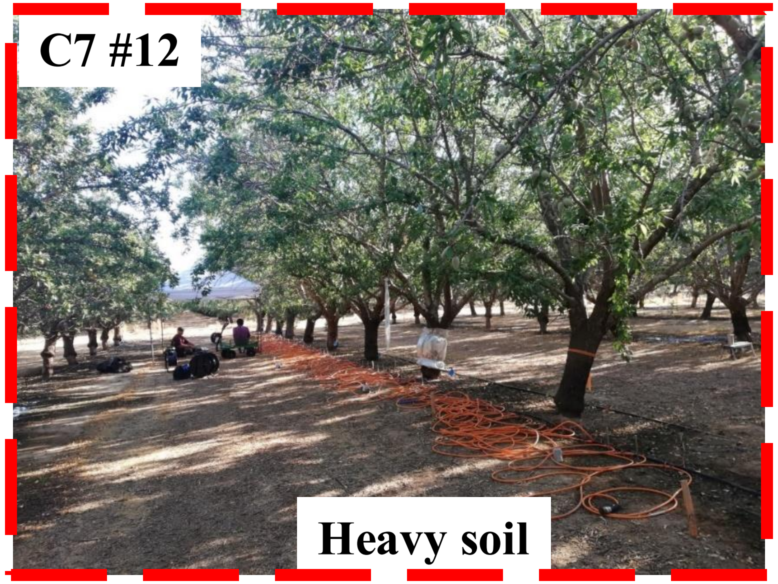


Measuring root water uptake and infiltration in different soils

Soil heterogeneity has a significant impact on irrigation management



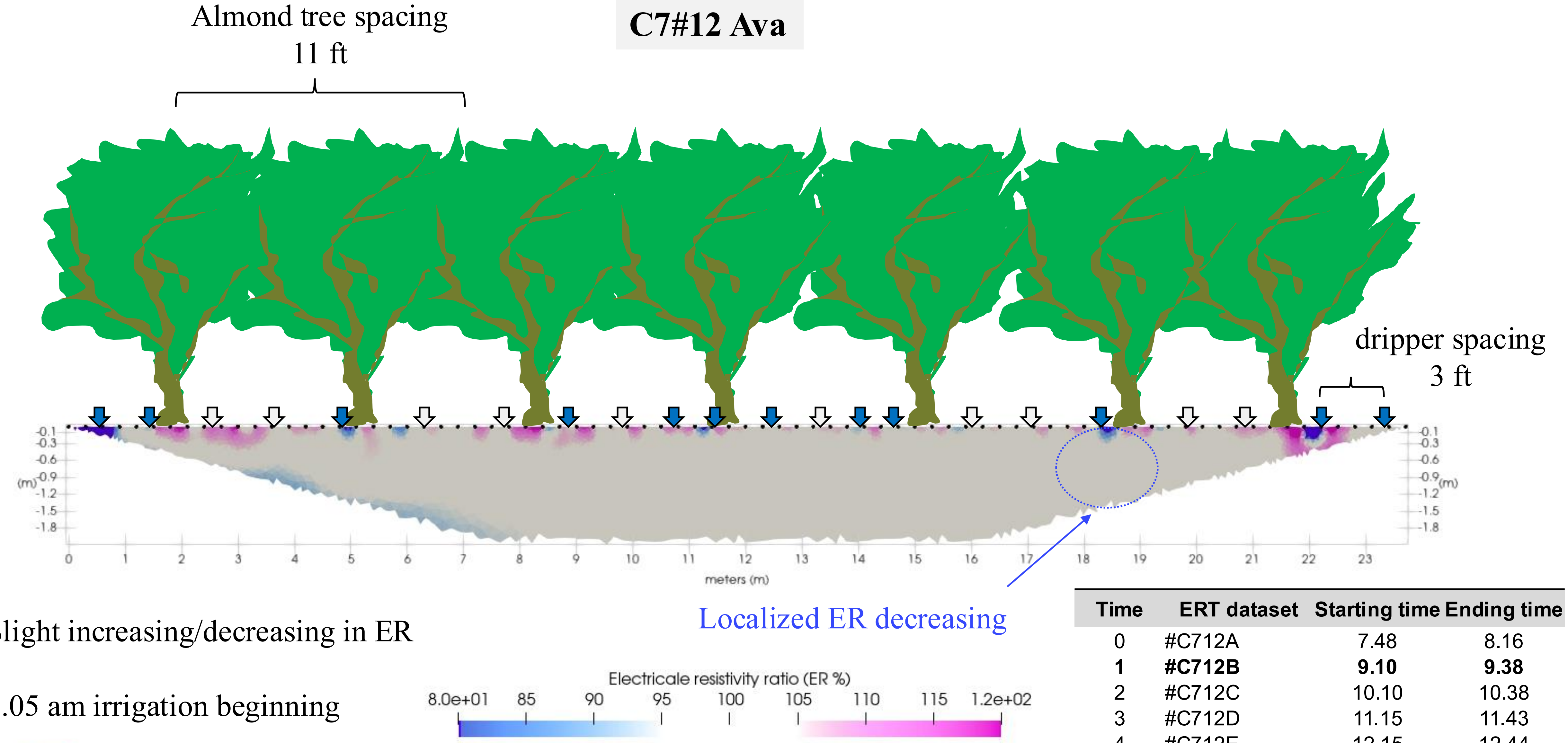
Infiltration, soil water storage, and root uptake in heavy soil



Vanella, Kisekka et al. 2022

ERT time-lapse survey: time 1 versus time 0

C7#12 Ava



Slight increasing/decreasing in ER

9.05 am irrigation beginning

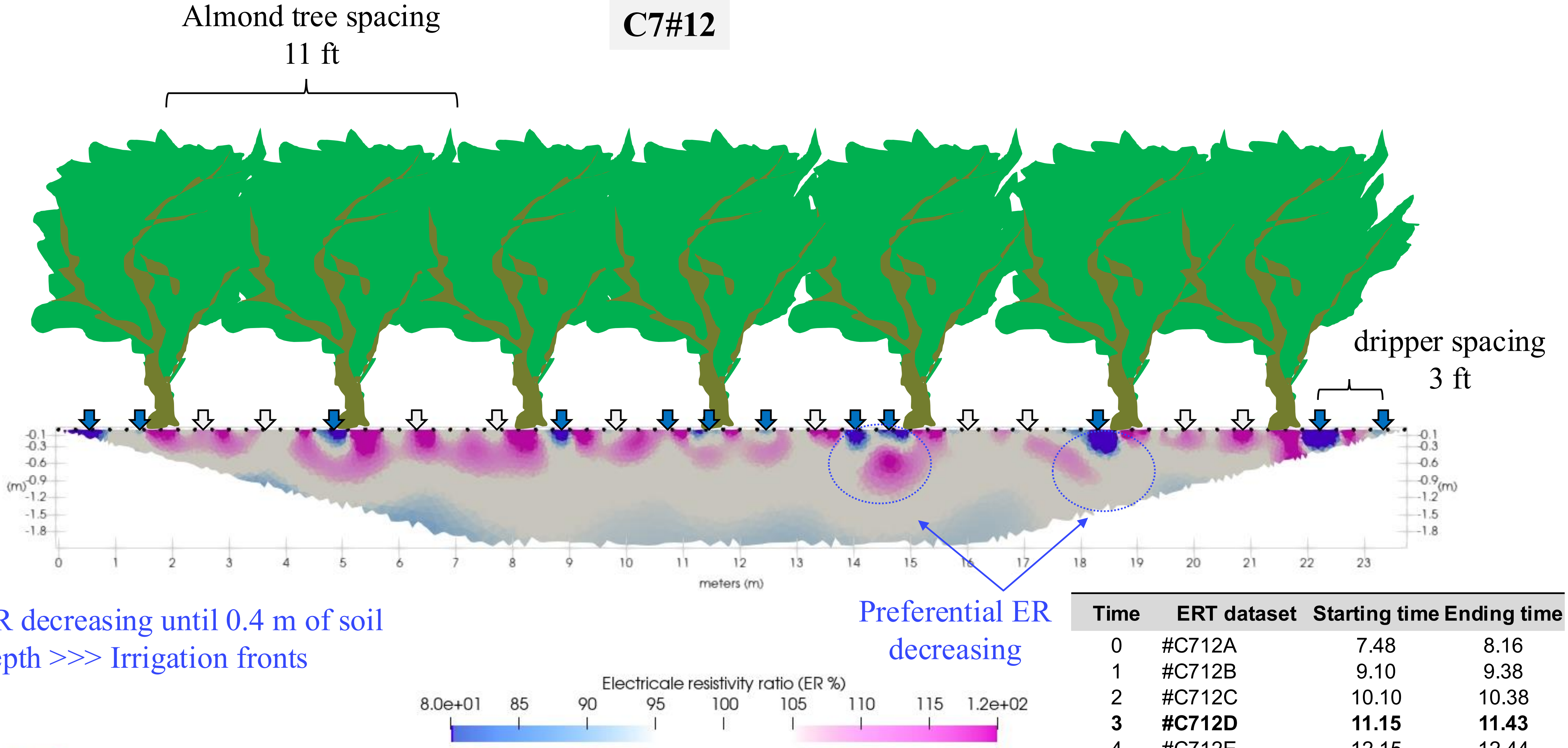
33 min after irrigation started

Time	ERT dataset	Starting time	Ending time
0	#C712A	7.48	8.16
1	**#C712B**	**9.10**	**9.38**
2	#C712C	10.10	10.38
3	#C712D	11.15	11.43
4	#C712E	12.15	12.44
5	#C712F	01.35	02.03
6	#C712G	03.00	03.28

Vanella, Kisekka et al. 2022

ERT time-lapse survey: time 3 versus time 0

C7#12



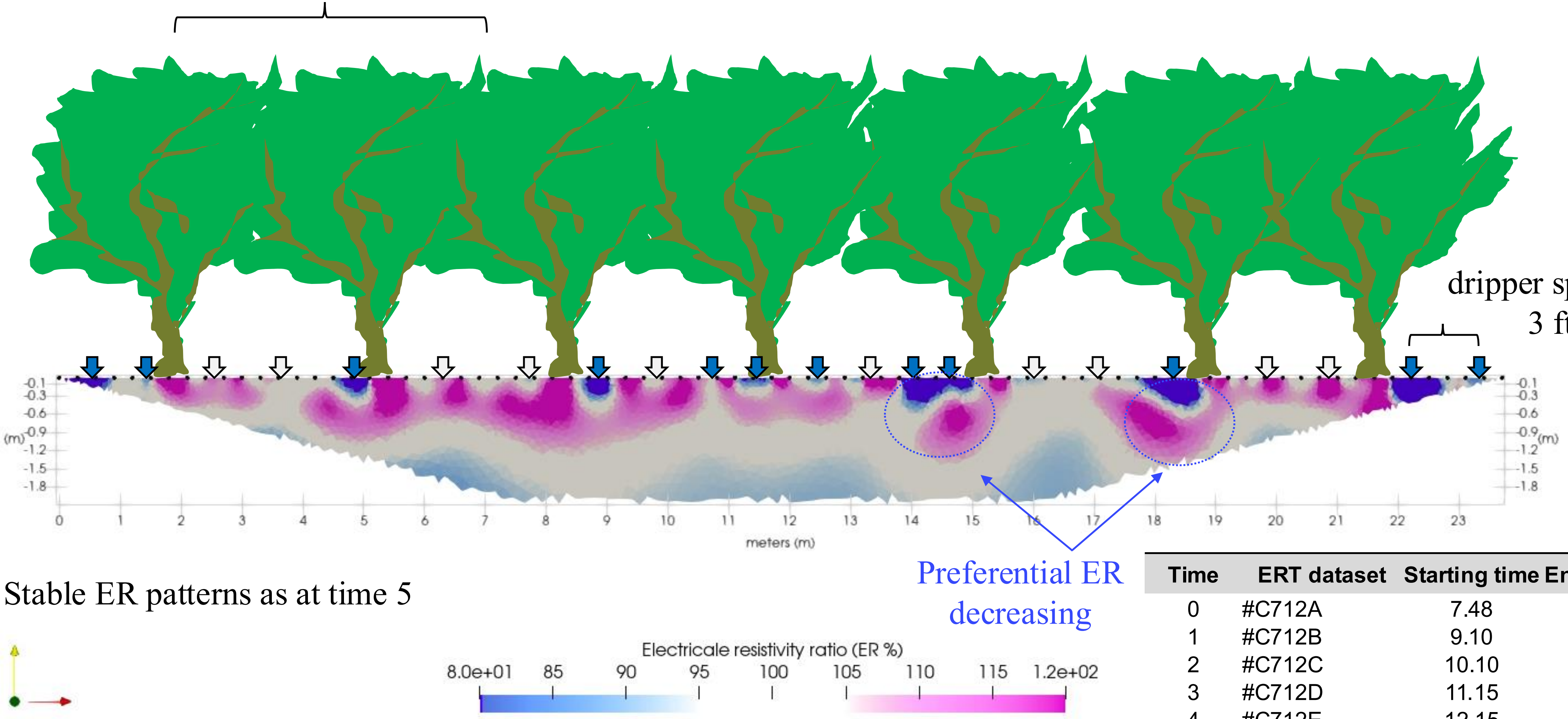
ER decreasing until 0.4 m of soil depth >>> Irrigation fronts

158 min after irrigation started

Time	ERT dataset	Starting time	Ending time
0	#C712A	7.48	8.16
1	#C712B	9.10	9.38
2	#C712C	10.10	10.38
3	**#C712D**	**11.15**	**11.43**
4	#C712E	12.15	12.44
5	#C712F	01.35	02.03
6	#C712G	03.00	03.28

ERT time-lapse survey: time 6 versus time 0

C7#12



Stable ER patterns as at time 5

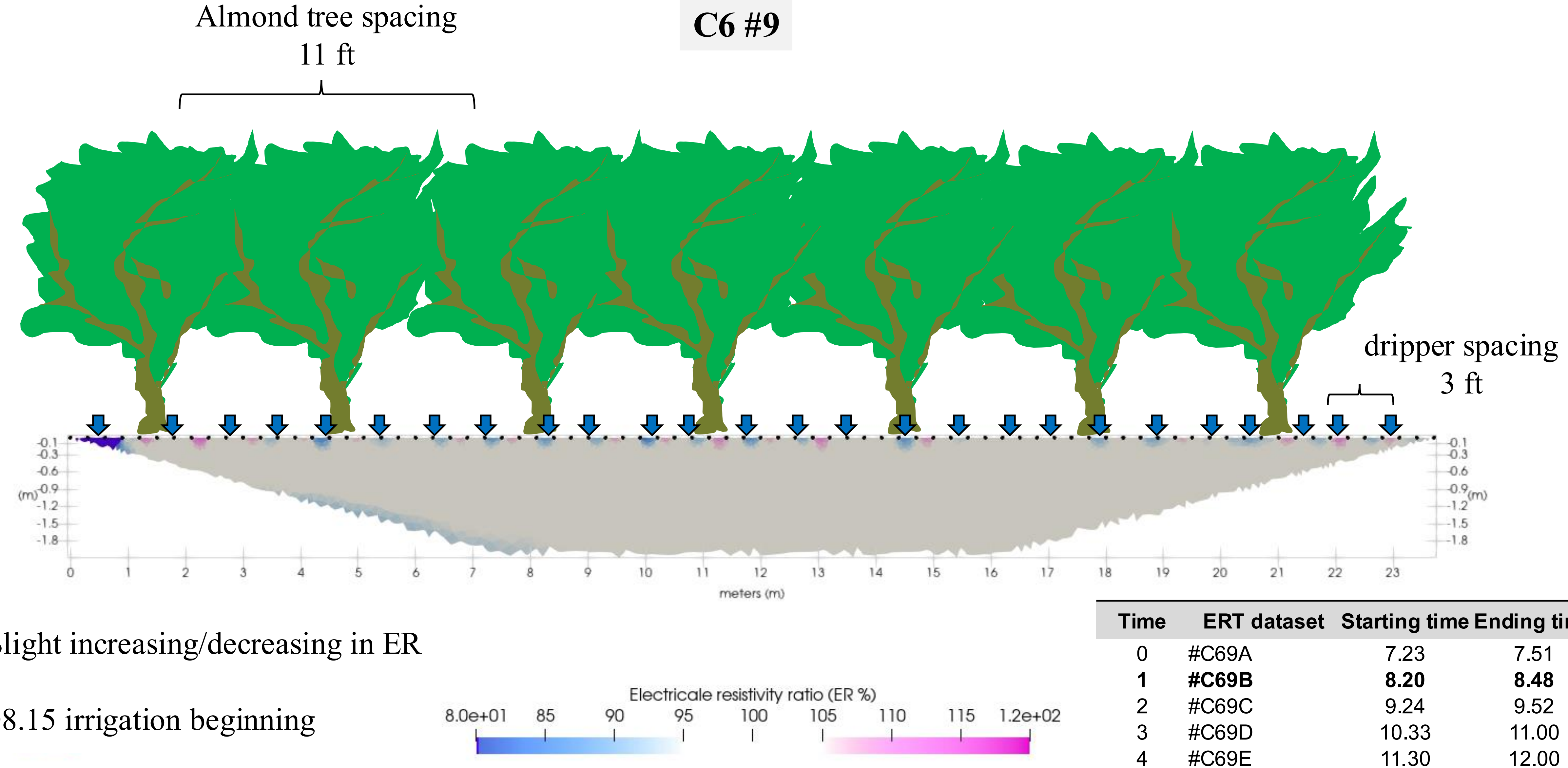
383 min after irrigation started

Time	ERT dataset	Starting time	Ending time
0	#C712A	7.48	8.16
1	#C712B	9.10	9.38
2	#C712C	10.10	10.38
3	#C712D	11.15	11.43
4	#C712E	12.15	12.44
5	#C712F	01.35	02.03
6	**#C712G**	**03.00**	**03.28**

Infiltration, soil water storage, and root uptake in heavy soil

ERT time-lapse survey: time 1 versus time 0

C6 #9



Time	ERT dataset	Starting time	Ending time
0	#C69A	7.23	7.51
1	**#C69B**	**8.20**	**8.48**
2	#C69C	9.24	9.52
3	#C69D	10.33	11.00
4	#C69E	11.30	12.00
5	#C69F	12.52	01.20
6	#C69G	02.13	02.40

Slight increasing/decreasing in ER

08.15 irrigation beginning

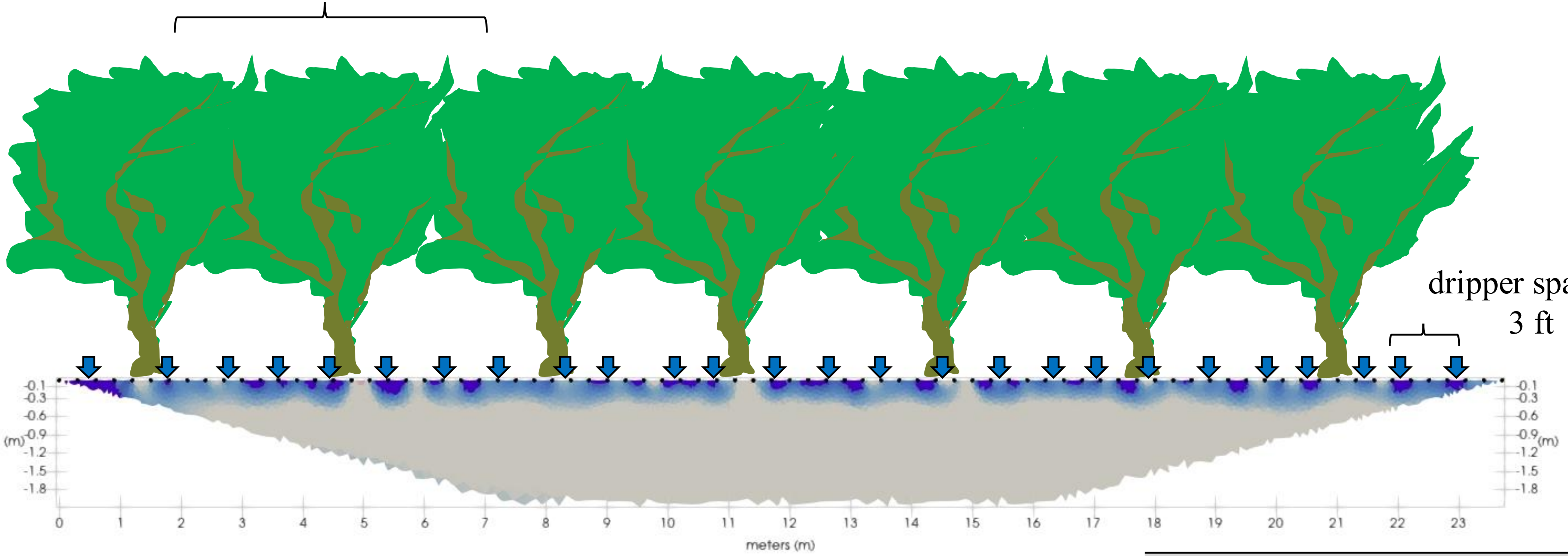
33 min after irrigation started

Vanella, Kisekka et al. 2022

ERT time-lapse survey: time 3 versus time 0

Almond tree spacing
11 ft

C6 #9

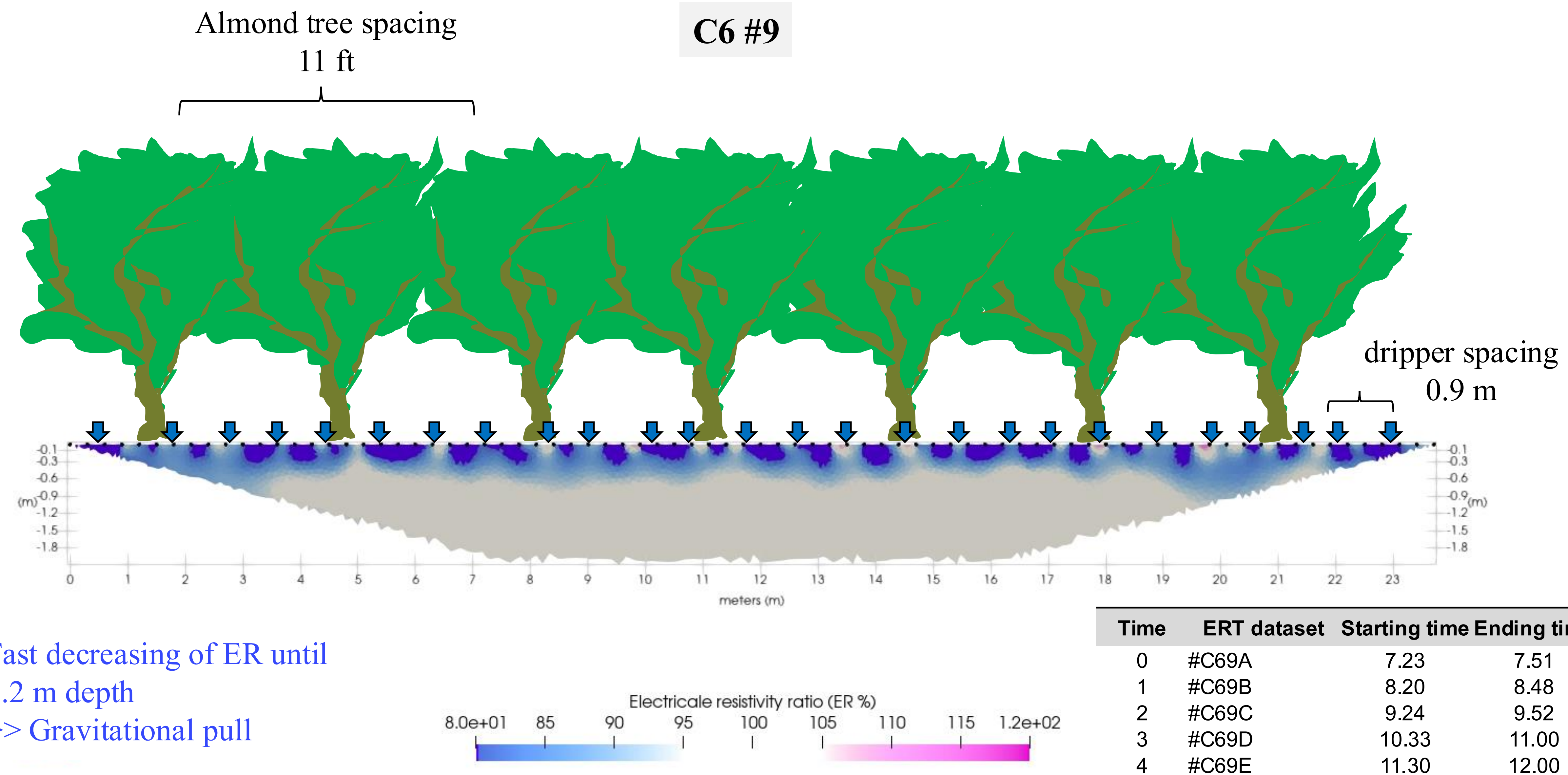


Fast decreasing of ER until
0.4 – 0.5 m depth
>> Gravitational pull

141 min after irrigation started

Time	ERT dataset	Starting time	Ending time
0	#C69A	7.23	7.51
1	#C69B	8.20	8.48
2	#C69C	9.24	9.52
3	**#C69D**	**10.33**	**11.00**
4	#C69E	11.30	12.00
5	#C69F	12.52	01.20
6	#C69G	02.13	02.40

ERT time-lapse survey: time 6 versus time 0



Fast decreasing of ER until
1.2 m depth
>> Gravitational pull

361 min after irrigation started

Time	ERT dataset	Starting time	Ending time
0	#C69A	7.23	7.51
1	#C69B	8.20	8.48
2	#C69C	9.24	9.52
3	#C69D	10.33	11.00
4	#C69E	11.30	12.00
5	#C69F	12.52	01.20
6	**#C69G**	**02.13**	**02.40**

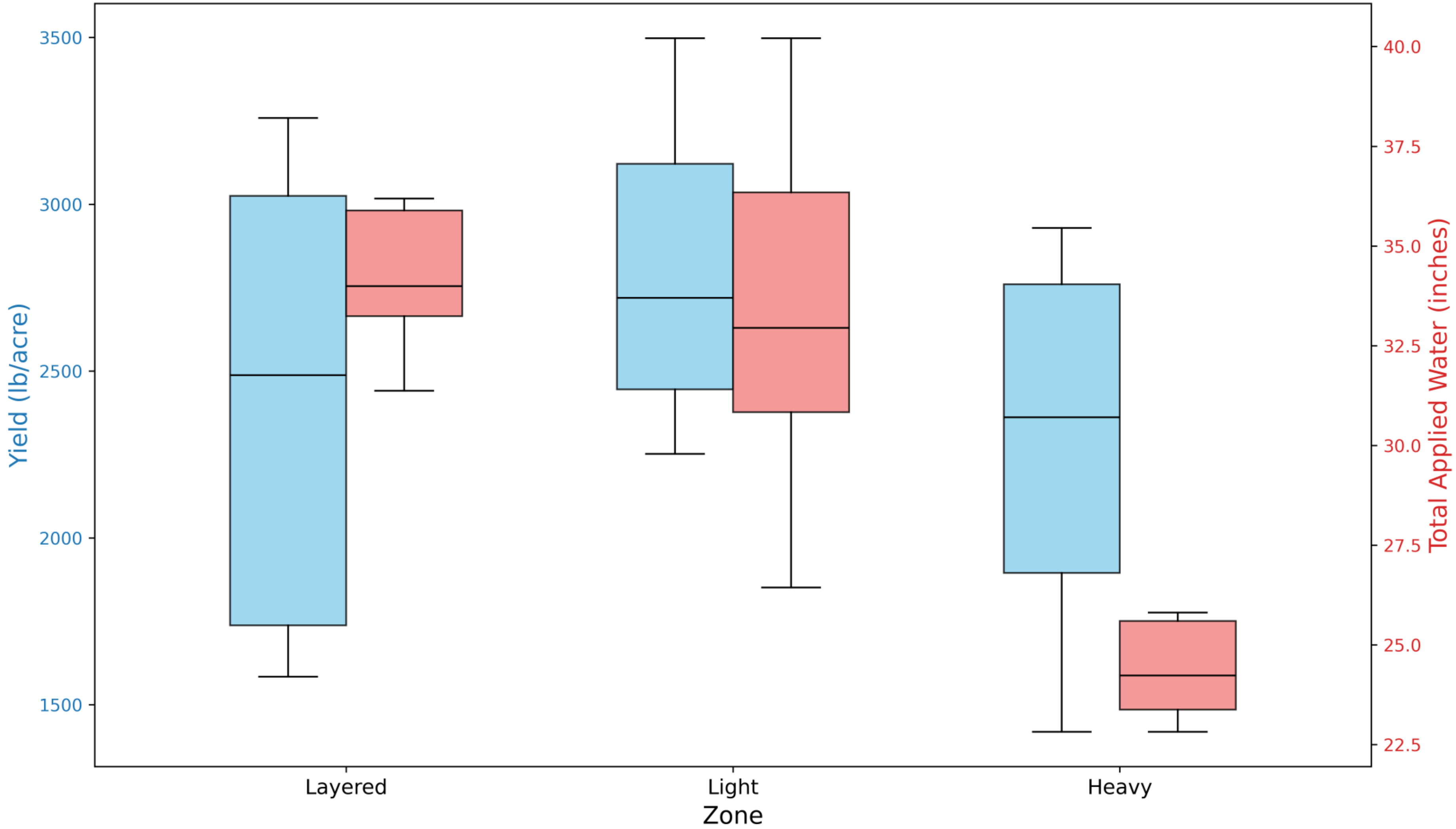
Key takeway:

Knowing site-specific infiltration rates can help to prevent water deficits and water/nutrients losses by drainage.

Heavy soils: Less frequent longer sets

Light soils: More frequent shorter sets

Almond Nut Yield and Applied Water by Irrigation Zone



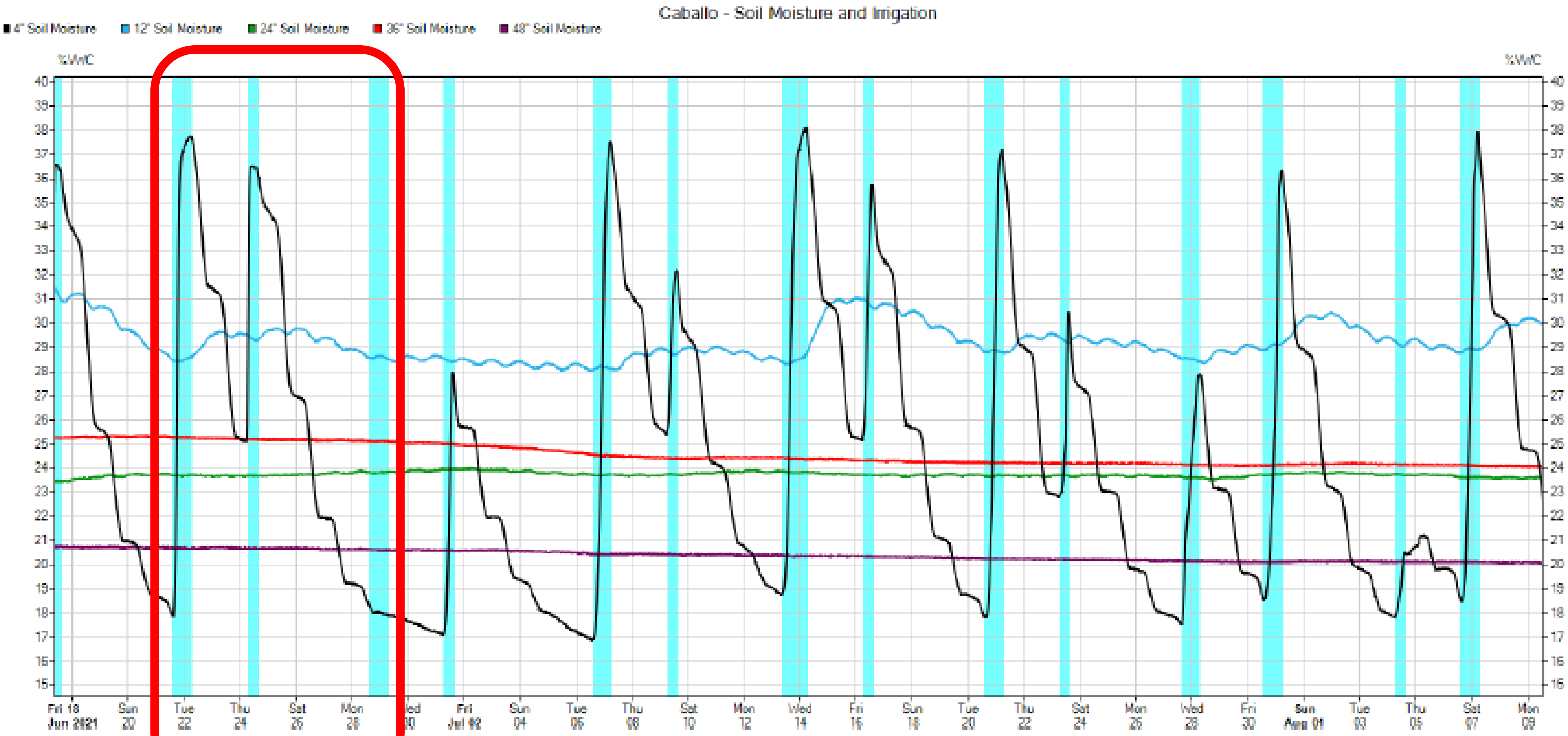
Water Use Efficiency 71 lbs/in 86 lbs/in 91lbs/in

Average almond WUE 61 lbs/in https://www.thealmonddoctor.com/blog/almond_water_use_efficiency

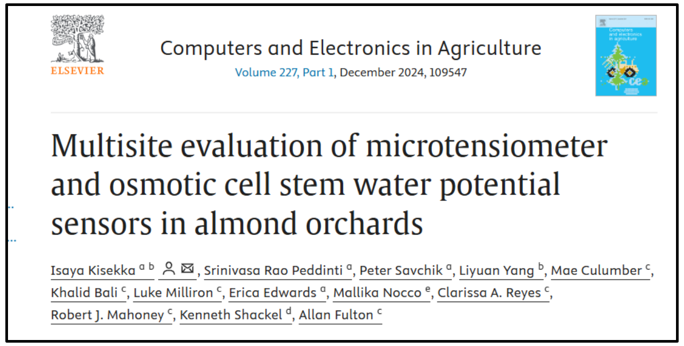
Precision irrigation informed by an integrated monitoring of the soil-plant-water system

- Soil water potential (SWP) monitoring
- Soil moisture monitoring
- ET monitoring

Soil water sensing is valuable for providing feedback on the adequacy of an irrigation set and for alerting you when you start to leach



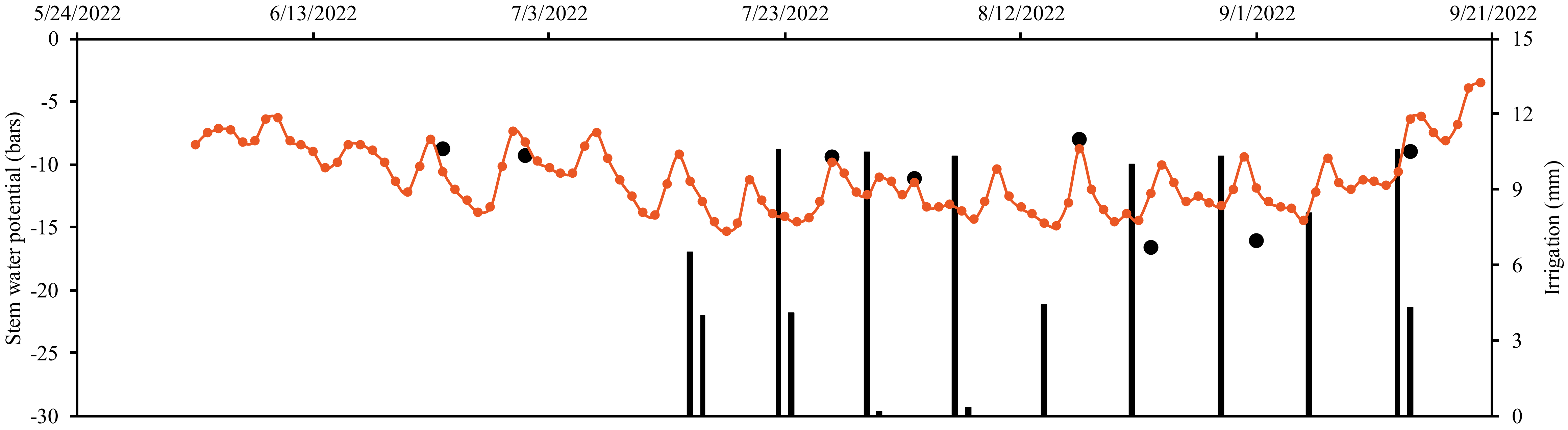
Plant stem water potential sensors



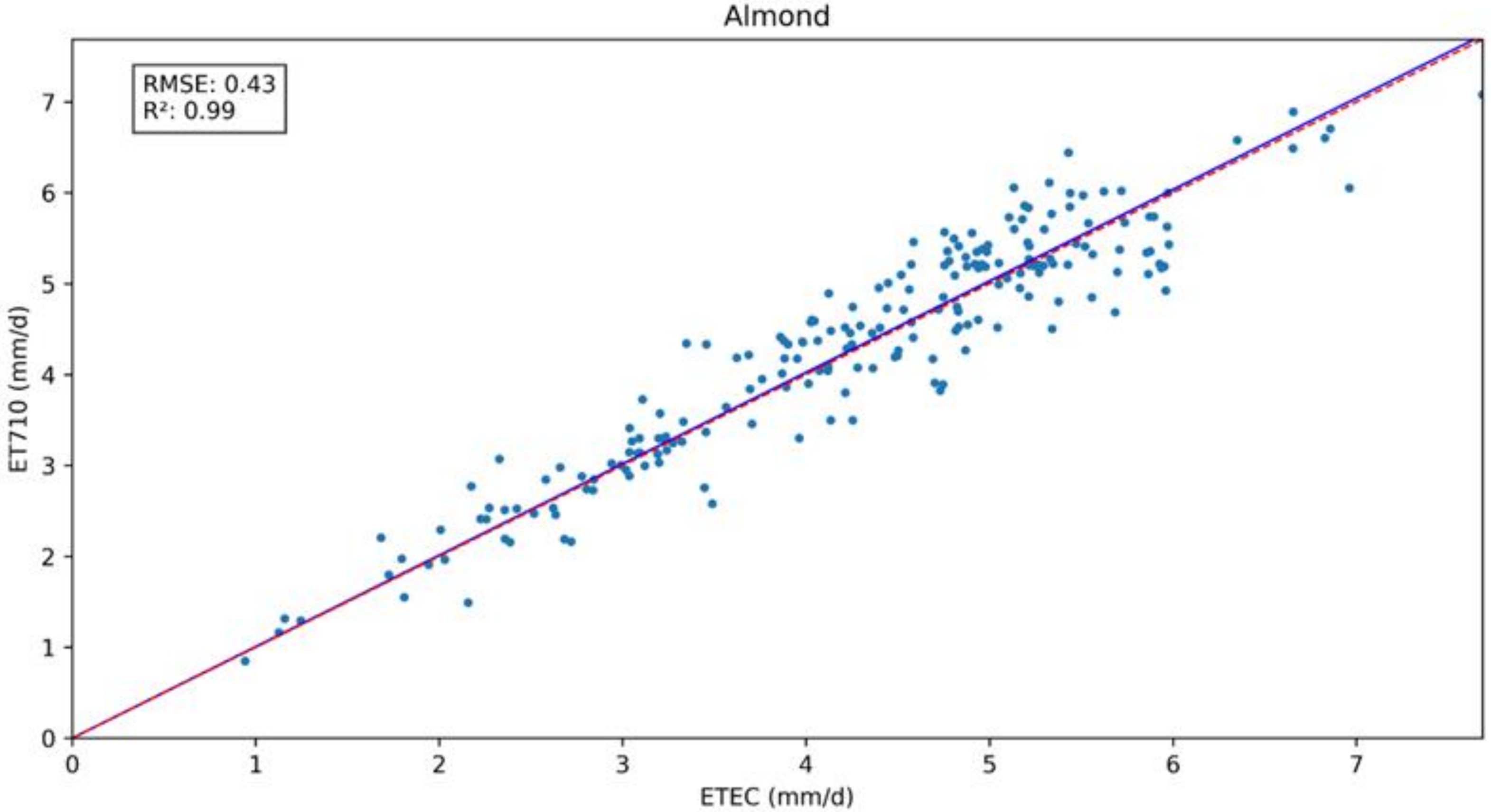
Computers and Electronics in Agriculture
Volume 227, Part 1, December 2024, 109547

Multisite evaluation of microtensiometer and osmotic cell stem water potential sensors in almond orchards

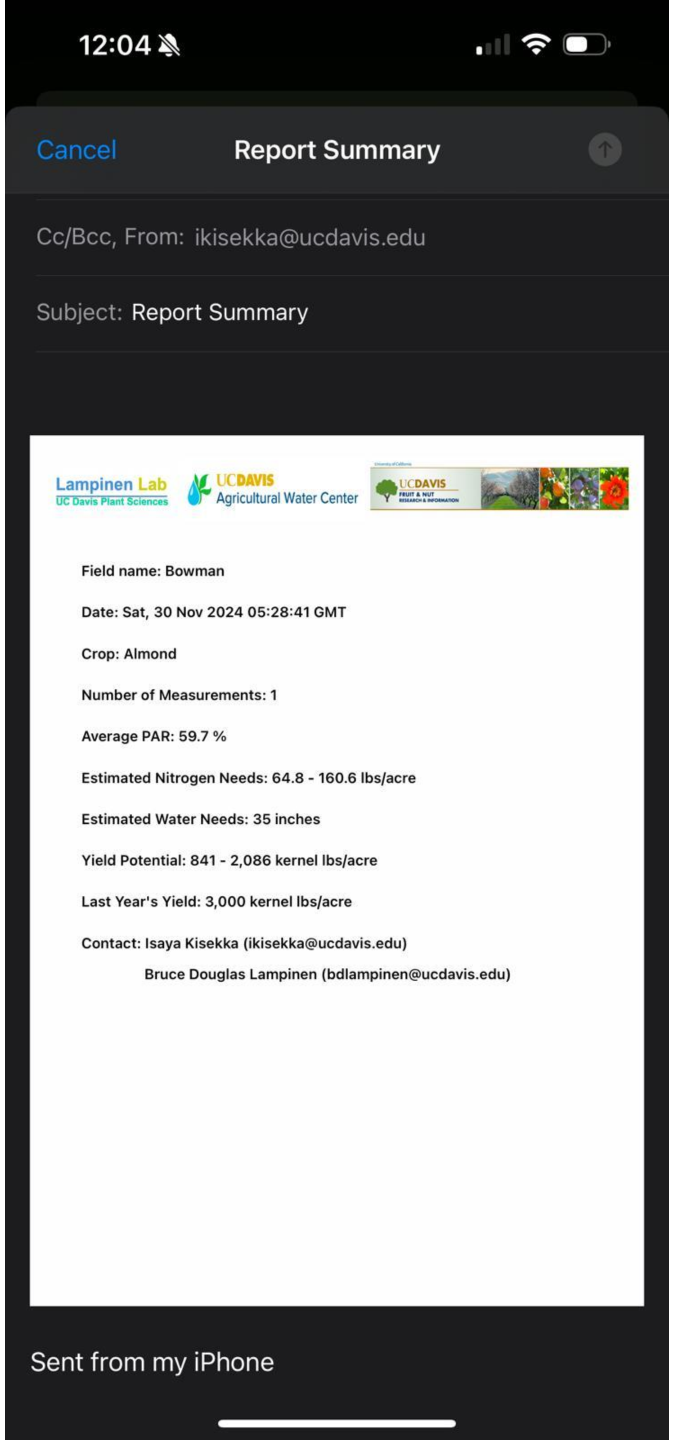
Isaya Kisekka[a b], Srinivasa Rao Peddinti[a], Peter Savchik[a], Liyuan Yang[b], Mae Culumber[c], Khalid Bali[c], Luke Milliron[c], Erica Edwards[a], Mallika Nocco[e], Clarissa A. Reyes[c], Robert J. Mahoney[c], Kenneth Shackel[d], Allan Fulton[c]



Low-cost ET sensors provide orchard-specific crop water use



Predicts attainable yield, water, and nitrogen requirements as a function of fPAR.



How growers can start implementing precision irrigation

- Map variability (soil, tree vigor)
- Identify zones
- Add at least a combination of two sensors in each zone (soil, plant, ET)
- Apply zone-specific irrigation
- Reassess yearly

Main takeaways

- Precision irrigation based on tree variety or zone management is scalable, actionable, and ready now
- Compatible with automation and AI-assisted irrigation
- Supports long-term water sustainability: Significant potential for industry-wide water savings, yield, and nut quality improvements
- Precision irrigation provides opportunity for Grower–Almond Board–University collaboration

Acknowledgments

california almonds
Almond Board of California

USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture

Collaborators: Grower Cooperators, students, postdocs, research scholars in the Kisekka Lab at UC Davis

THANK YOU!

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Professor

Director: Agricultural Water Center

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CULTIVATING A HEALTHIER FUTURE

Field Screening Dwarfing Rootstocks for Off-Ground Harvested Almond Orchards

Roger Duncan

Pomology Advisor, Emeritus
University of California
Cooperative Extension
Stanislaus County

University of California
Agriculture and Natural Resources

Spanish SHD spacing: 12.5’ x 3.9’
(894 trees / acre)


6th SHD almond mechanical harvest
1:28 / 4:51
Scroll for details
HD

Tenias Offground Harvester

Maximum tree height ~ 18’
Row spacing ~ 18’

TOL Offground Harvester

Dwarfing Rootstock Trial for Almonds – UC Kearney Ag Center

Objectives:

- Screen currently available “dwarfing” almond and stone fruit rootstocks for compatibility with Nonpareil and Monterey almond scions

- Document vigor relative to Nemaguard

Dwarfing Rootstocks, Source, and Genetic Background.

Rootstock	Genetic Background	Source
Nemaguard	Peach	USDA
Viking	Peach, almond, plum, apricot	Zaiger Genetics
Brights Hybrid 5	Peach x almond	Brights Nursery
Rootpac 20	Plum x plum	Agromillora
Controller 6	Peach x peach	UC Davis
Controller 9	Plum x peach	UC Davis
Citation	Plum x peach	Zaiger Genetics
266LZ4	Proprietary	Zaiger Genetics
95LG249	Proprietary	Zaiger Genetics
D63.182	Proprietary	Wawona
MP-29	Peach x plum	USDA
TRIO 25-07	Proprietary	Fowler
3776	Proprietary	Sierra Gold
DA 6 (Bantam)	Plum	Sierra Gold
Observational Only		
FL x K2	Peach x peach	UC Davis
Hybrid 29	Proprietary	Sierra Gold
K37.068	Proprietary	Wawona
ATAP	Proprietary	Fowler Nursery
TRIO 22-07	Proprietary	Fowler Nursery

Dwarfing Rootstock Trial for Almonds

- Planted September 2020
- UC Kearney Ag Center, Parlier, CA
- 16 “dwarfing” rootstocks, 3 standards
- Orchard planted to accommodate Tenias over-the-row harvester
- Spacing: 8’ x 18’ (303 trees / acre)
- Wire trellis instead of staking
- No scaffolds below 3’
- No training, no pruning

4th Leaf Nemaguard

Nonpareil 8’ x 18’ Monterey

4th Leaf Rootpac 20.

Monterey 8’ x 18’ Nonpareil

Rootpac 20

- Used extensively in Spanish SHD almonds
- *About 20% the canopy size of Nemaguard.*
- *Both varieties had mild, early signs of incompatibility (rolled, burned leaves, brown line at bud union).*
- *Better by the 4th leaf.*
- *Profuse crown suckering.*

Controller 9 (aka P30-135)

- *Both varieties showed extensive signs of incompatibility, including severe stunting and leaf rolling, undergrowth of the rootstock and a brown line at the bud union.*
- *Half of the Nonpareil trees have died.*

Nonpareil Monterey

Half of all Nonpareil trees on ***DA6 (a.k.a. Bantam)*** *have collapsed and died (left) while Monterey on DA6 look good (right) and are about half the size of trees on Nemaguard.*

Nonpareil

Monterey

Citation:

- *In contrast, 54% of Monterey trees collapsed by late summer in the 1rst leaf; 68% by end of the 4th leaf.*
- *Nonpareil showed moderate signs of incompatibility on Citation for the first two years, but most trees have recovered and look very good by the 4th leaf (left).*

Nonpareil

Monterey

MP-29

- Noted for resistance to oak root fungus
- No signs of incompatibility, very little suckering.
- Nonpareil canopy was 43% of Nemaguard.

Controller 6

- No signs of incompatibility.
- Nonpareil canopies of trees were 73% of those on Nemaguard 2nd leaf but have nearly caught up by 5th leaf.

Graft Compatibility of Nonpareil & Monterey Scions on Dwarfing Rootstocks

	Percent Trees with Stunted Growth and Rolled, Necrotic Leaves 1rst & 2nd leaf		Trees Dead From Apparent Graft Incompatibility Thru 4th leaf (%)	
	Nonpareil	Monterey	Nonpareil	Monterey
New Root 2	100	100	100	60.7
266LZ4	100	100	100	100
DA 6	100	0	50.0	0
Controller 9 (aka P30-135)	21.4	28.6	48.1	0
Citation	17.9	78.6	3.7	67.9
Rootpac 20	100	100	0	0
Controller 6 (aka HBOK 27)	0	0	0	0
D63.182	0	0	0	0
TRIO 2507	0	0	0	0
3776	0	0	0	0
MP-29	0	0	0	0
Nemaguard	0	0	0	0
Viking	0	0	0	0
Fl x K2	0	0	0	0
Hybrid 29	0	0	0	0
ATAP[1]	0	-	0	-
TRIO 22-07	0	-	0	-
K37.068[1]	0	0	0	0

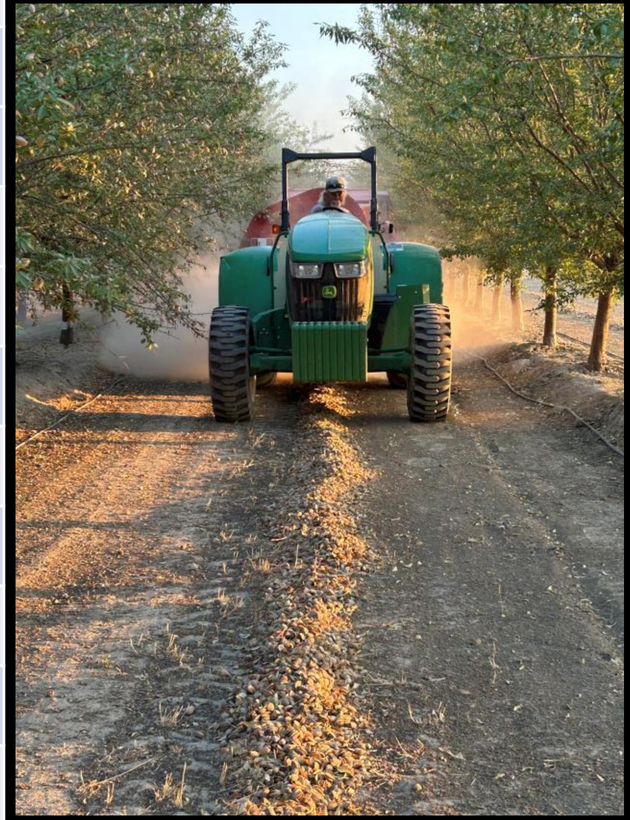
Trunk Circumference of Nonpareil and Monterey Scions on Experimental Rootstocks.				
Rootstock	Trunk Circumference (cm)[1]		Percent of Nemaguard	
	Nonpareil	Monterey	Nonpareil	Monterey
Brights 5	44.0 a	42.8 a	108	116
Viking	43.9 a	42.4 ab	108	115
Controller 6	41.6 ab	37.5 cd	102	102
Nemaguard	40.8 ab	36.9 cde	-	-
Citation[2]	39.6 bc	34.0 ef	97	92
D63.182	39.4 bc	38.1 c	97	103
3776[2]	35.4	33.8	87	89
TRIO 25-07[2]	33.7	35.3	83	96
MP-29	33.7 de	32.9 f	83	89
Rootpac 20	36.7 c	33.8 ef	90	92
DA6[2]	29.6 e	39.2 abcd	73	106

[1]Tree size measurements shown in this table are from surviving trees which may be a misrepresentation for Monterey on Citation and Nonpareil on DA6.

[2]Rootstocks are not fully replicated and for observation only

Yields of Third - Fifth Leaf Trees on Experimental Rootstocks. Trees planted at 8’ x 18’ (303 trees / acre).

Rootstock	Cumulative Yield (3rd - 5th Leaf)		2025 Yield (5th leaf)	
	Nonpareil	**Monterey**	**Nonpareil**	**Monterey**
Brights 5	6264 a	6035 a	2816 ab	3064 a
Viking	5720 ab	5720 ab	2558 abcd	2637 ab
Controller 6	5576 ab	5782 ab	2889 a	2535 b
Nemaguard	4895 bc	4560 c	2159 bcd	1868 cd
3776*	4510	3421	1789	1501
Citation	4278 cd	1241 fg	2195 bcd	773 g
D63.182	3486 de	3862 cd	1441 e	1836 cd
MP-29	3113 e	3383 de	1562 e	1646 cd
TRIO 25-07*	1804	1157 g	714	478
Rootpac 20	1512 fg	1540 fg	906 f	876 fg
Controller 9	981 g	1615 ef	488 fg	1001 efg
DA 6	326 h	2618 e	221 g	1402 cde



*Not fully replicated – observation only

Thank you for listening.

Thank you to the Almond Board for funding several decades of rootstock and variety research

Roger Duncan

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University of California
Agriculture and Natural Resources
UC Cooperative Extension

Nickels Soil Lab Projects, 2025

Almond Board of California

December 11, 2025

Franz Niederholzer, UCCE Advisor Colusa and Sutter/Yuba Counties

University of California
Cooperative Extension

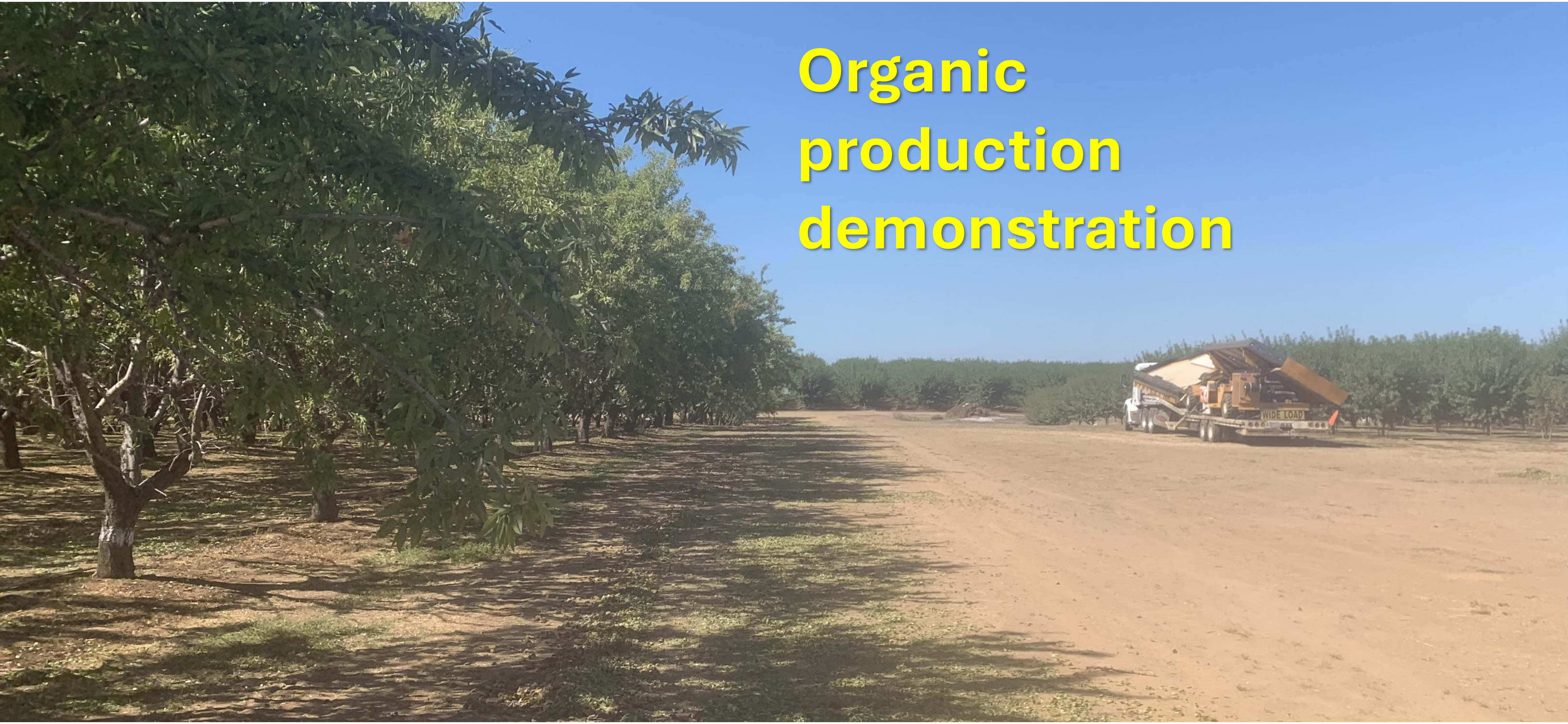
Agriculture & Natural Resources

The Nickels Soil Lab background.

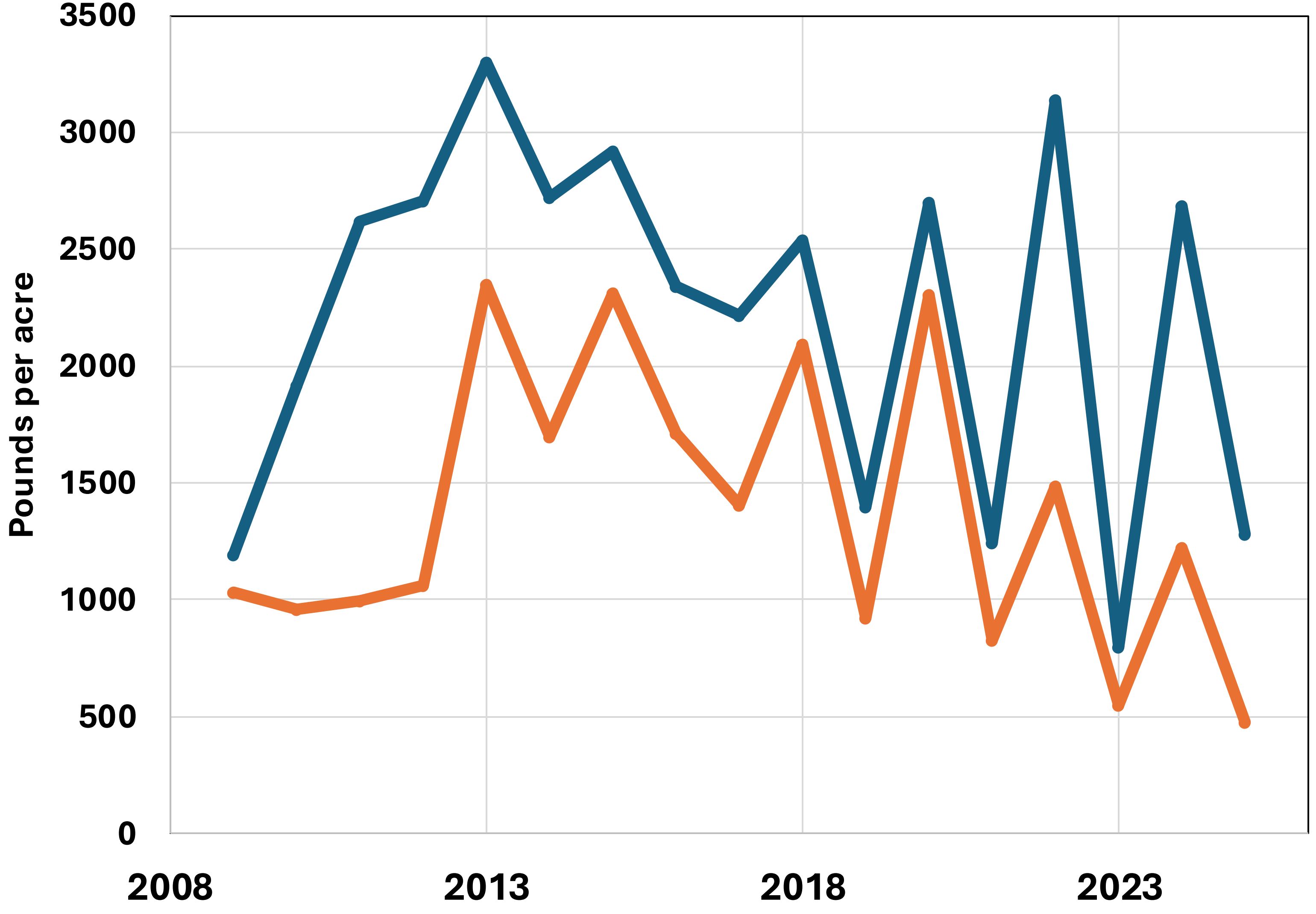
- 162 acres, SW of Arbuckle, CA (Colusa County). Class 2 or 3, gravelly loam soils.
- Bequeathed by Leslie J. Nickels for ag research in1959. The Nickels Soil Lab is a private entity, operated by the Nickels Trust under supervision of the County Court of Colusa. The Nickels Trust ≠ UC.
- Formal legal arrangement with UC ANR in 1983. Nickels Trust farms, UCCE Colusa Co coordinates research by UC and USDA researchers. For many years, nut sales paid for day-to-day farming. Strong support from Almond Board of CA for big ticket items (well, irrigation infrastructure, etc.)
- Currently 80 acres of almonds, 9 acres of walnuts, 2 acres of table olives. 13 research/demo projects. Operating costs are 15-25% above commercial operations. [There are 10+ orchards each with different spacings, trees, etc. to get the most data out of the resources (land, water, etc.) available.]
- With tighter nut pricing and higher costs, Nickels is operating (since 2022) with additional support from the Almond Board of California, the state of California (thank you Sen Dahle and Assem. Aguiar-Curry), grower donations, and manufacturers' material support along with support from JCS Marketing and Colusa-Glenn Farm Credit.

Projects and background…

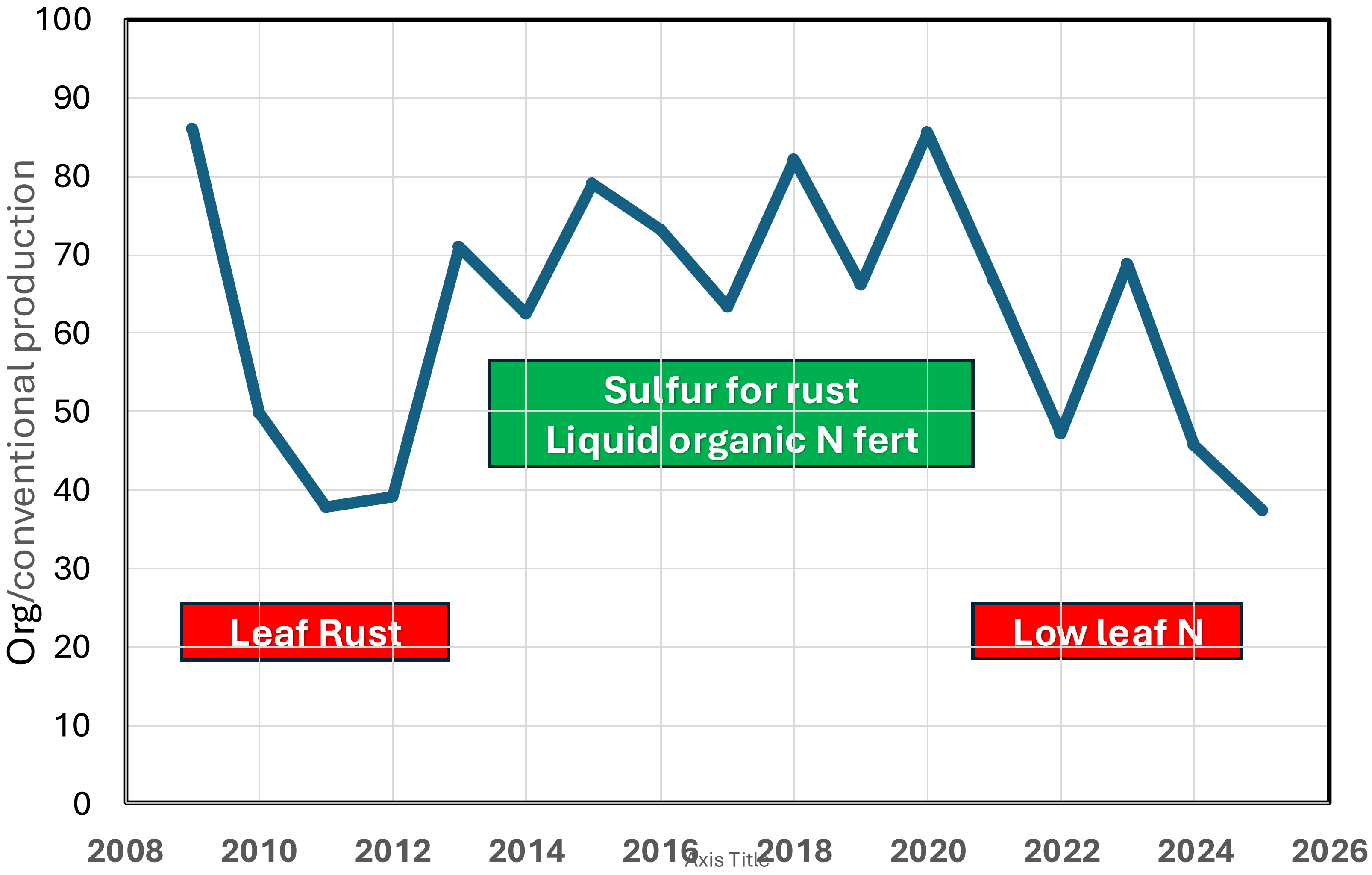
1. **Organic almond production demonstration block (5.5 acres)**
    - **2006** planting. 16’ x 22’ on **Lovell** rootstock, 2x shallow buried (6”) drip
2. **Comparison of high value Nonpareil/pollinizer planting to 100% self-fertile almond (Independence) planting. (5.5 acres)**
    - **2013** planting. 15’ x 20’ on **Viking** rootstock, 2x line drip
3. **Tree spacing trial, almonds (16 acres)**
    - **2017** planting. 12’, 14’, 16’, or 18’ x 21’ spacing on **Titan** peach/almond hybrid or **Rootpac-R** almond/plum hybrid. 2x line drip


Organic production demonstration
WIDE LOAD

Seventeen years of yield data comparing conventional and organic production in the same system.



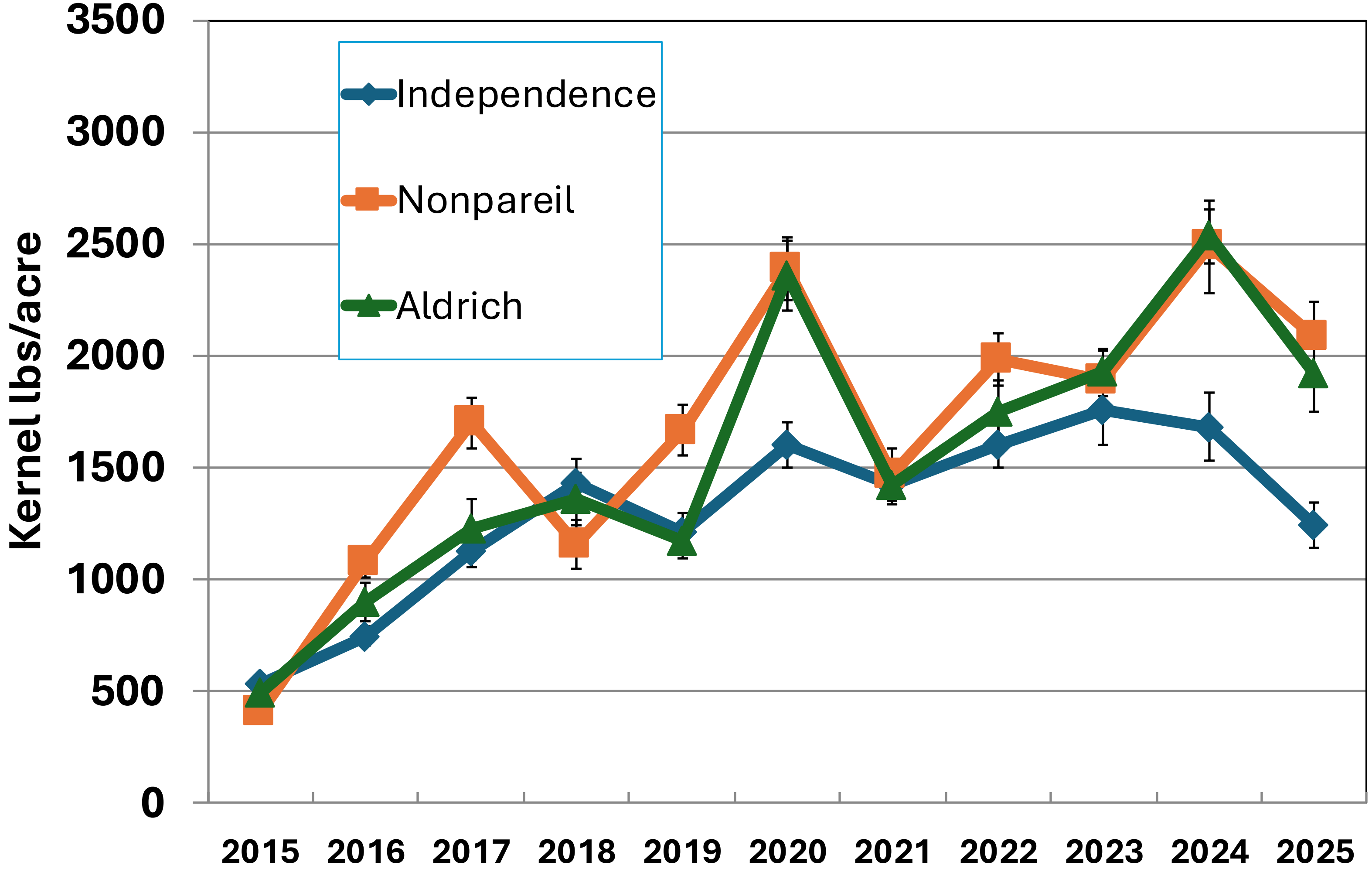
Disease control and adequate nitrogen nutrition were/are major factors impacting yield in this project.




2021
25/25/50
100
100
100
25/25/50
25/25/50

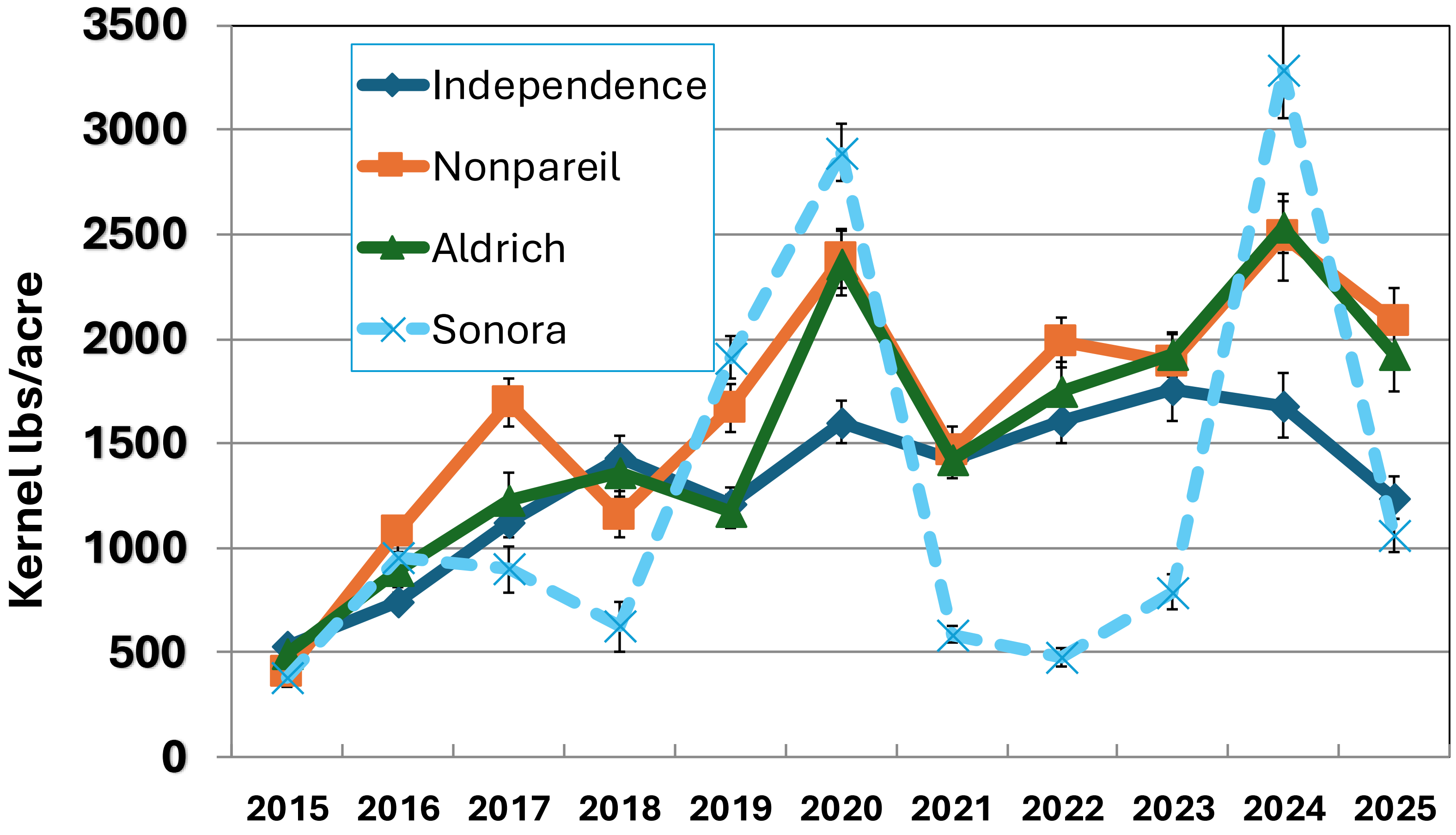
Orchard spacing
15’ x 20’

Nonpareil and Aldrich generally produced more than Independence in this planting. Independence yields are consistent and equal to Nonpareil when measured per PAR.



The "wild card in the deck" is Sonora w/ highly variable performance in this trial. Looks great in some years.

Lessons from this trial: Plant Independence on a proven, high vigor rootstock for higher yield. Fix yield issues or move on from Sonora.



Tree spacing trial planted in 2017. 12’, 14’, 16’, or 18’ down the row. 21’ row spacing.
May 2024. 50% NP, 25% Aldrich, 25% Kester

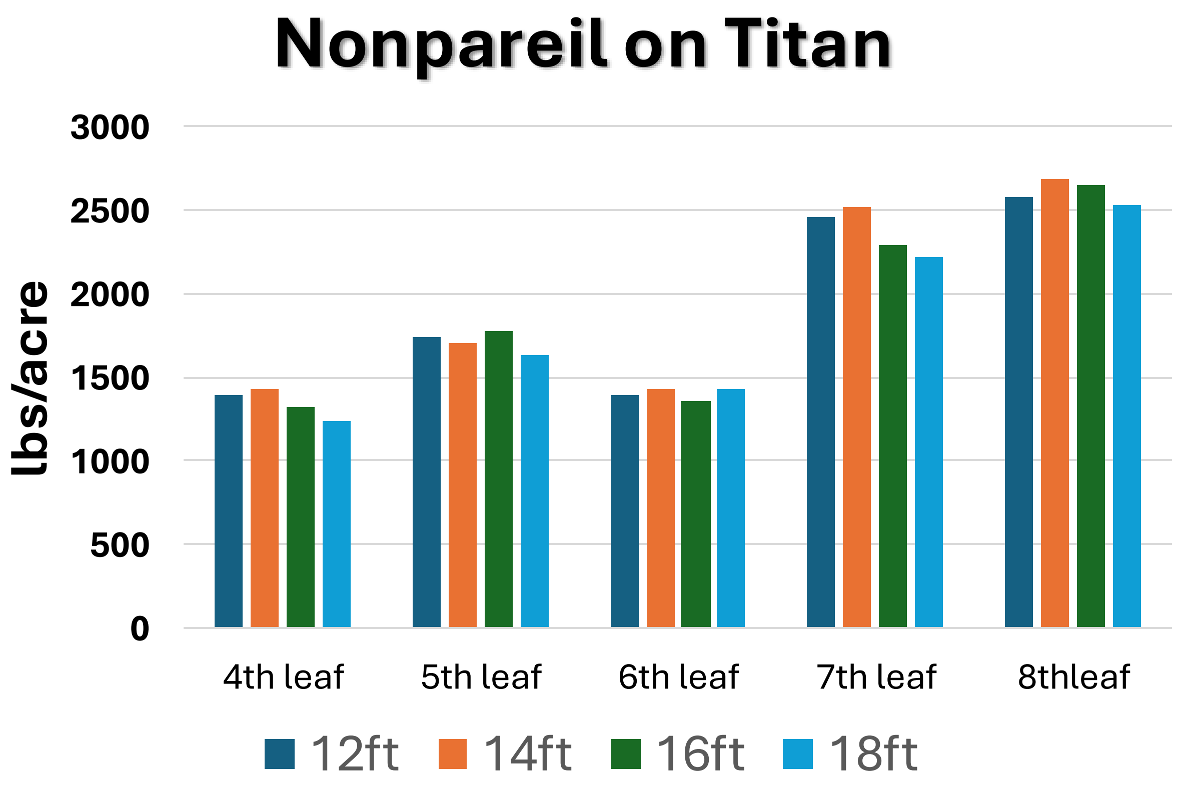

12’ x 21’
Nonpareil
Kester

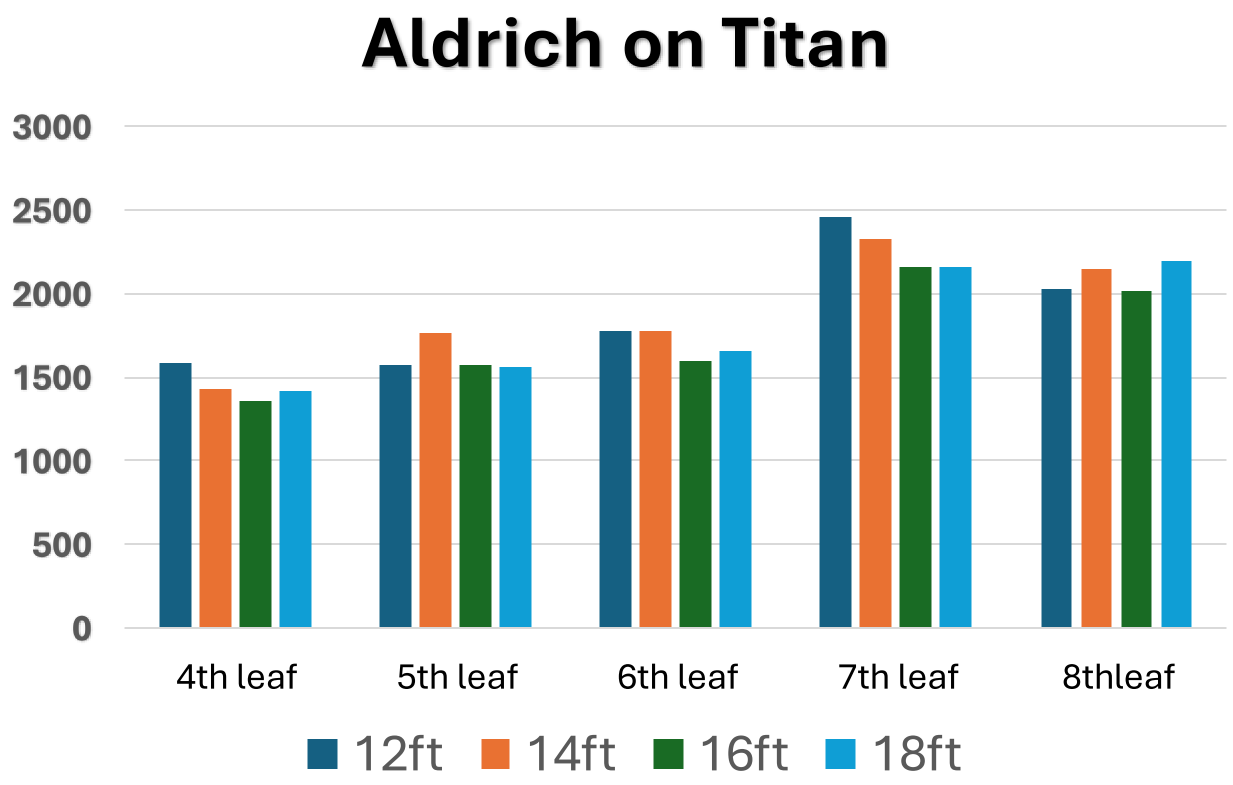

18’ x 21’
Nonpareil
Kester

Cumulative yields (kernel lb/acre) for cultivars at different spacing on Titan or Rootpac-R rootstock (**2020-24**). Data in the columns followed by the same letter are not significantly different at the 5% level using Tukey HSD. Data for Titan-rooted trees are from 4th-8th leaf. Rootpac-R rooted tree data are from 3rd-7th leaf. **All data are from cart weights reduced 25% to account for rocks.**

		Titan (peach x almond) rootstock			Rootpac-R (almond x plum) rootstock		
Row Spacing (ft)	Trees /acre	Nonpareil	Aldrich	Kester	Nonpareil	Aldrich	Kester
12'	173	9548 ab	9408 a	5984 ab	6796 a	7112 a	5820 a
14'	148	9766 a	9428 a	6350 a	6473 a	6483 a	5884 a
16'	130	9291 ab	8719 a	5577 b	6441 a	6256 a	5391 a
18'	115	8861 b	9002 a	5902 ab	6518 a	6287 a	5657 a

Difference in yield by spacing have been relatively small, but consistent. Tighter (12' or 14') has been better then wider (16' x 18'). Cart weights are reduced 25% due to rocks






Thank you!

THANK YOU!

2025 THE ALMOND CONFERENCE

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