RETHINKING SEEPAGE IRRIGATION MANAGEMENT FOR HORTICULTURAL PRODUCTION IN FLORIDA

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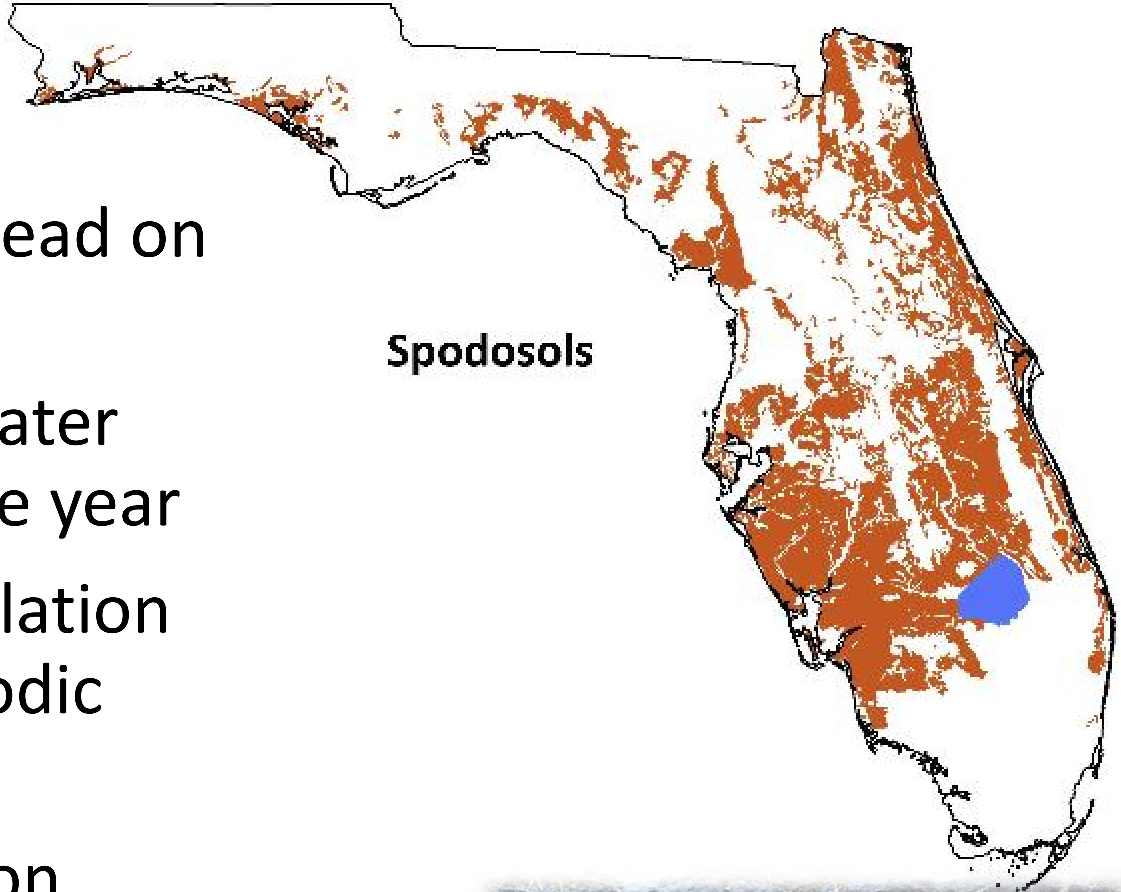
Presentation outline

- Overview of horticultural production areas under subirrigation in Florida
- Understanding seepage irrigation
- Relationship crop ETc, yield and water table level, water usage
- Alternative irrigation methods and potential water conservation
- Strategies for irrigation scheduling
- Research for future improvements
- Final remarks

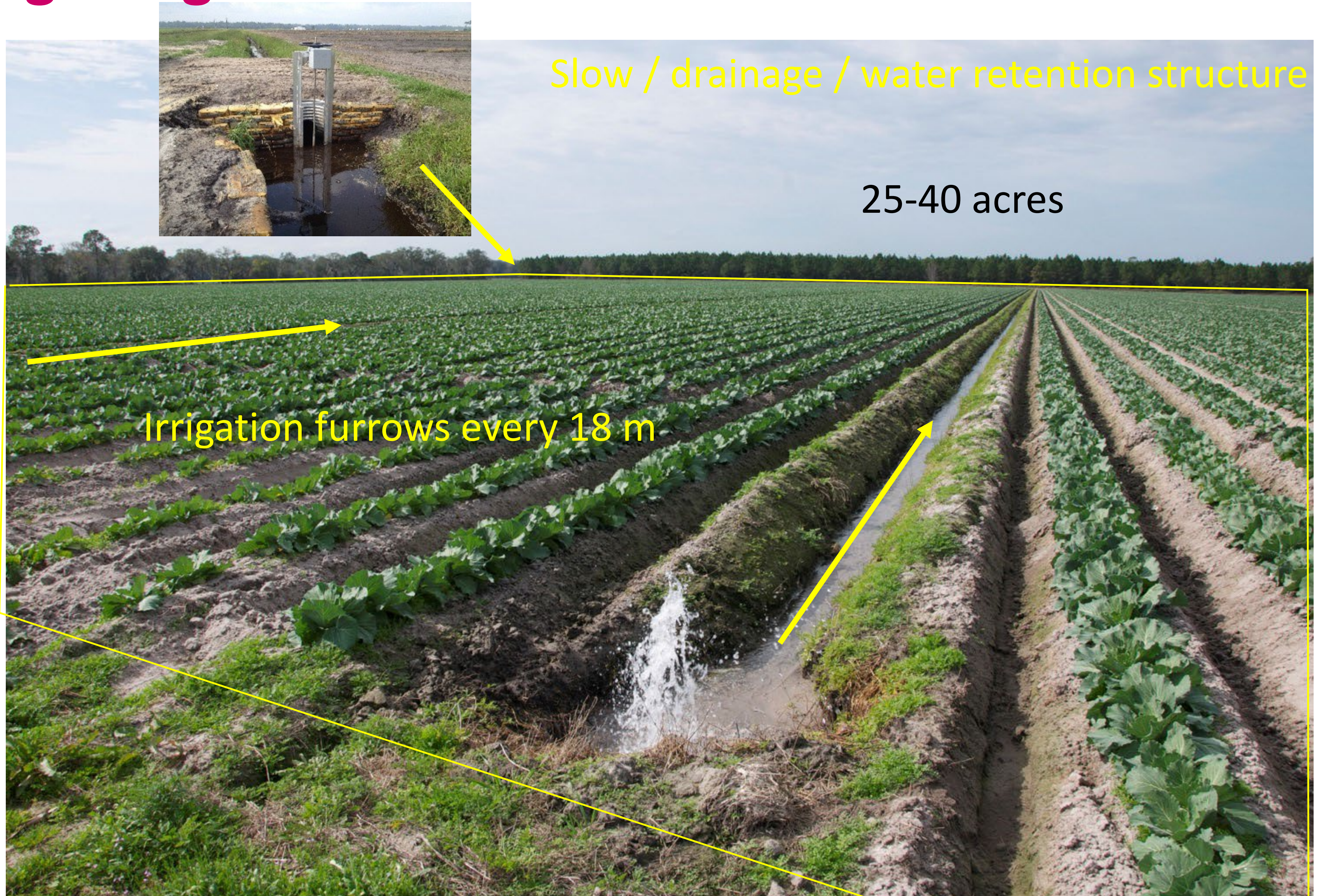
Spodosols

- Covering approx. 8.4 million acres widespread on flatwoods landscapes
- suborder Aquods, poorly drained with a water table at or near the surface for much of the year
- soils are sandy and acidic, with an accumulation of organic matter, aluminum, and iron (spodic horizon) in the subsoil
- Estimate 975,492 acres of seepage irrigation
- Water consumption for potato crop estimated in 18-20 in/year (457-508 mm/yr)

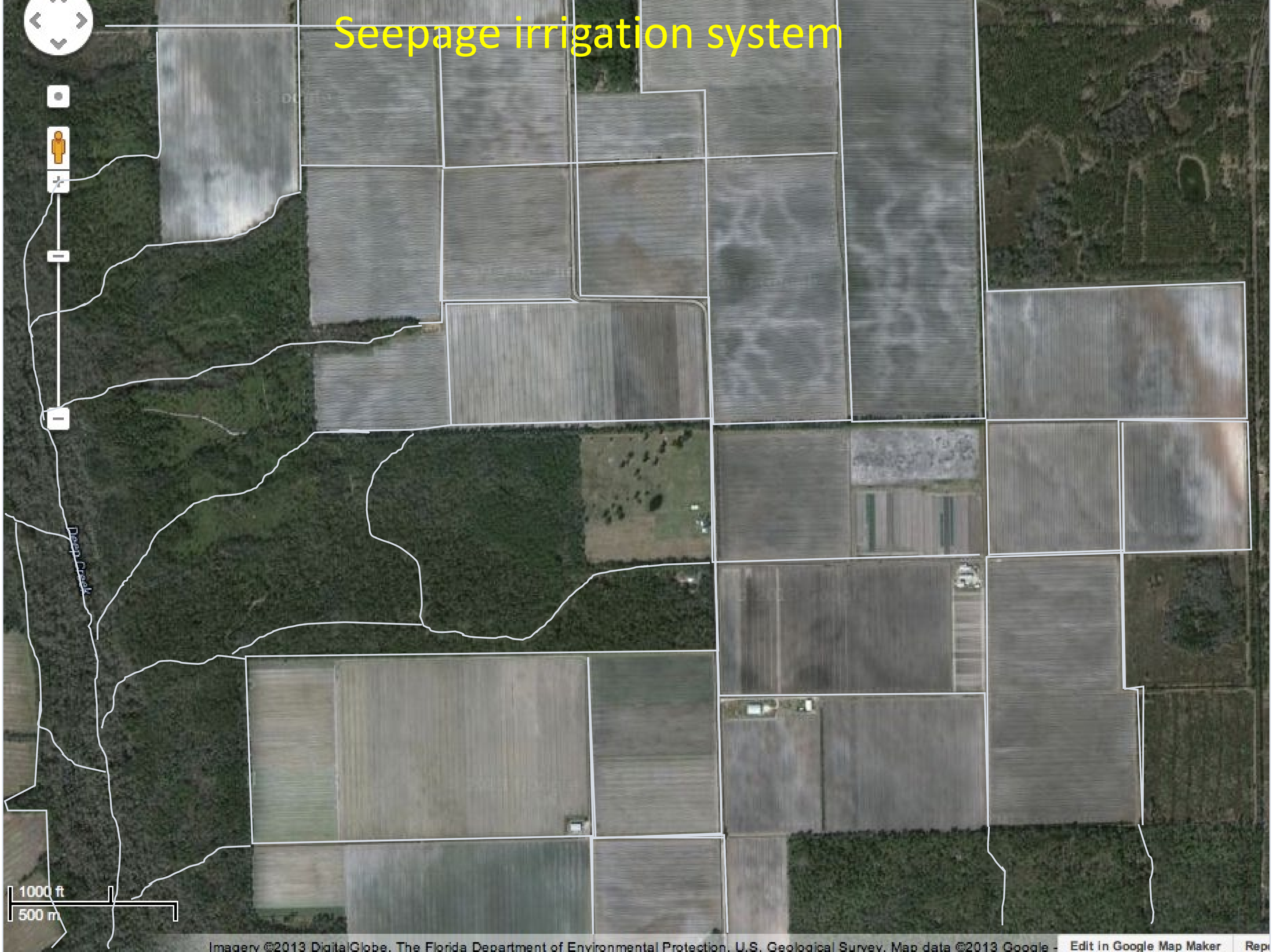


Smajstrla et al. 2000. Harris et al., 2010. Mylavarapu et al. 2016. https://edis.ifas.ufl.edu/publication/SS655

Seepage irrigation



Seepage irrigation system



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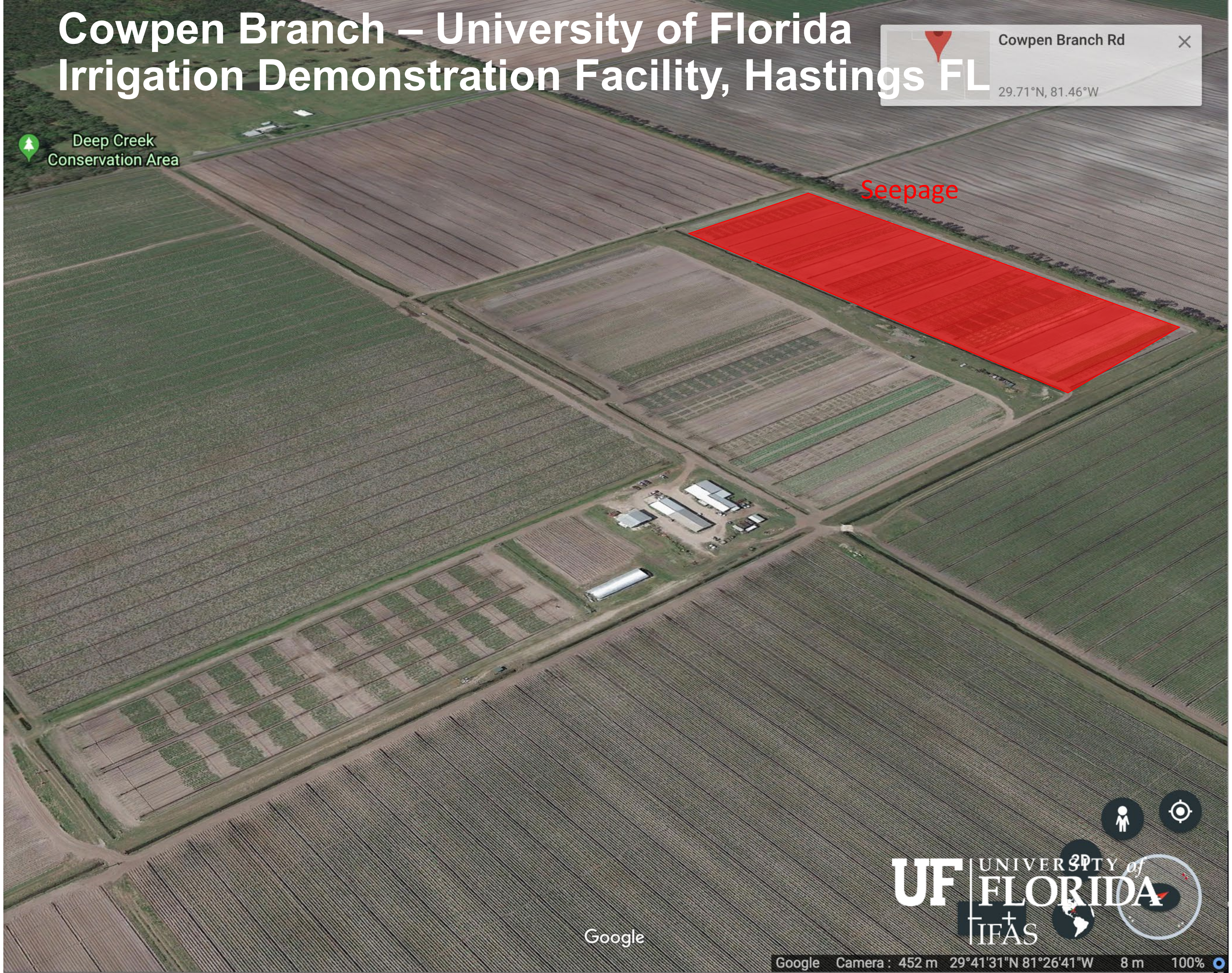
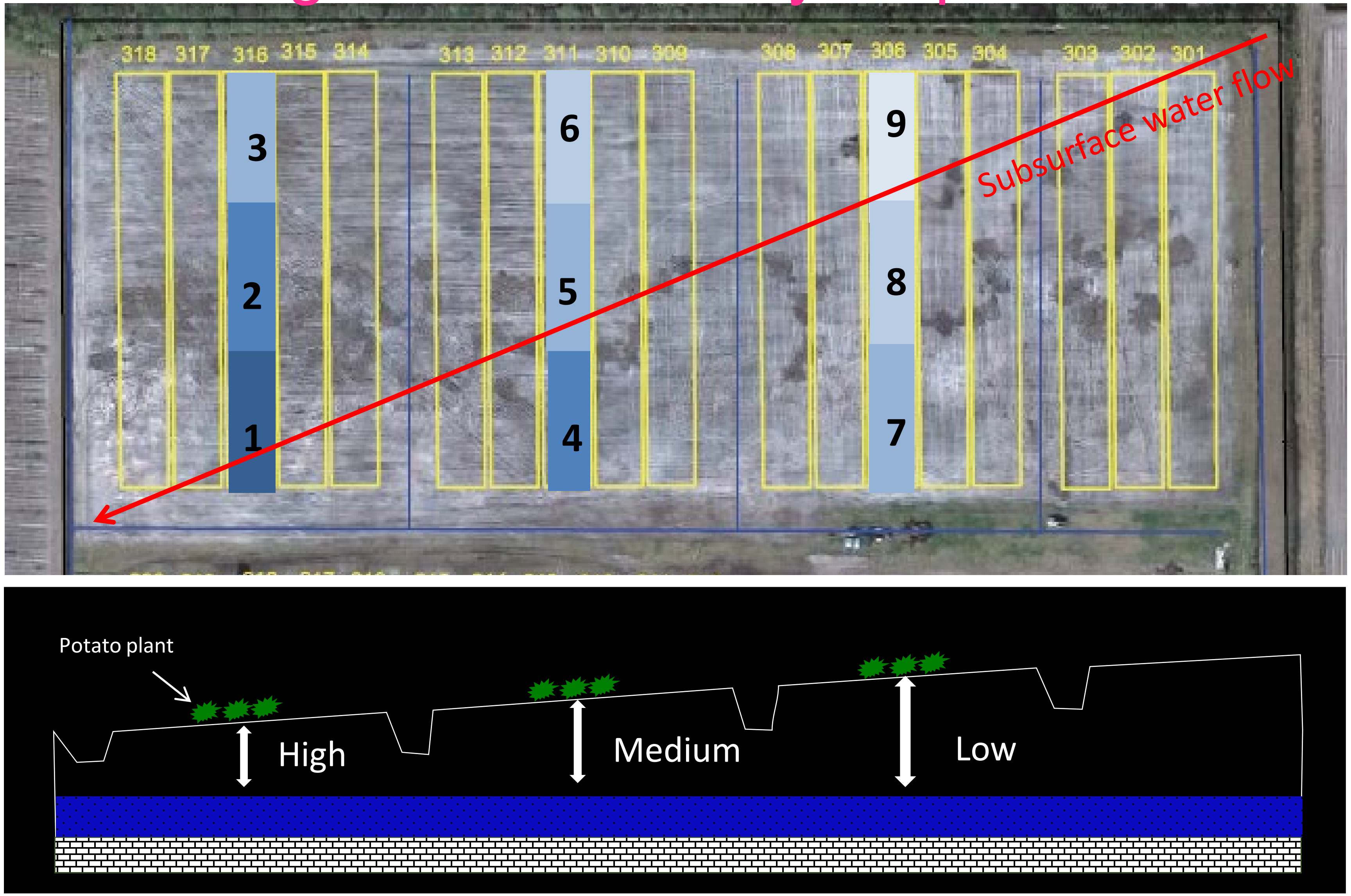
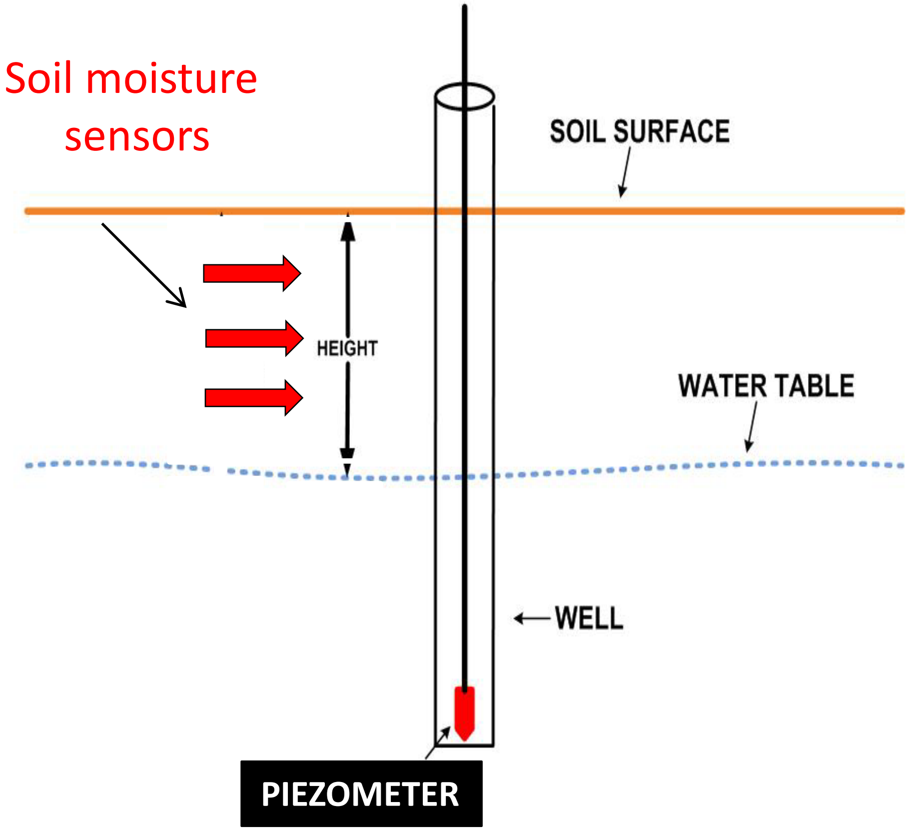


Seepage water table management and nitrogen use efficiency for potatoes



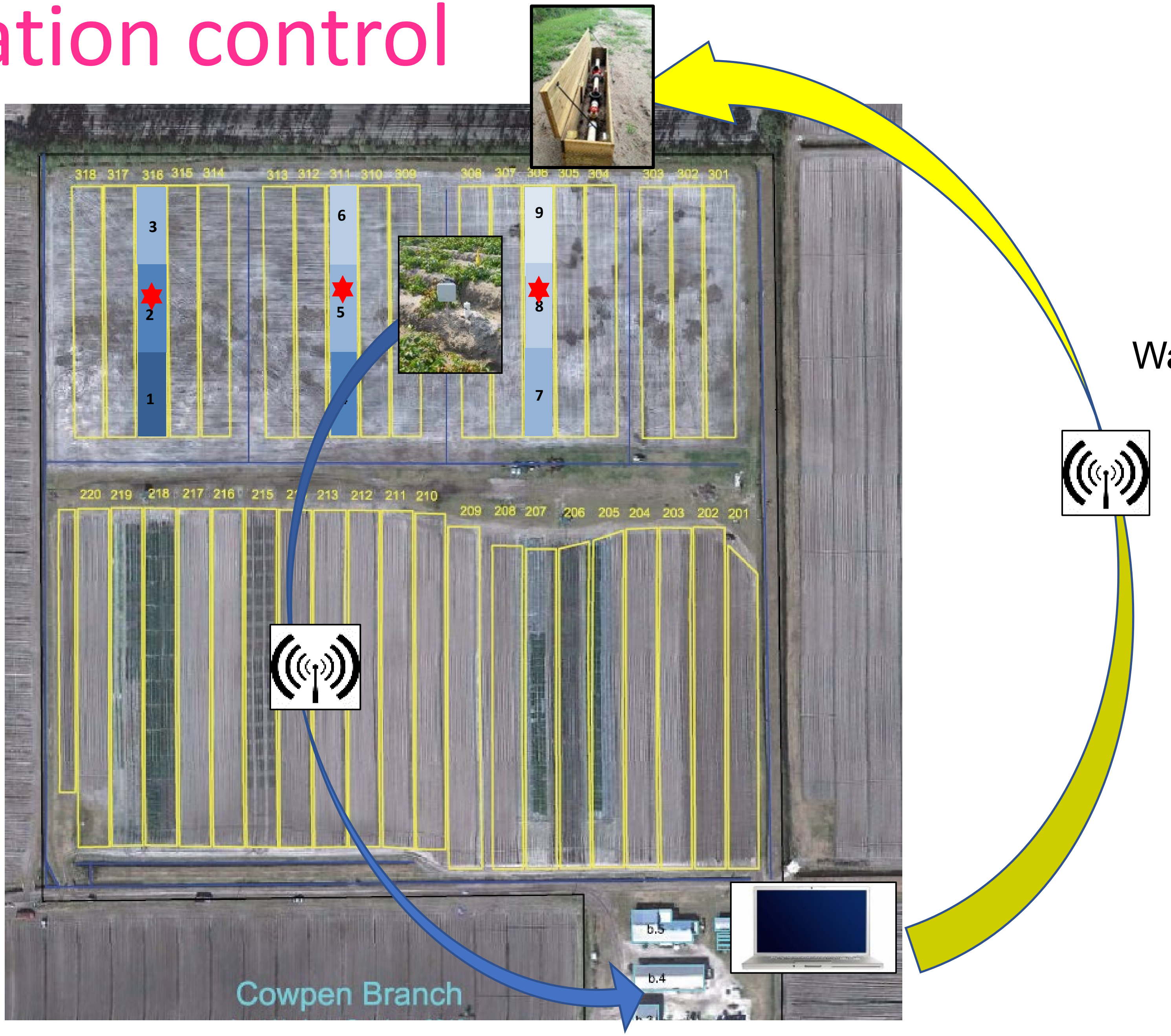
Rens, L. R., Zotarelli, L., Ribeiro da Silva, A. L. B., Ferreira, C. J. B., Tormena, C. A., Rowland, D. L., & Morgan, K. T. (2022). Managing water table depth thresholds for potato subirrigation. *Agricultural Water Management, 259*, 107236. doi:https://doi.org/10.1016/j.agwat.2021.107236

Irrigation control



Rens, L. et al (2022). doi:https://doi.org/10.1016/j.agwat.2021.107236

Irrigation control



Water table levels target set at
36 cm
53 cm
71 cm
below surface

Rens, L. et al (2022). doi:https://doi.org/10.1016/j.agwat.2021.107236

RCBD:

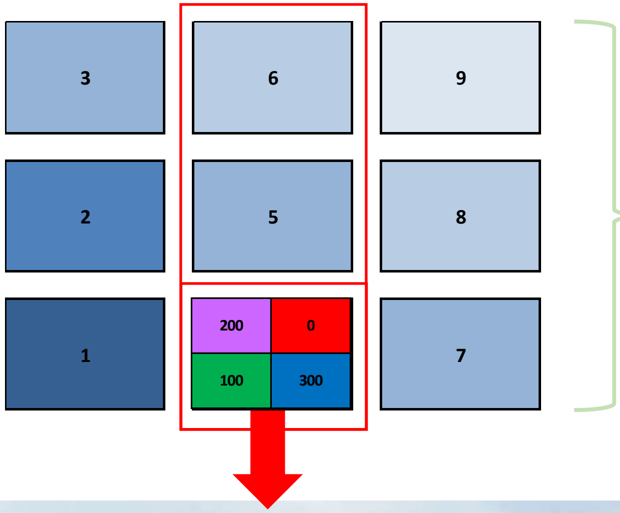
Split Plot:

4 N-Rates

- 0, 100, 200, 300 lb/ac

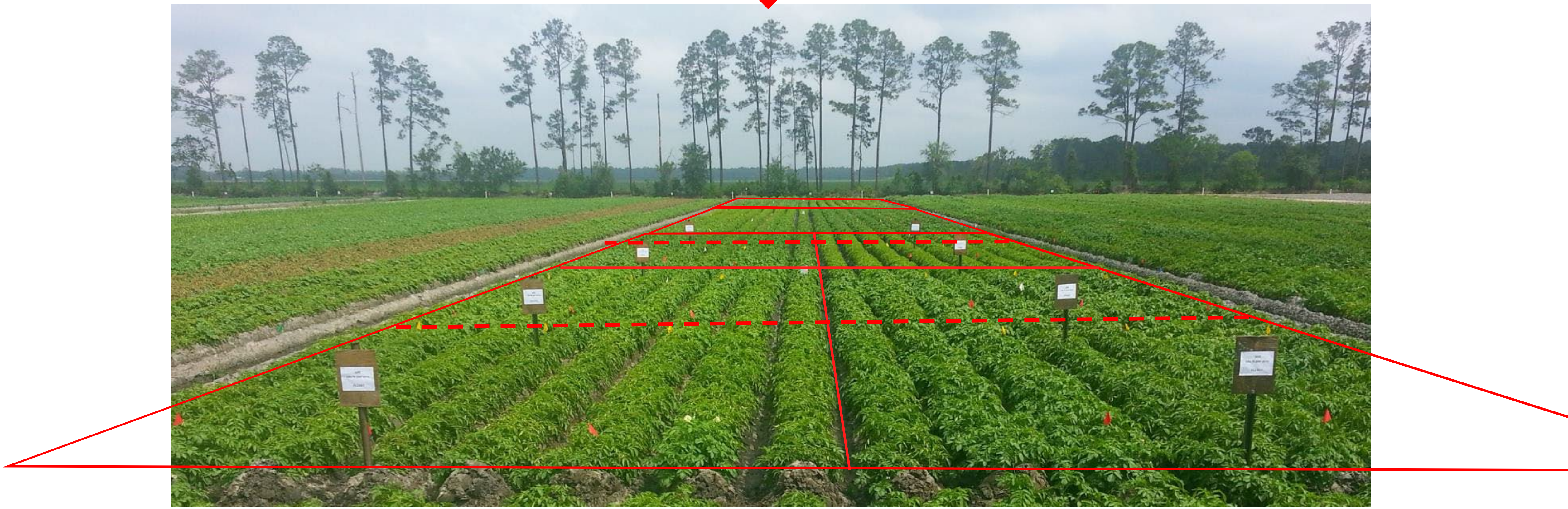
x 2 Varieties

- Atlantic/FL1867



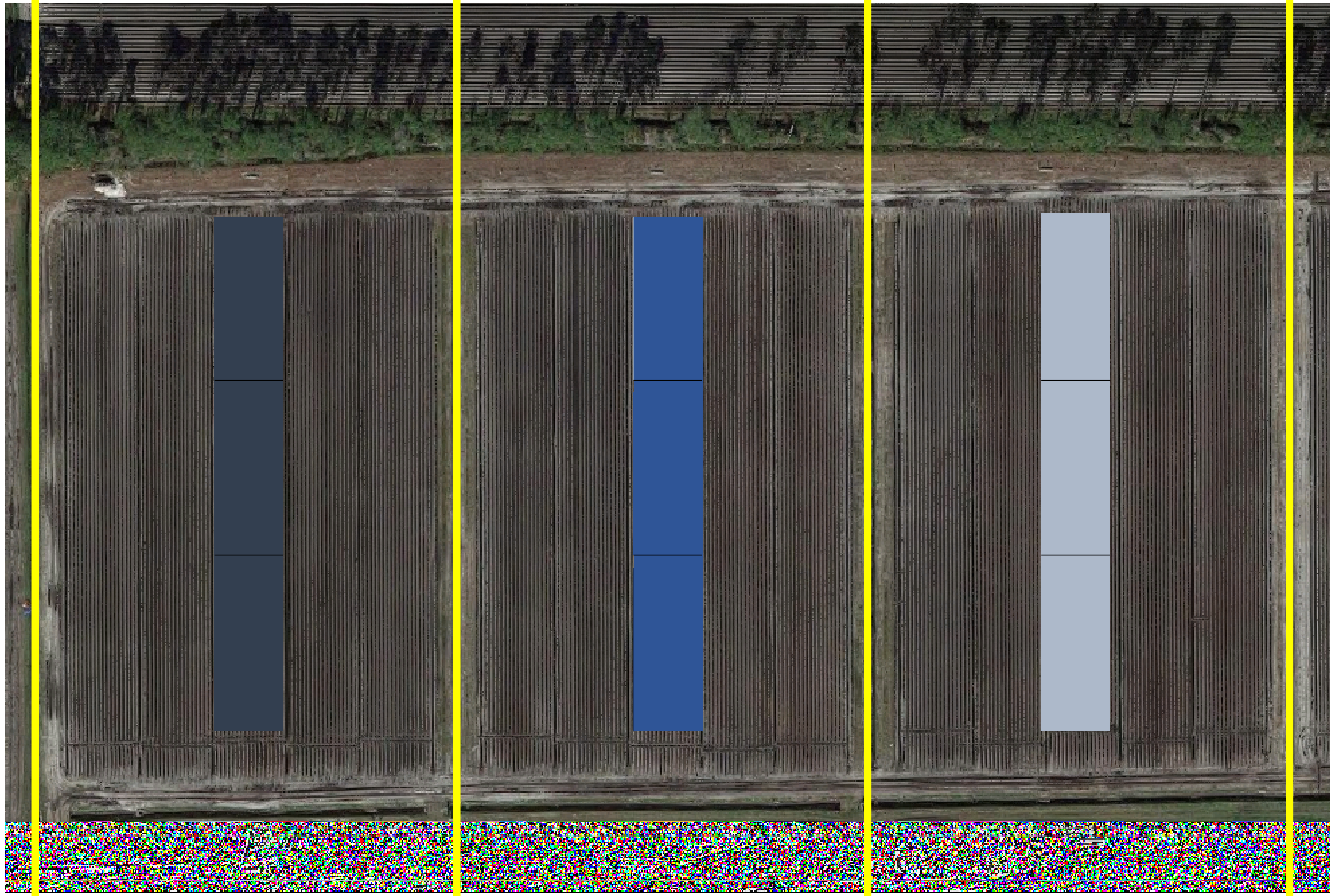
9 repetitions

Soil Moisture Covariate



Rens, L. et al (2022). doi:https://doi.org/10.1016/j.agwat.2021.107236

Irrigation volume applied to maintain water table level target



	High	Medium	Low
Water table level	**-36 cm**	**-54 cm**	**-71 cm**
2013	346 mm (0%)	194 mm (43%)	94 mm (72%)
2014	1160 mm (0%)	764 mm (34%)	420 mm (63%)

(% reduction from high water table treat.)

Rens, L. et al (2022). [doi:https://doi.org/10.1016/j.agwat.2021.107236](https://doi.org/10.1016/j.agwat.2021.107236)

Potato root length under high (HWT) and low (LWT) water table level at 76 and 104 DAP

Depth (cm)	Total Root Length (mm)			Total Root Length (mm)		
	HWT	LWT	‡p value	HWT	LWT	‡p value
	2013			2014		
	76 DAP			76 DAP		
0–10	45.3 bc§	84.6 b	ns	36.9 ab	19.9 bc	ns
10–20	140.4 a	143.4 a	ns	100.7 a	69.9 b	ns
20–30	87.4 b	170.9 a	***	9.1 b	218.9 a	***
30–40	1.0 c	33.8 bc	ns	0.0 b	26.4 bc	ns
40–50	0.0 c	0.0 c	ns	0.0 b	1.6c	ns
Mean	54.8 B	86.6 A		29.3 B	67.4 A	
†p value	***	***		***	*	
	104 DAP			90 DAP		
0–10	81.6 ab	42.4 bc	ns	20.3 ab	21.9 bc	ns
10–20	90.9 a	99.1 ab	ns	51.2 a	63.2 ab	ns
20–30	94.0 a	135.9 a	ns	5.6 ab	107.6 a	***
30–40	0.0 b	40.9 bc	ns	0.6 b	16.9 bc	ns
40–50	0.0 b	0.0 c	ns	0.0 b	0.0 c	ns
Mean	53.3 A	63.7 A		15.5 B	41.9 A	
†p value	*	*		*	***	

†p value associated with the simple effect of rooting depth within each water table treatment and sampling date; *ns*, not significant; *$p < 0.05$, ***$p < 0.001$.
‡p value associated with the simple effect of water table treatment within each rooting depth and sampling date; *ns*, not significant; *$p < 0.05$, ***$p < 0.001$.
§Values followed by the same lowercase letter within water table treatments indicate that averages are not significantly different ($p < 0.05$) among soil layers.

mini-rhizotron installed in potato field

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Water table level and ETc

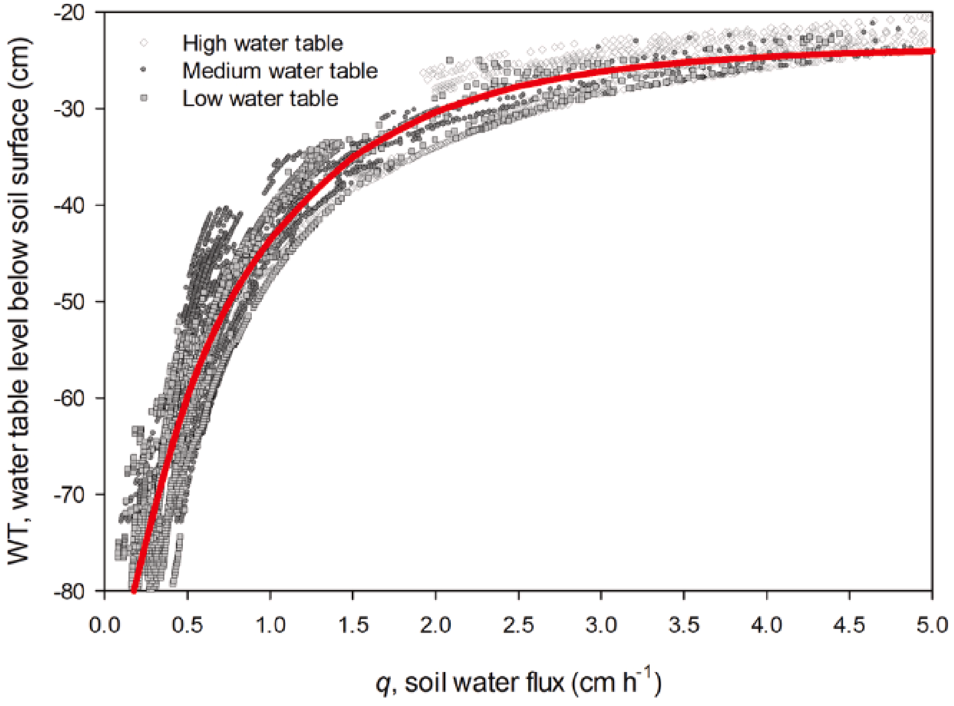


Fig. 3. Relationship between the soil water upward flux (q) at the 22-cm soil depth and the water table level below the top of the hilled potato row for high water table (HWT), medium water table (MWT), and low water table (LWT) treatments in Hastings, FL.

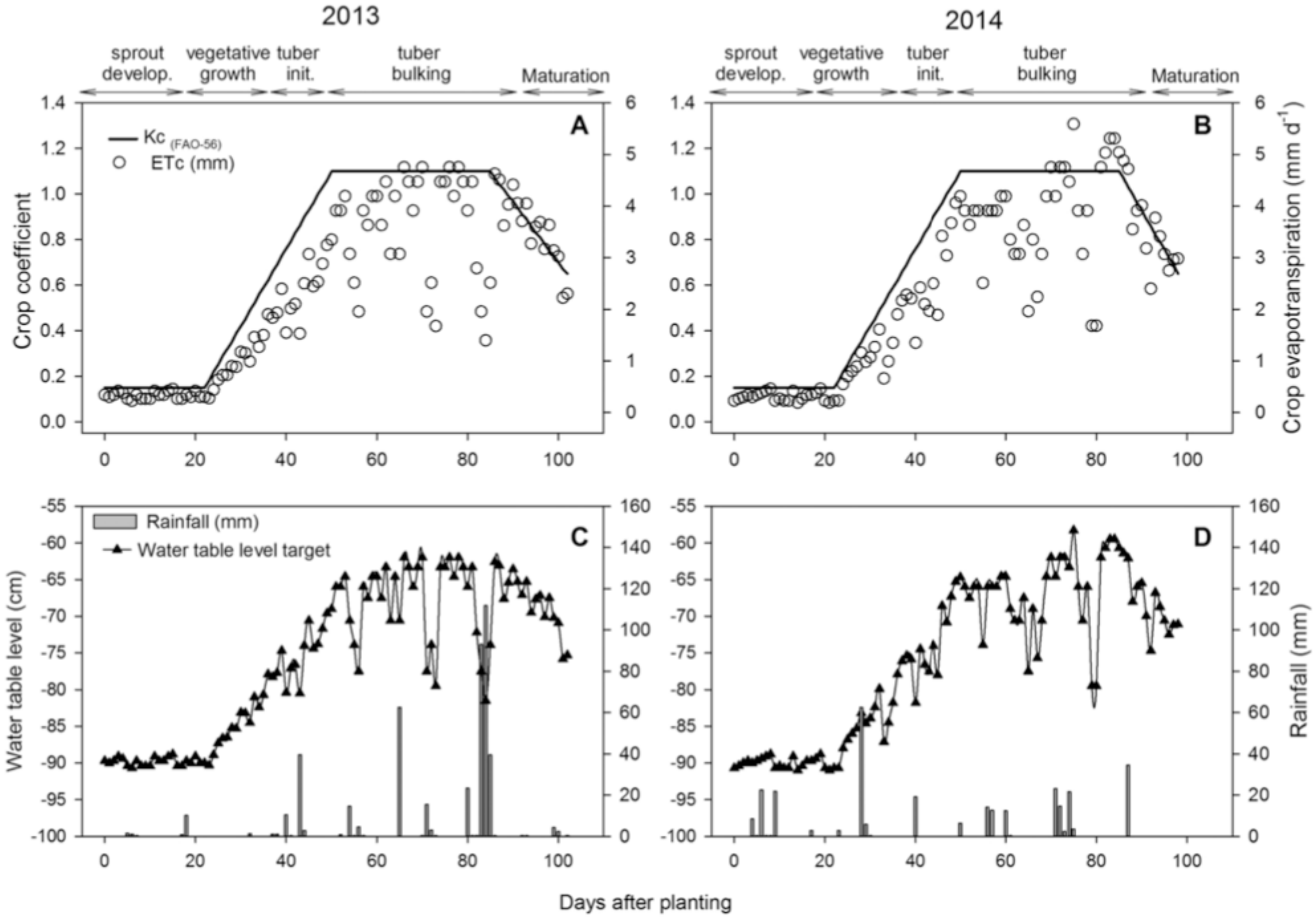


Fig. 4. Potato crop stages and respective crop coefficients (Kc) from FAO-56, and daily crop evapotranspiration (ETc) for 2013 (A) and 2014 (B) seasons. Rainfall distribution and estimated water table level target as a function of soil water upward flux at 17-cm to supply the daily potato ETc demand in 2013 (C) and 2014 (D) seasons in Hastings, FL.

Rens, L. et al (2022). doi:https://doi.org/10.1016/j.agwat.2021.107236

Potato yield response to soil moisture and water table level

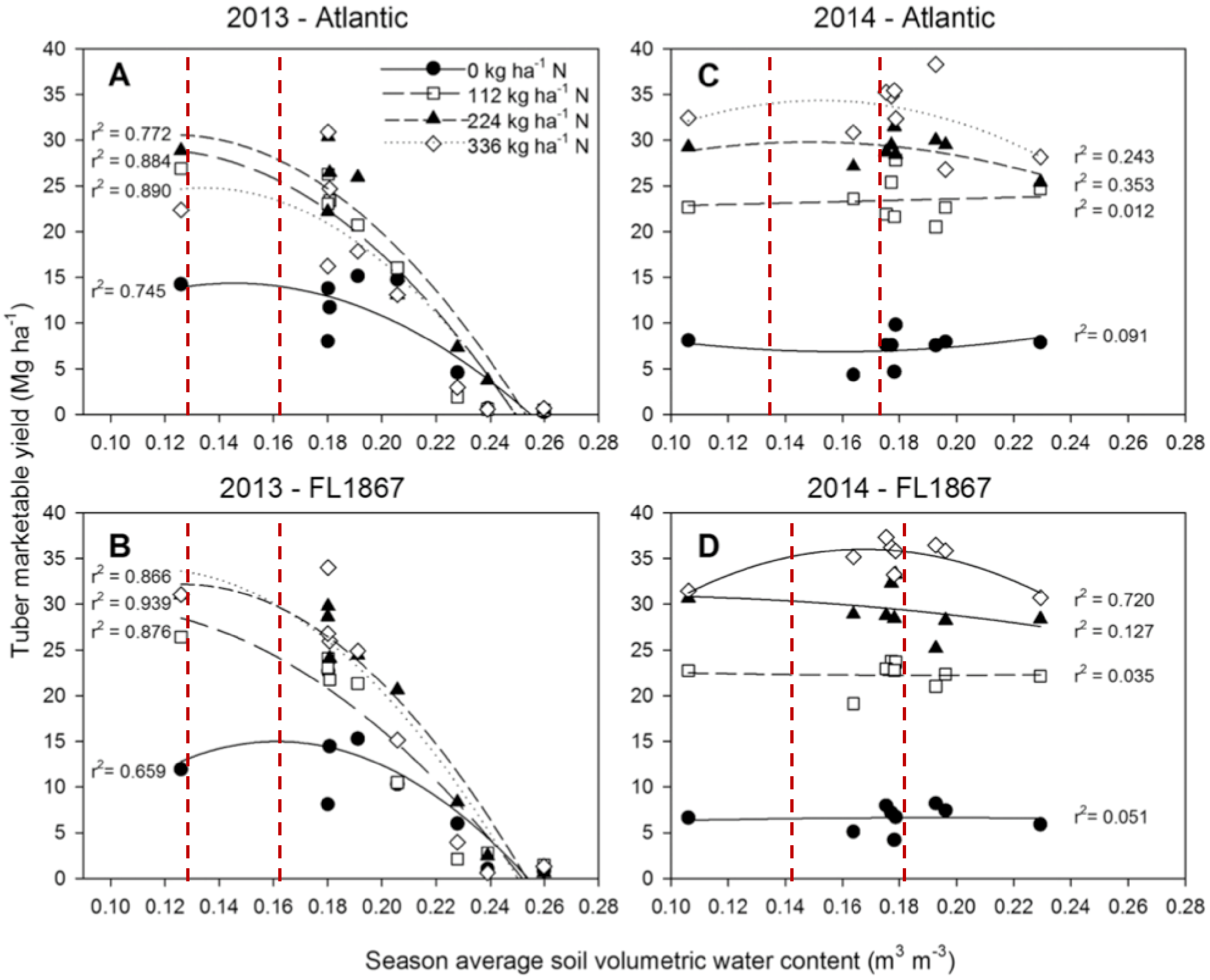


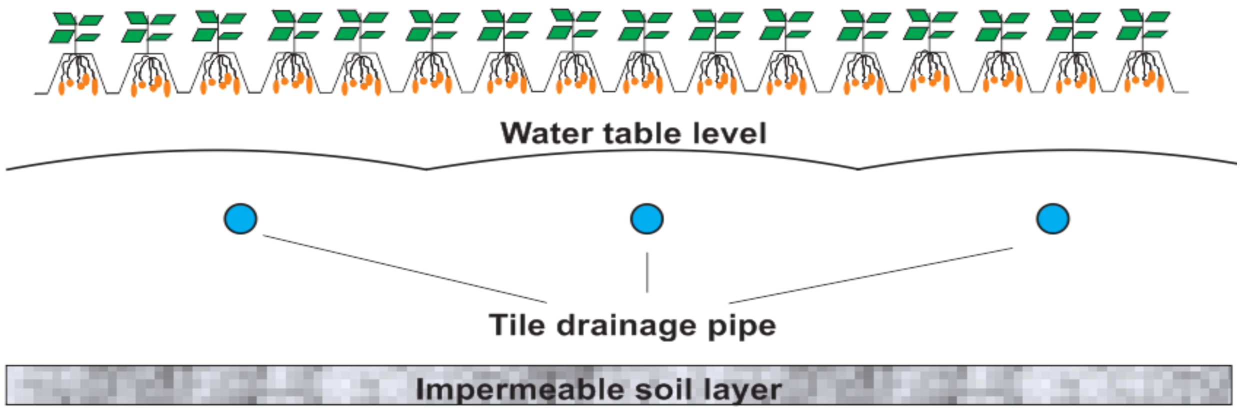
Fig. 8. Relationship between average soil moisture and marketable yield in 2013 and 2014 on 'Atlantic' and 'FL1867' potato cultivars grown with 0, 112, 224, or 336 kg ha^{-1} of N.

Rens, L. et al (2022). doi:https://doi.org/10.1016/j.agwat.2021.107236

Alternative Irrigation Methods

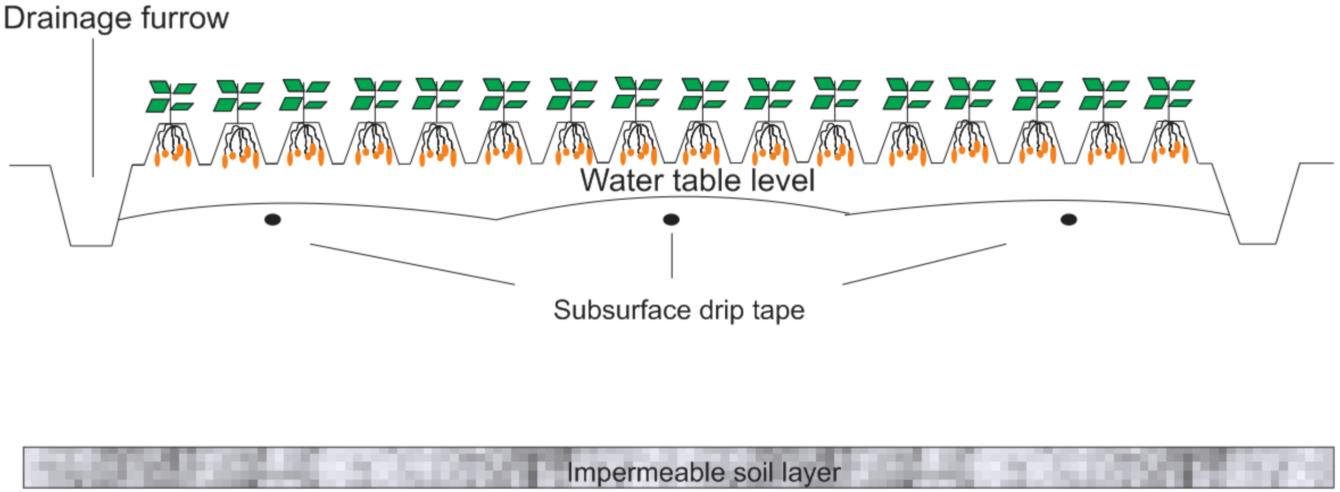
Subsurface drain tile

- 4,700 acres of seepage converted to SDT
- Great control of drainage, and irrigation
- no furrows – (gain of 12% of the area)
- Popular among growers



Subsurface Drip Irrigation

- Subsurface drip irrigation for water table management (enhanced seepage)
- About 700 acres converted
- Rely on furrows for drainage



Sprinkler + Seepage Hybrid

- Sprinkler irrigation
- Well drained vs high water table soil
- **Continuous water table control needed**
- Fertigation
- About 1,650 acres of seepage converted

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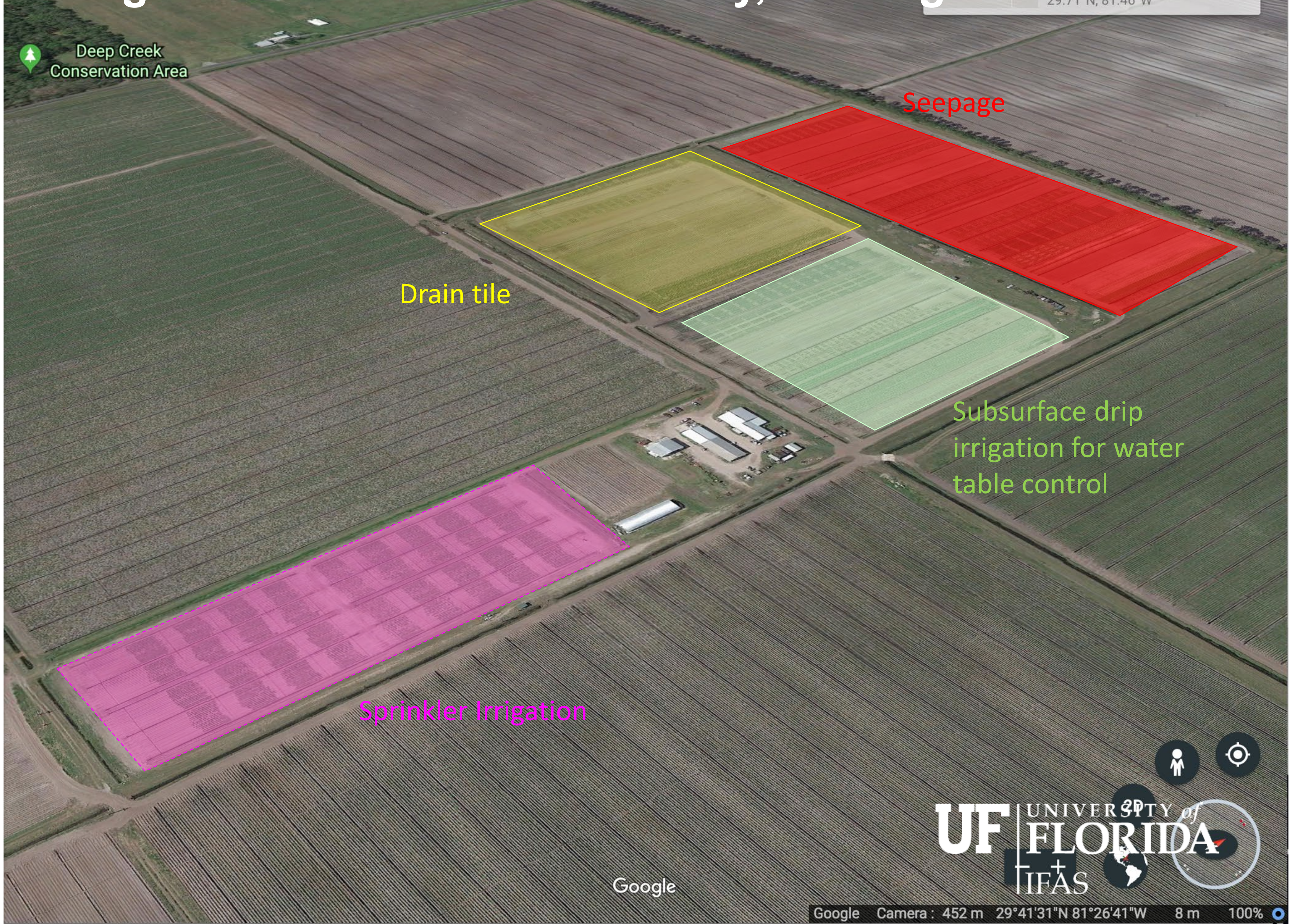


Comparison across irrigation methods

				Irrigation method		
Yr	Crop Evapotr. (ETc)	Rainfall	Seepage	Drain tile	SDI	Sprinkler
				mm		
2015	257	184	295	144	125	96
2016	282	294	287	194	165	89
Average	270	239	291	169	145	93
Reduction compared to seepage				42%	50%	68%

Note: water table was managed to maintain soil moisture between 0.11-0.16 cm/cm^3 across irrigation methods

da Silva et al. (2022) submitted

Tuber yield

Effects of irrigation method on total potato tuber yield

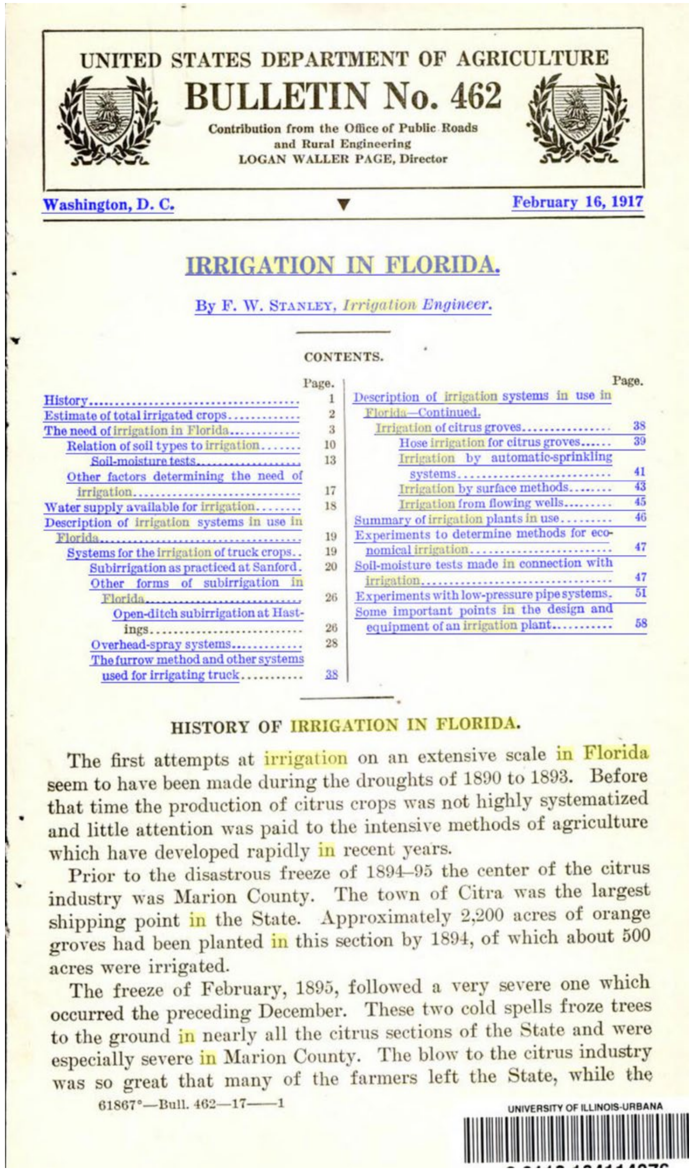
	Seepage	Drain tile	SDI	Sprinkler	*p* value
		Mg ha^{-1}			
Total Yield	32.2 C	13% ↑	8% ↑	=	< 0.0001
Marketable Yield	26.0 BC	10% ↑	=	=	0.0003

Marketable yield = tuber with diameter > 4.7 cm

Alternative irrigation methods maintained or increase tuber yield

da Silva et al. (2022) under review

Precision Irrigation Management



UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 462

Contribution from the Office of Public Roads and Rural Engineering
LOGAN WALLER PAGE, Director

Washington, D. C. ▼ February 16, 1917

IRRIGATION IN FLORIDA.

By F. W. Stanley, *Irrigation Engineer.*

CONTENTS.

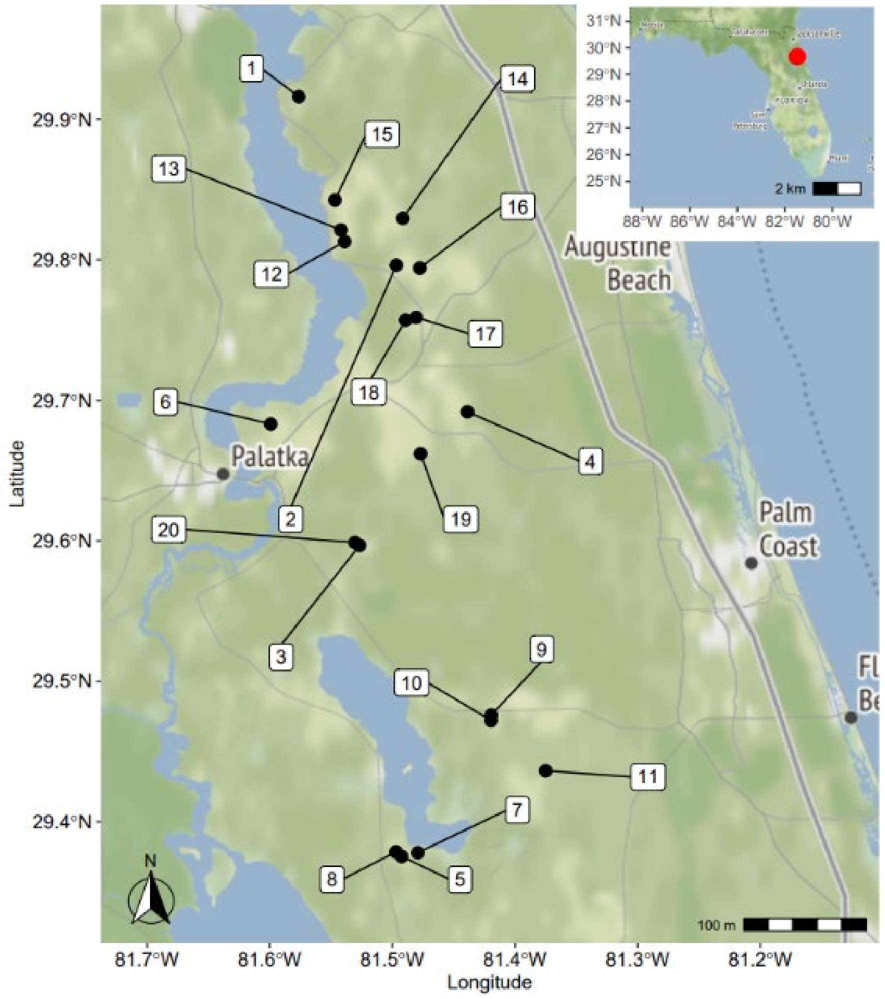
HISTORY OF IRRIGATION IN FLORIDA.

The first attempts at irrigation on an extensive scale in Florida seem to have been made during the droughts of 1890 to 1893. Before that time the production of citrus crops was not highly systematized and little attention was paid to the intensive methods of agriculture which have developed rapidly in recent years.

Prior to the disastrous freeze of 1894–95 the center of the citrus industry was Marion County. The town of Citra was the largest shipping point in the State. Approximately 2,200 acres of orange groves had been planted in this section by 1894, of which about 500 acres were irrigated.

The freeze of February, 1895, followed a very severe one which occurred the preceding December. These two cold spells froze trees to the ground in nearly all the citrus sections of the State and were especially severe in Marion County. The blow to the citrus industry was so great that many of the farmers left the State, while the

Soil particle size distribution in regional scale



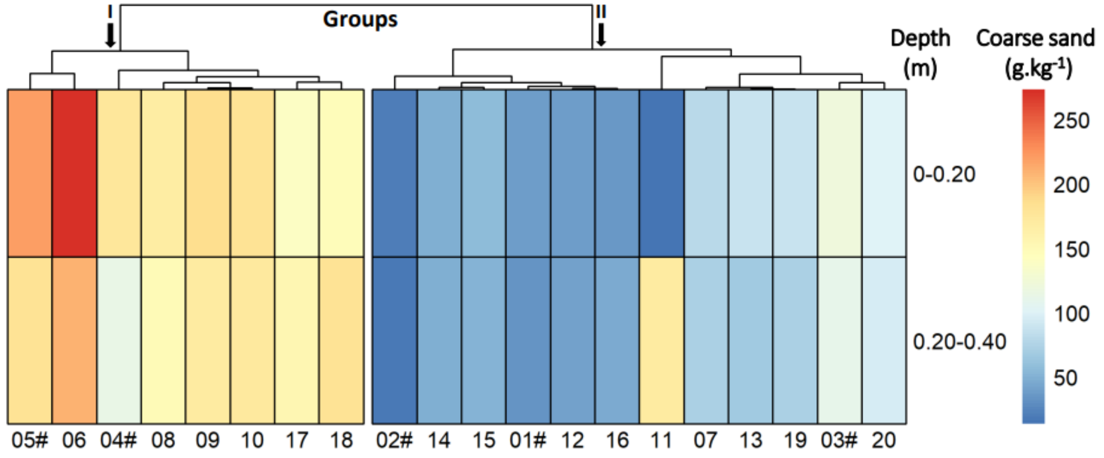


Fig.3. Cluster diagram of the coarse sand ($g.kg^{-1}$) fraction from the 0-0.20 and 0.20-0.40 m soil depth layer.

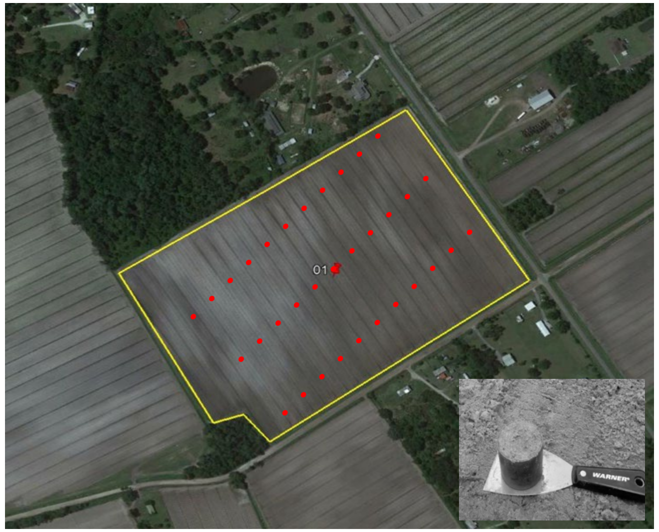
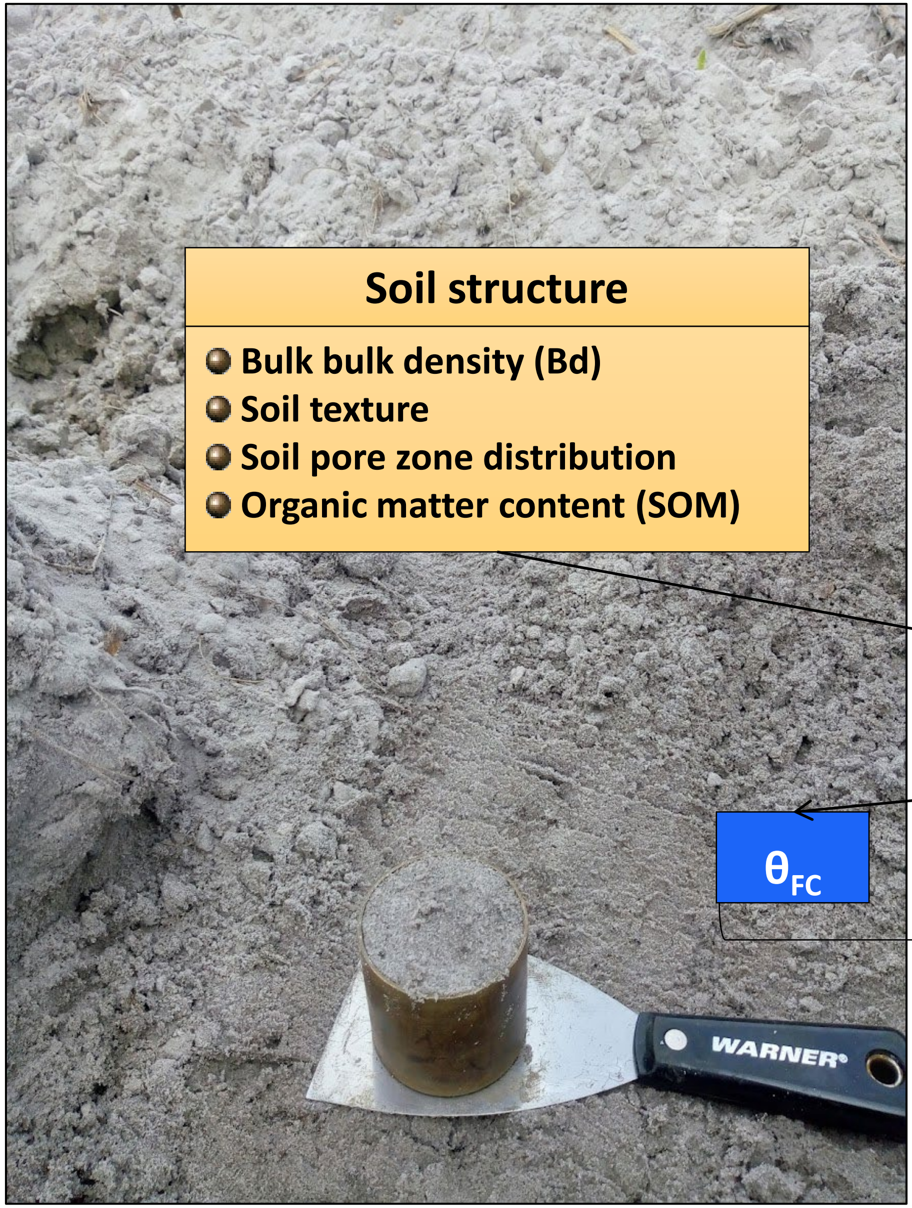


Fig.4. Soil undisturbed sampling in the selected sites on the layers 0-0.20 m and 0.20-0.40 m.

Soil physics quality and available water to plant
Principles of Least Limiting Water Range



Soil structure

- Bulk bulk density (Bd)
- Soil texture
- Soil pore zone distribution
- Organic matter content (SOM)

Soil structure + water management = crop growth

- **Available water to plant**
  Limits between soil field capacity (FC = -60hPa) and permanent wilting point (WP = -15.000hPa)
- **Penetration resistance** (Limit PR<1.5-2.0 MPa)
- **Air-filled porosity** (Limit <10%)

Interrelationship

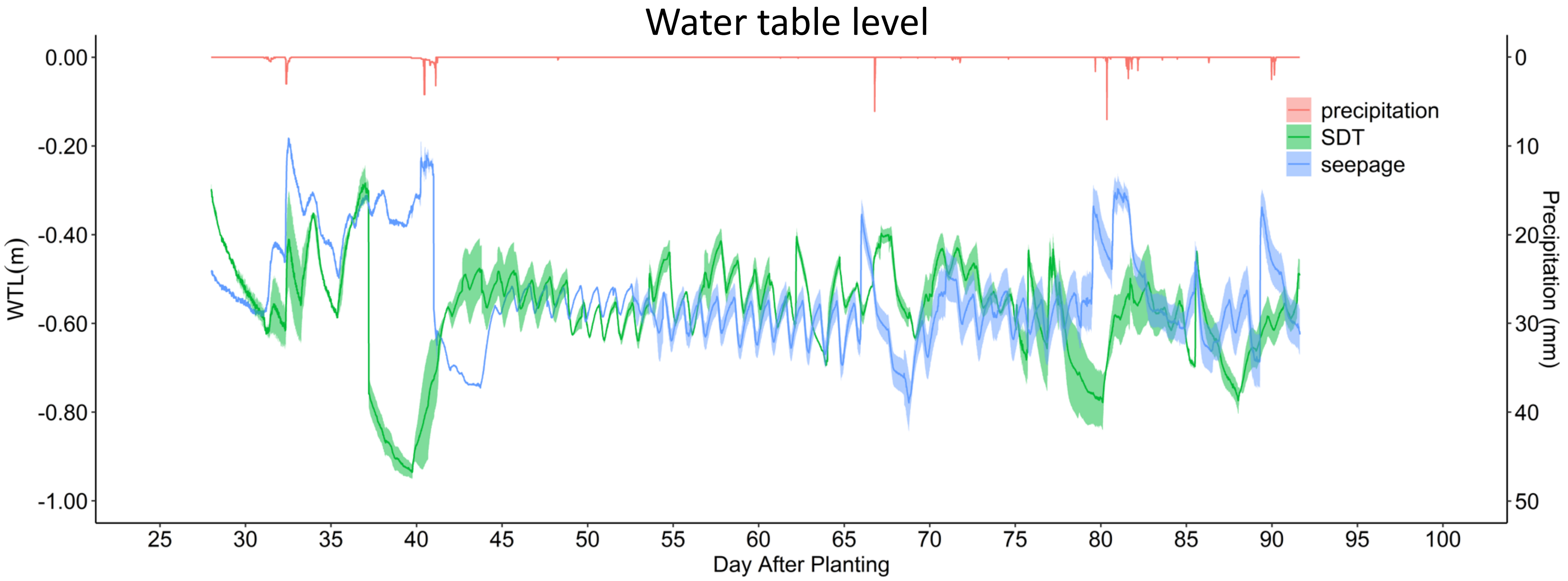
- Bd

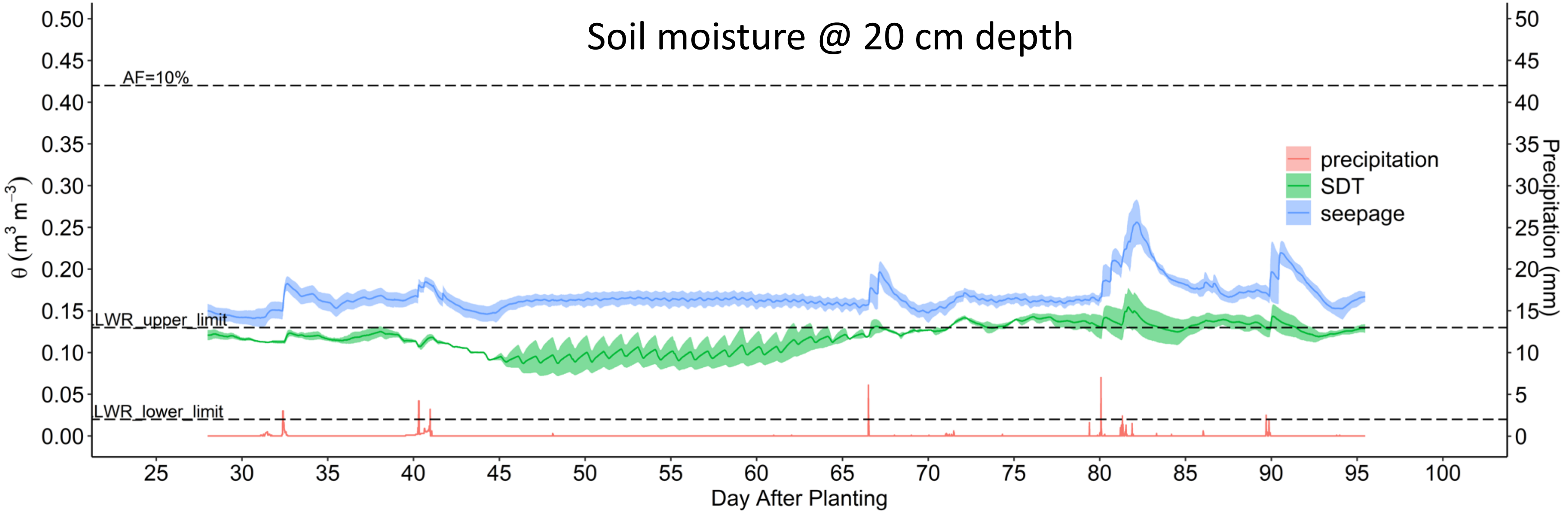
θ_{FC} θ_{WP} θ_{AFP} θ_{PR}

LLWR

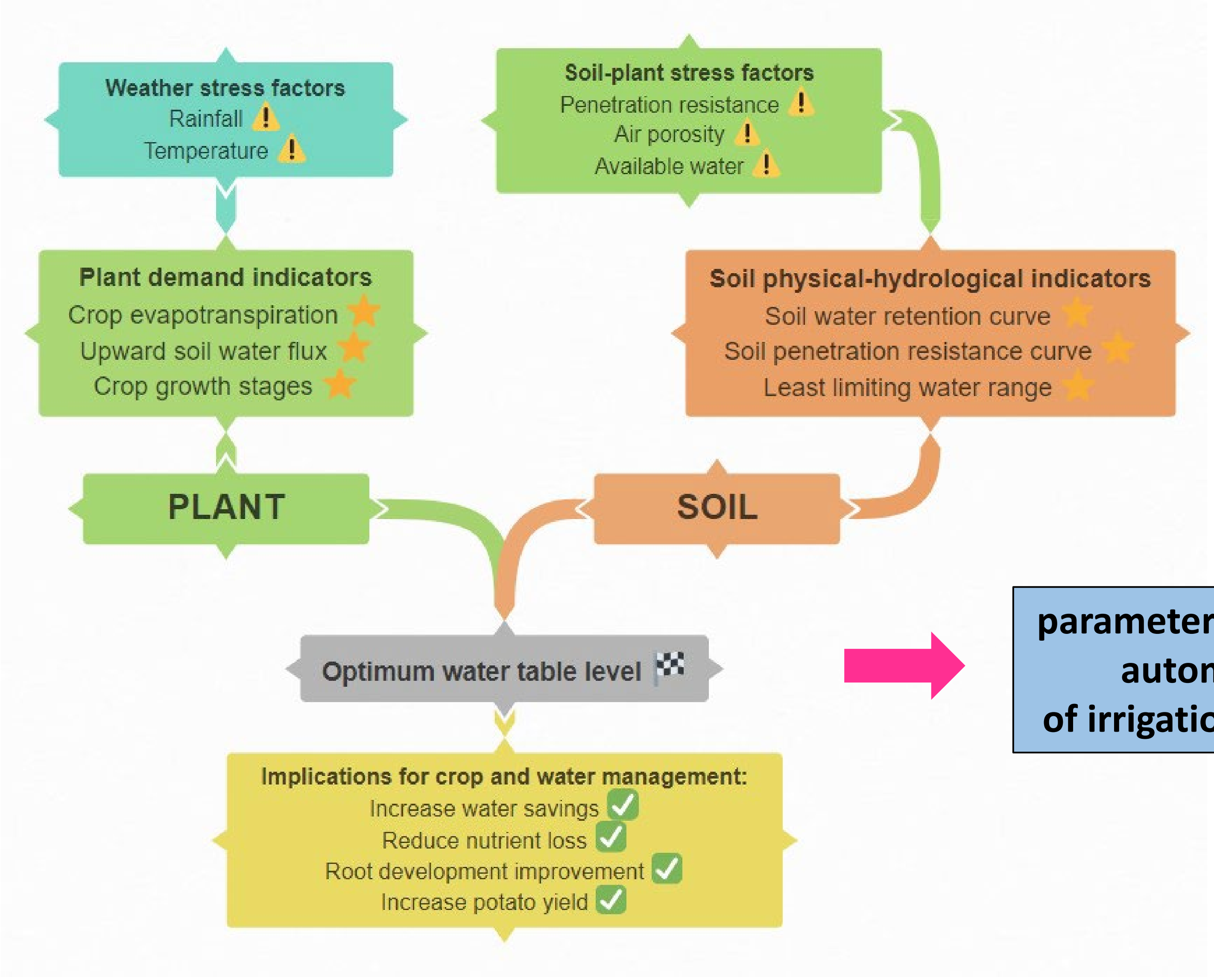
- Irrigation
- Drainage

Soil moisture and water table level under seepage and SDT





Modeling to support irrigation recommendation - concept



parameters for future automation of irrigation/drainage

Data collection and processing
Analysis of systems
Predictive modeling
Data visualization
Decision analytics
Machine learning
Spatial analysis

Project framework

Final Remarks

https://www.mysticstamp.com/Products/United-States/1150/USA/

Alternative irrigation methods (current)

- 4,700 acres converted to subirrigation with drain tile
- 1,700 acres converted to sprinkler
- 600 acres converted to subsurface drip irrigation

Estimated water conservation today

- 500 million gallons per year
- (equivalent of water for ˜17,000 houses per year)

Extrapolating to Florida seepage area (975,000 acres)

- Potential water savings of 75,000 million gallons per year
- Supply water to 2.5 million houses for a year

Impact on water quality

Thank you

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