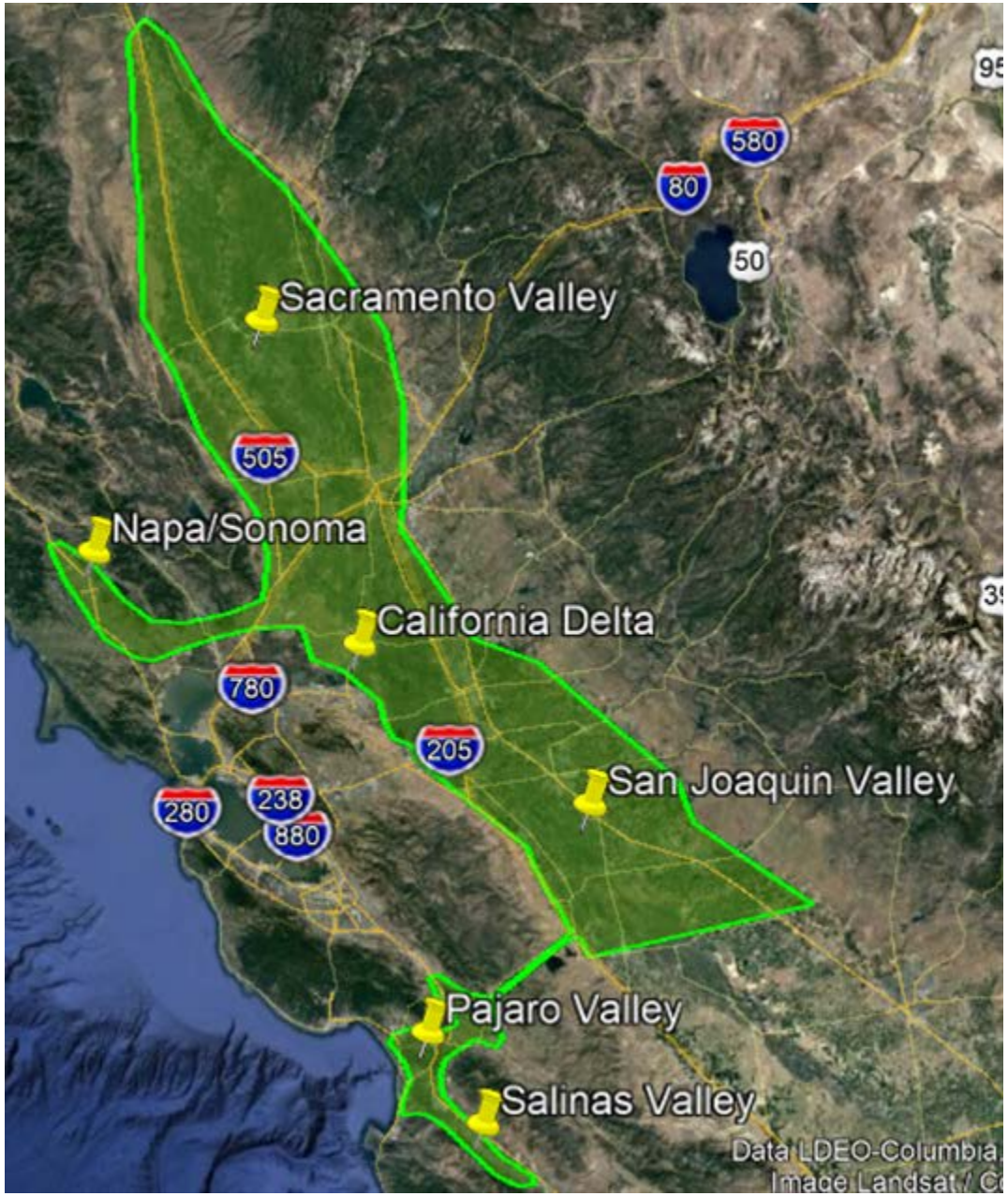
Hortau for Hops

How monitoring soil tension can help you better control input costs, keep plants healthy, and promote a high-quality harvest

TRAVIS GOLDMAN, HORTAU

HORTAU



Travis Goldman

Irrigation Management Advisor

Hortau

CCA: 732597

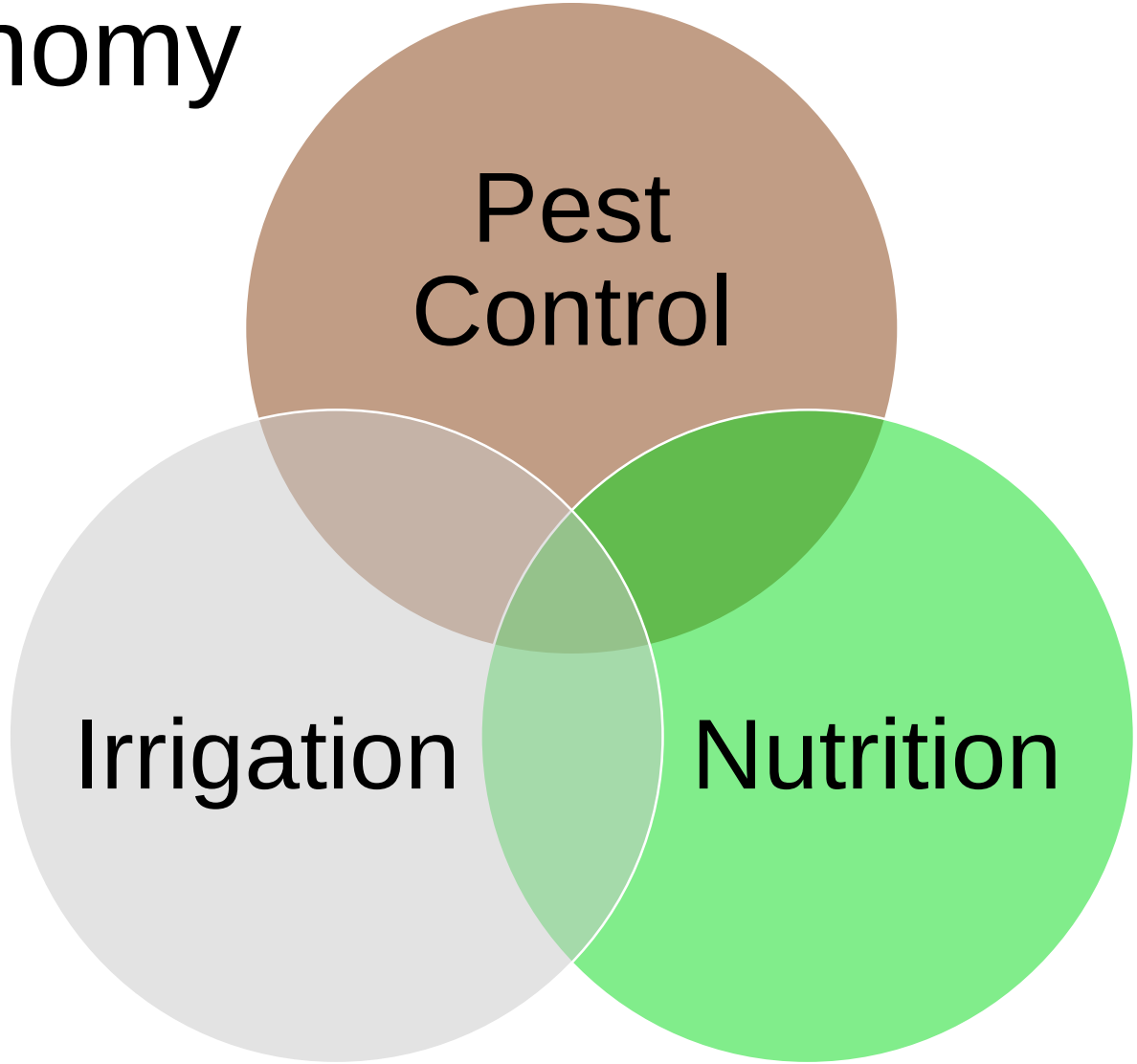
CAIS: 127075

Alfalfa
Almonds
Apples
Apricots
Asparagus
Artichokes
Apricots
Blackberries
Blueberries
Broccoli
Brussel Sprouts
Cannabis/Hemp
Carrots
Cauliflower
Celery
Cherries
Corn
Garlic
Hops
Onions
Peppers
Tomatoes
- (Fresh market/solids)
Onions
Lettuce -
(Romaine/Iceberg/Artisan)
Pistachios
Raspberries
Strawberries
Walnuts
Wine Grapes
Zinnias

What are the three pillars of agronomy?

Three Pillars of Agronomy

- Each discipline is vital to consistent, reliable crop performance
- Each is advanced or limited by one another
- Consideration of each control variables



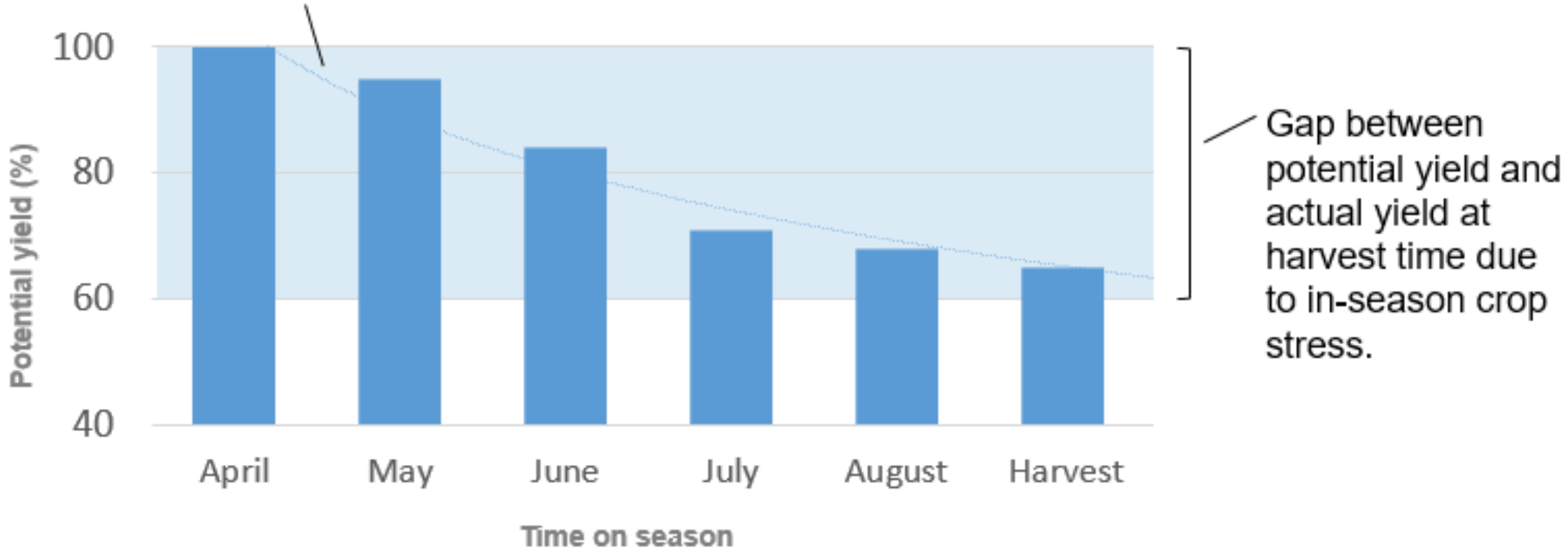
Why Irrigation Matters

- Goal is to maximize production, not just get crops to survive
- **Water deficit “overrides” all other functions**

Why precision irrigation matters

Each season crop stress factors can reduce yield by more than 50%[1]

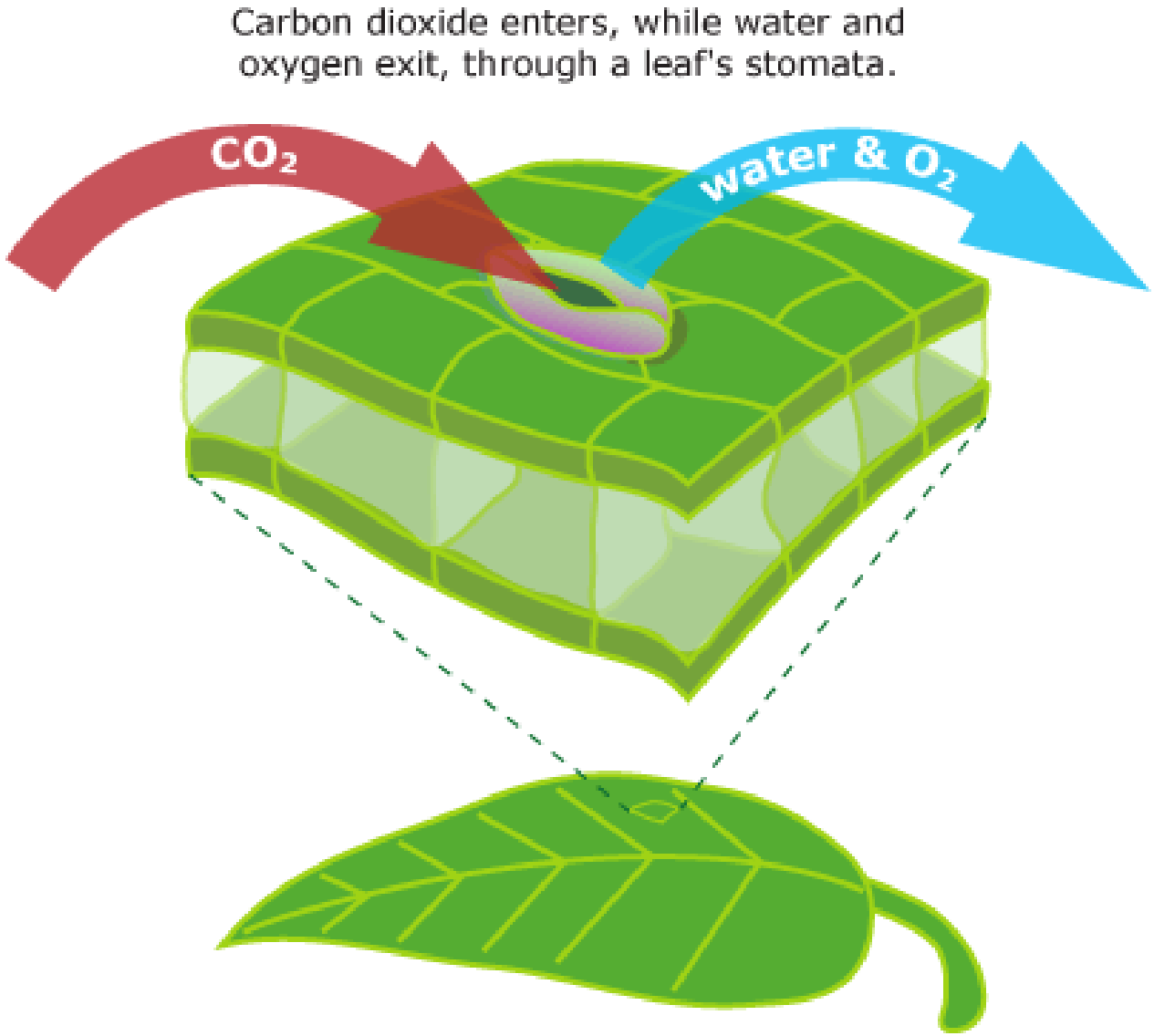
During the season, the crop is exposed to different stress factors that cause yield losses.
These losses happen quickly and can never be retrieved.
The only way to avoid them is to anticipate and correct the situation before any damage is done.



1 - Lisar et al, 2012. Water Stress in plants: Causes, Effects and Responses.

Stomatal Control

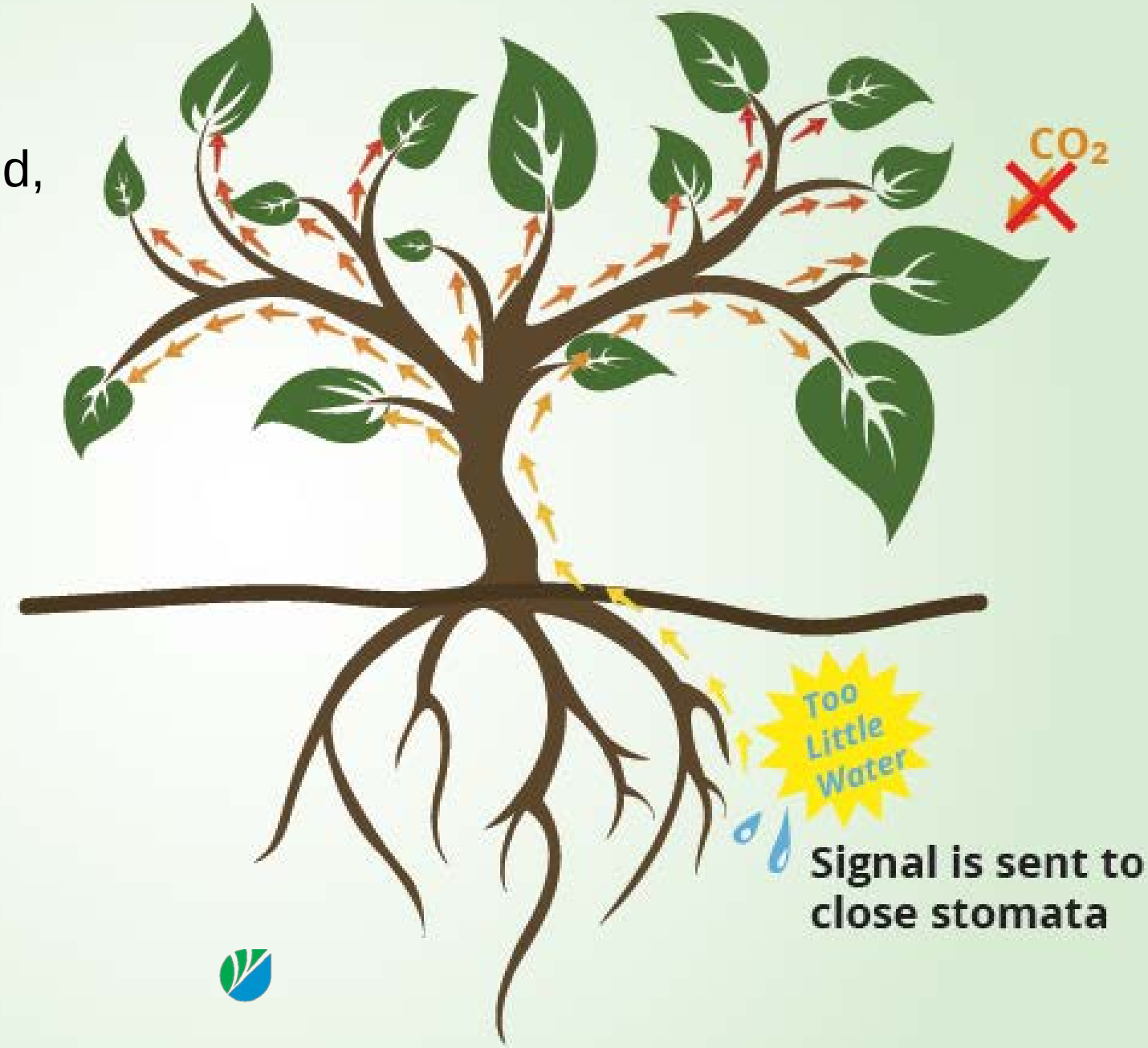
- Gas exchange critical to photosynthesis
- Stomata have 3 functions
  - Let CO2 in
  - Let water out
  - Regulate water loss
- When stomata close to save water, CO2 is also limited
- When CO2 is limited, the plant factory is limited.



Stomatal Control

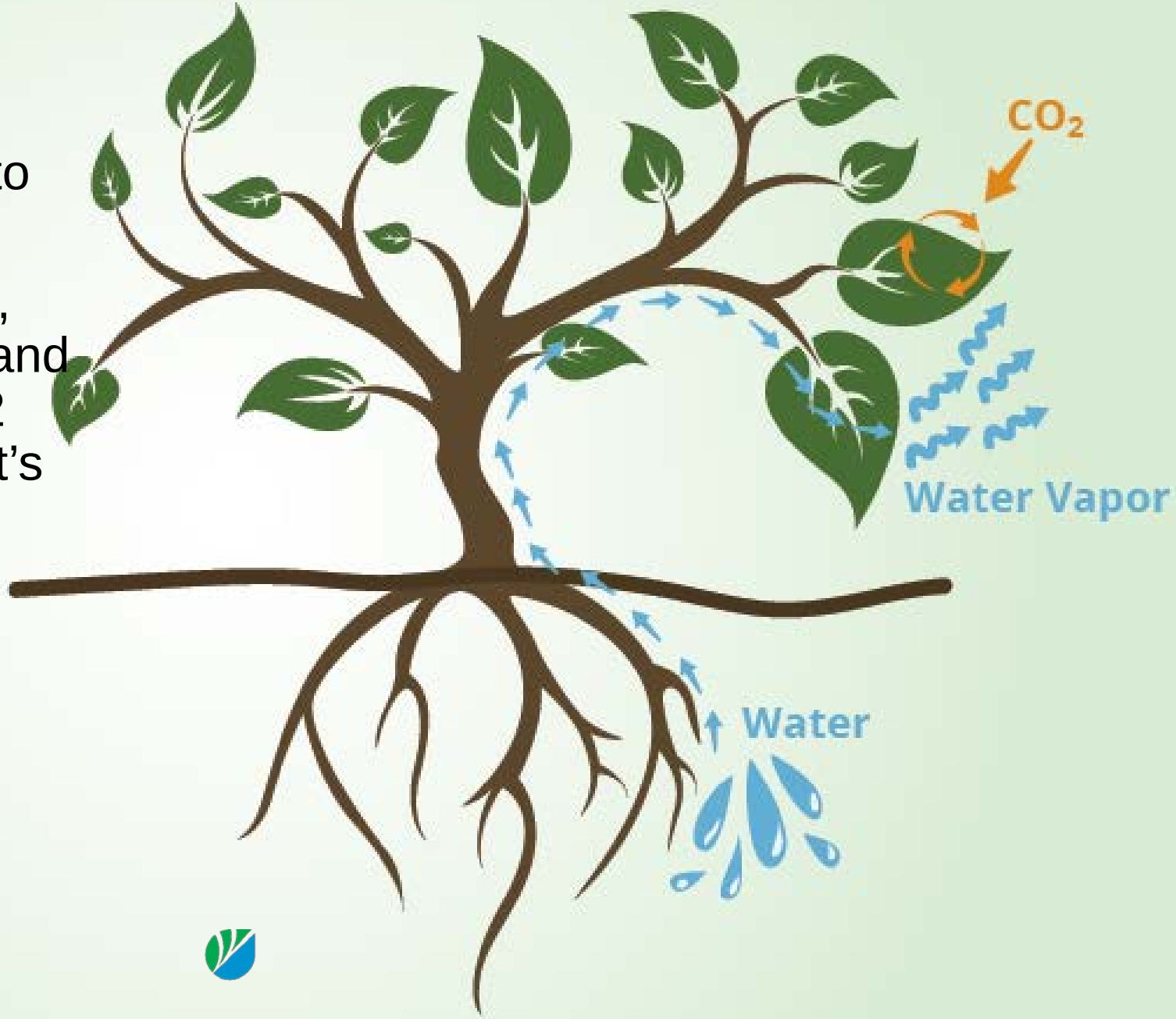
- When water becomes limited, the roots send signal to leaves to begin closing stomata

- **Water deficit “overrides” all other functions**



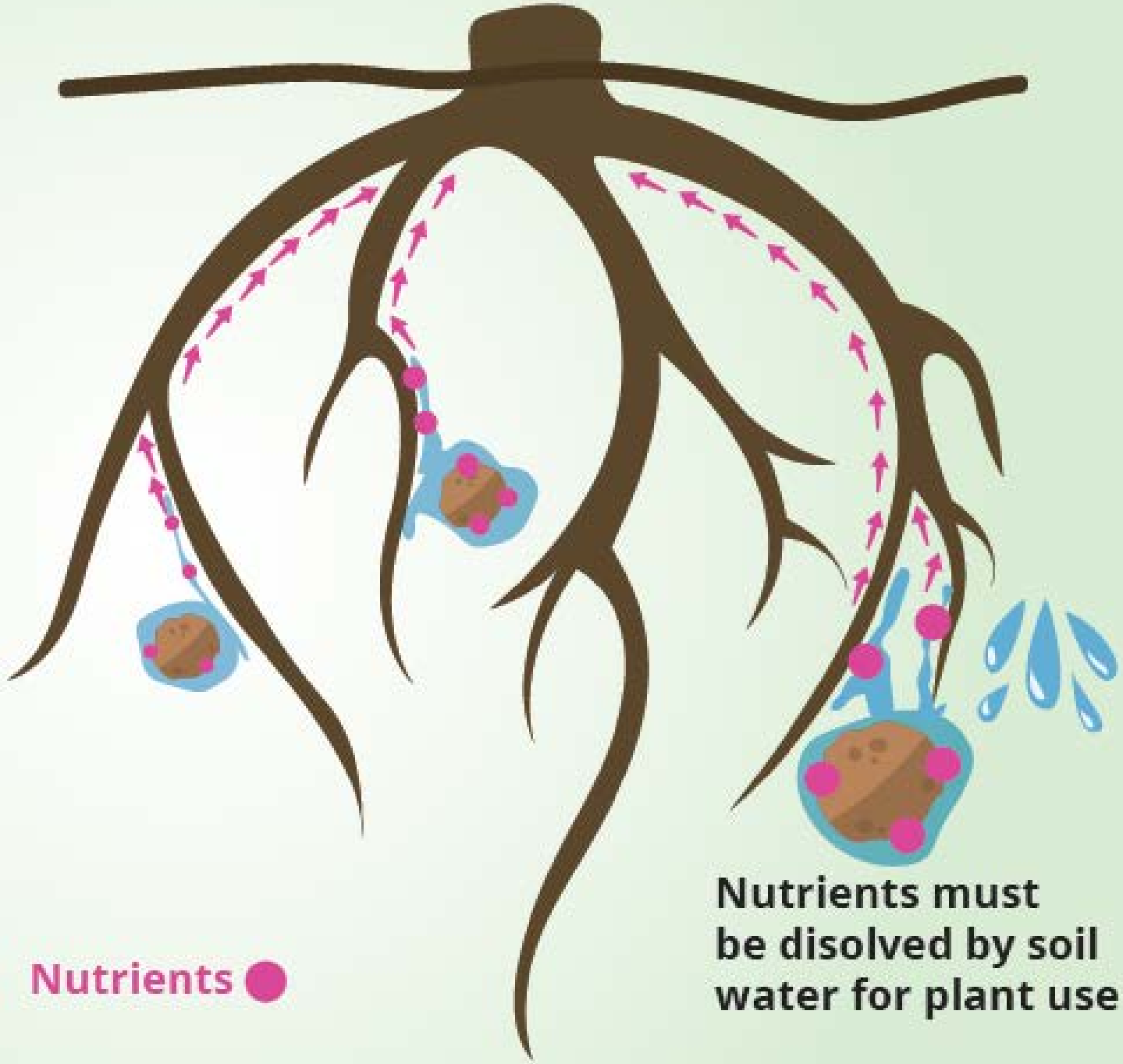
Stomatal Control

- Stomata’s function in relation to the whole system
- When water is freely available, water flows through the plant and through the stomata, and CO2 flows freely in to feed the plant’s factory

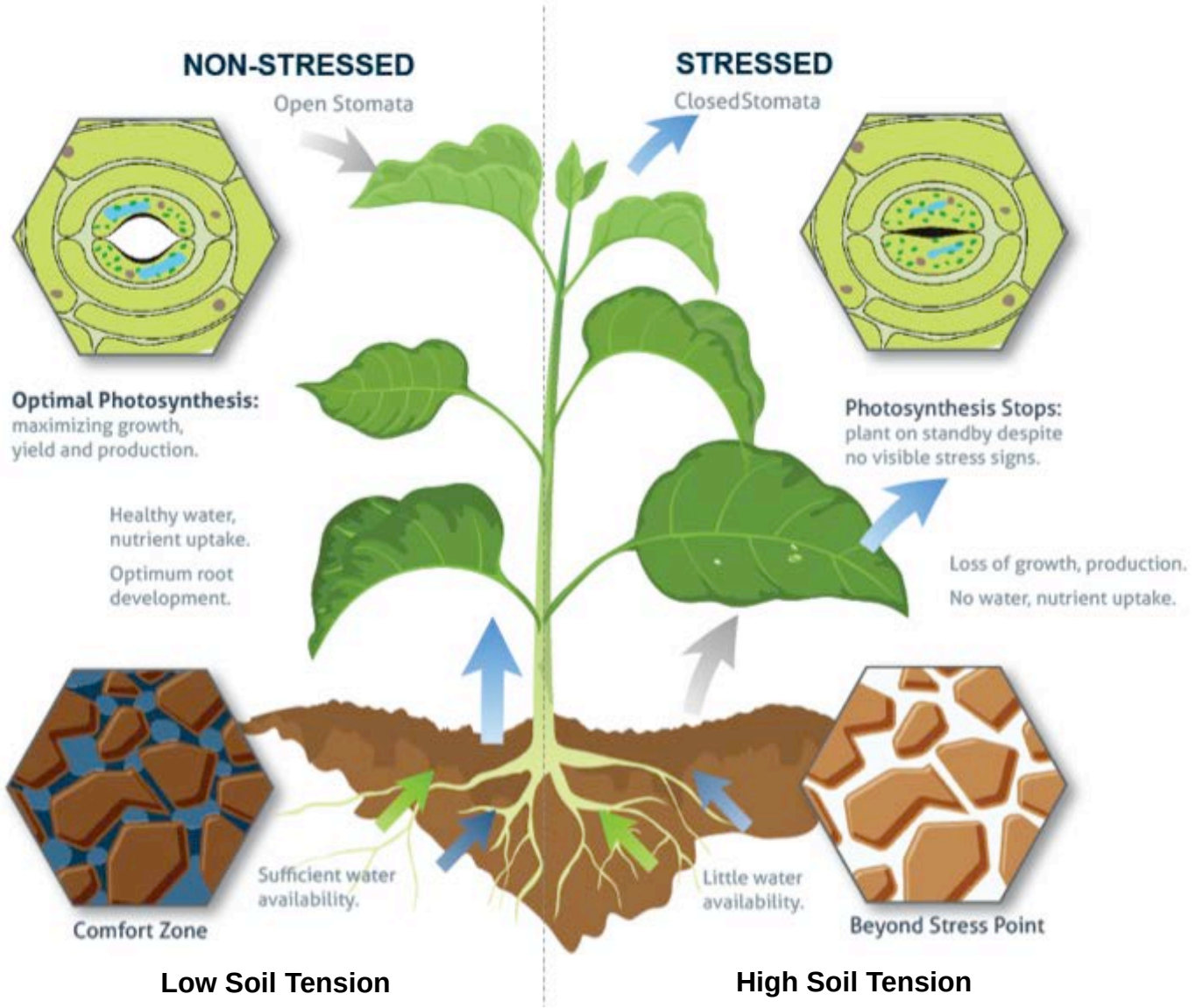


Nutrient Uptake

- Soil nutrients are dissolved or suspended in soil solution
- Soil solution carries nutrients into roots and through the plant (Mass Flow)
- Nutrient uptake does not occur from soil particle to plant



How? Measure and anticipate what matters most: soil tension



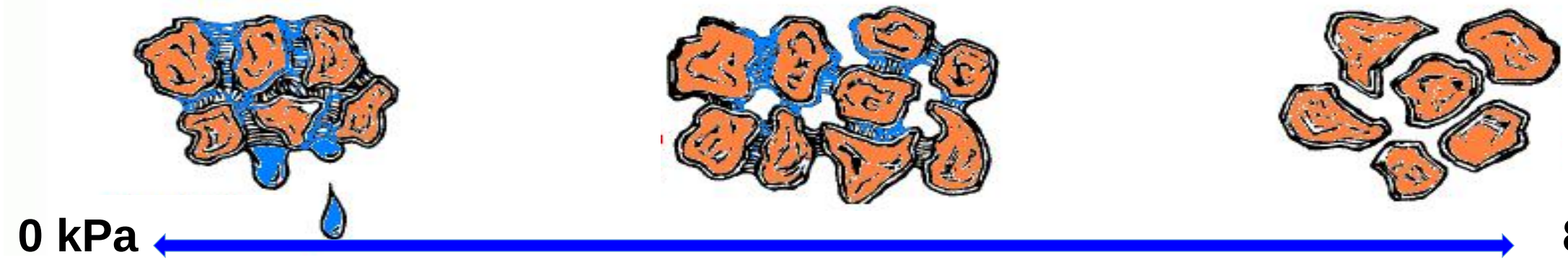
Soil tension is the proven way to measure **directly** and **accurately** plant stress. Hortau's technology allows growers to **maximize** their crop yield's potential by getting **real-time data**

The Right Measurement

Soil Tension

- How hard to pull water from soil
- Indicates plant needs
- Is the same, no matter the soil
  - No need to calibrate
- Reflects soil physical properties
  - Enables better management decisions

Tension Response Curve



0 kPa ⟷ 80 kPa

Ensure optimal growing conditions by staying within the comfort zone

What does 0 kPa look like?

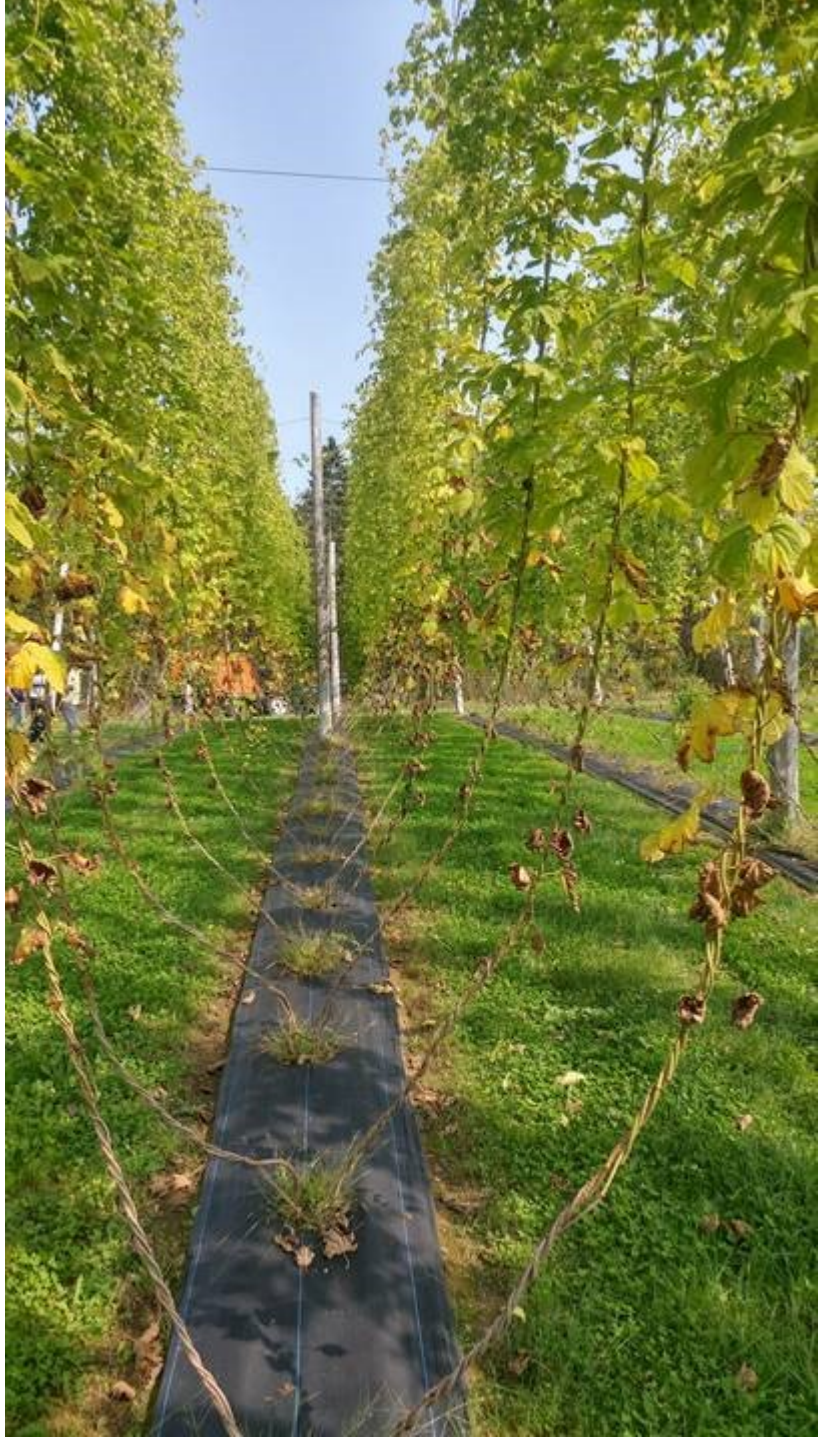
- All macro and micropores of the soil are full
- No oxygen is present
- Soil can not sustain this much water and will leach until back to field capacity
- **WE’VE MADE MUD**

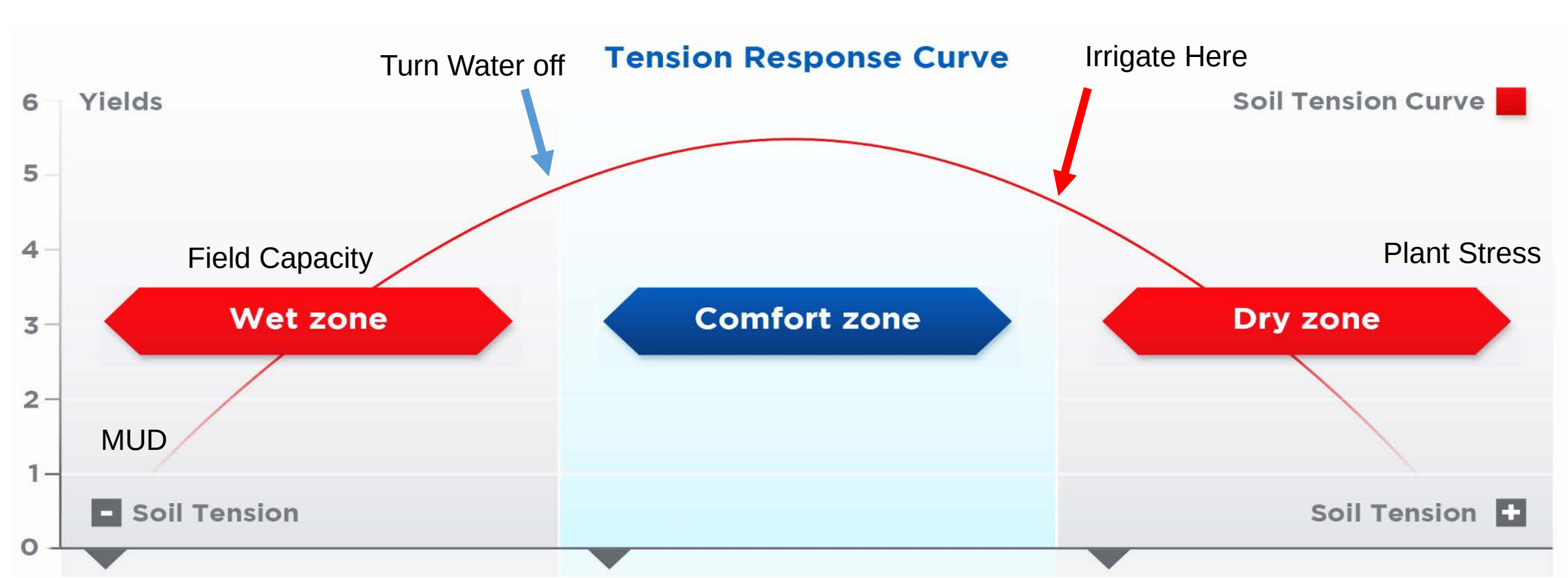
The Comfort Zone “The Blue Band”

- Good balance of available water and air for the roots
- Improved transpiration rates
- Improved nutritional uptake by the plant
- Improved photosynthesis
- **NO DOWN TIME**

How Dry is Too Dry?

Do we wait till we see plant stress?

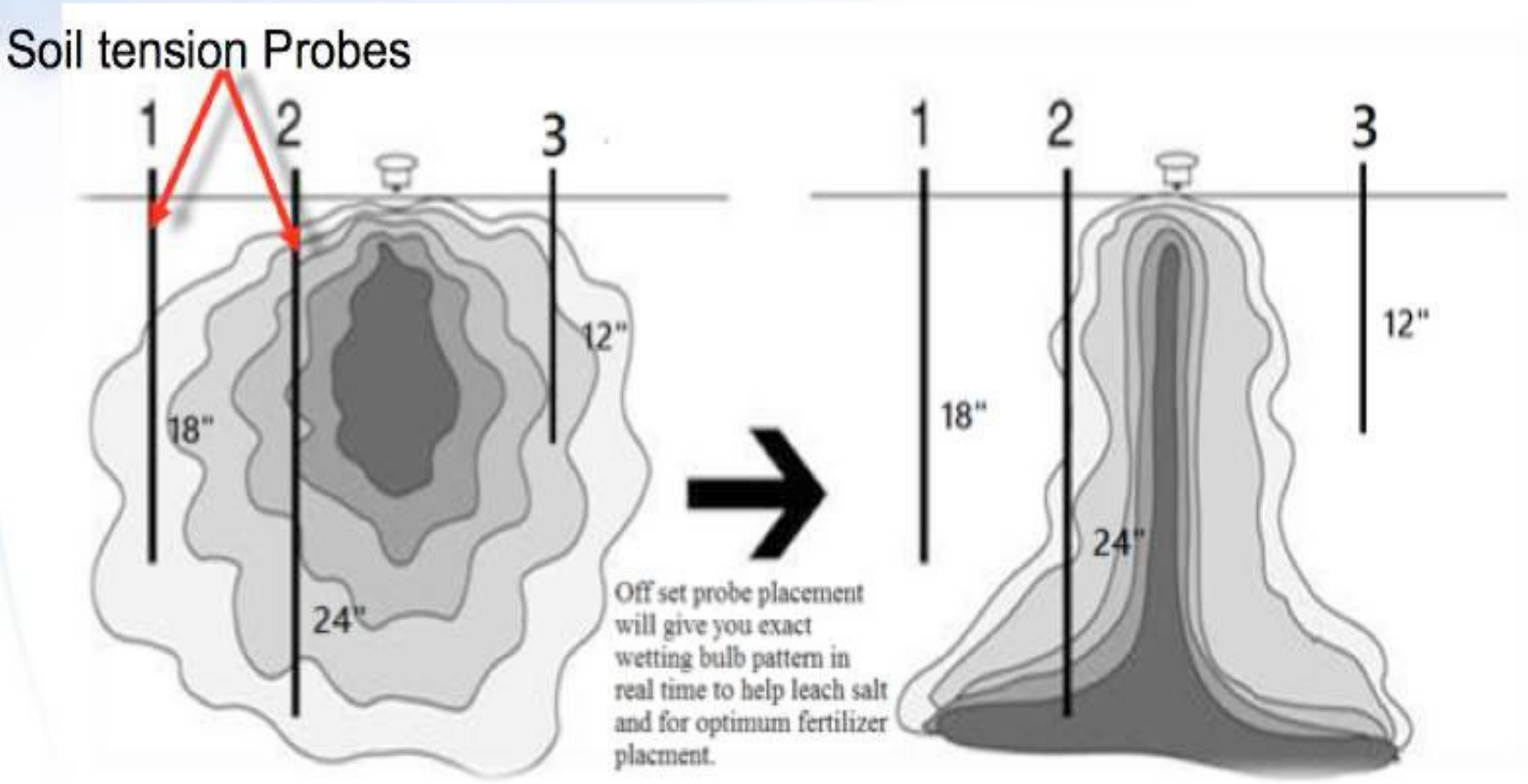




0 kPa ⟷ 80 kPa

Ensure optimal growing conditions by staying within the comfort zone

How Real Time Data is Used



Keys to Irrigation Management

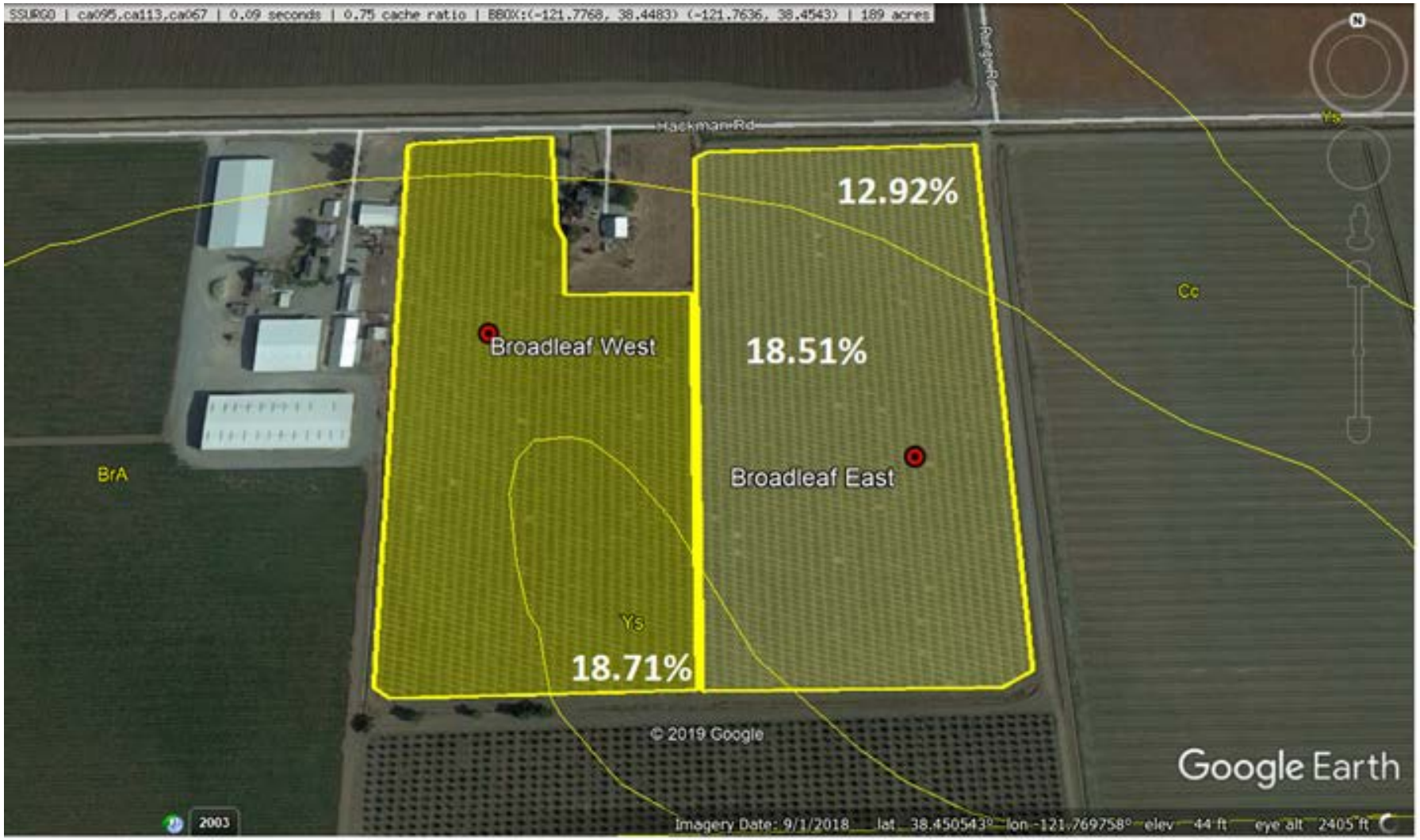
What are my **soils**?

What is my **pump capacity?**

What is my **application rate?**

What is my **water quality**?
-BMP for irrigation maintenance

What are my soils?

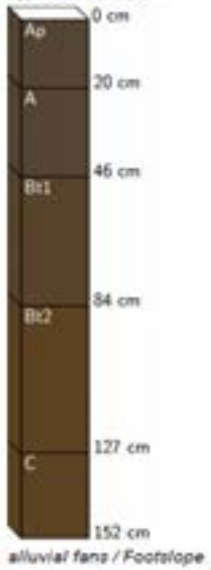


What are my soils?

Brentwood clay loam, 0 to 2 percent slopes (SSURGO Export 2019-09-16)

Components within map unit 456062

Brentwood (85%)
Typic Xerochrepts



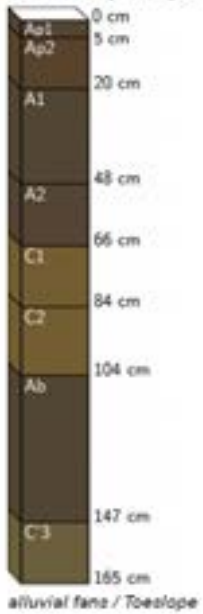
alluvial fans / Footslope

18.51% AWHC

Yolo silty clay loam, 0 to 2 percent slopes, MLRA 17 (SSURGO Export 2019-09-16)

Components within map unit 456139

Yolo (85%)
Fluventic Haploxerepts



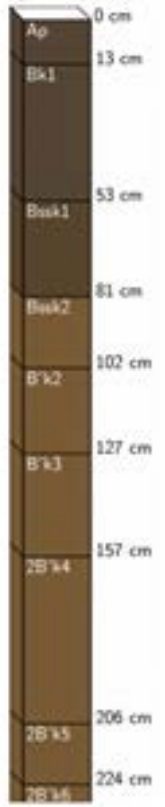
alluvial fans / Toeslope

18.71% AWHC

Capay clay, 0 percent slopes, MLRA 17 (SSURGO Export 2019-09-16)

Components within map unit 456065

Capay (85%)
Typic Haploxererts



12.92% AWHC

Plant Available Water (PAW)

Brentwood Clay Loam @ 2.22”/ft

Yolo Silt Clay Loam @ 2.25”/ft

Capay Clay @ 1.55”/ft

University Approach (% by volume)
AWHC(RZ) @ 100% = 6.66”
AWHC(RZ) @ 50% = 3.33”
AWHC(RZ) @ 25% = 1.667”

What is my application rate?

Irrigation System: 12’ Rows with double line drip
Emitter: 0.53 GPH w/ 24” spacing
-0.008833 GPM every 24”

$$\text{Application Rate (in/hr)} = \frac{96.3(0.008833\ \text{GPM})x2}{12' \times 2'} = 0.0708\text{”/hr}$$

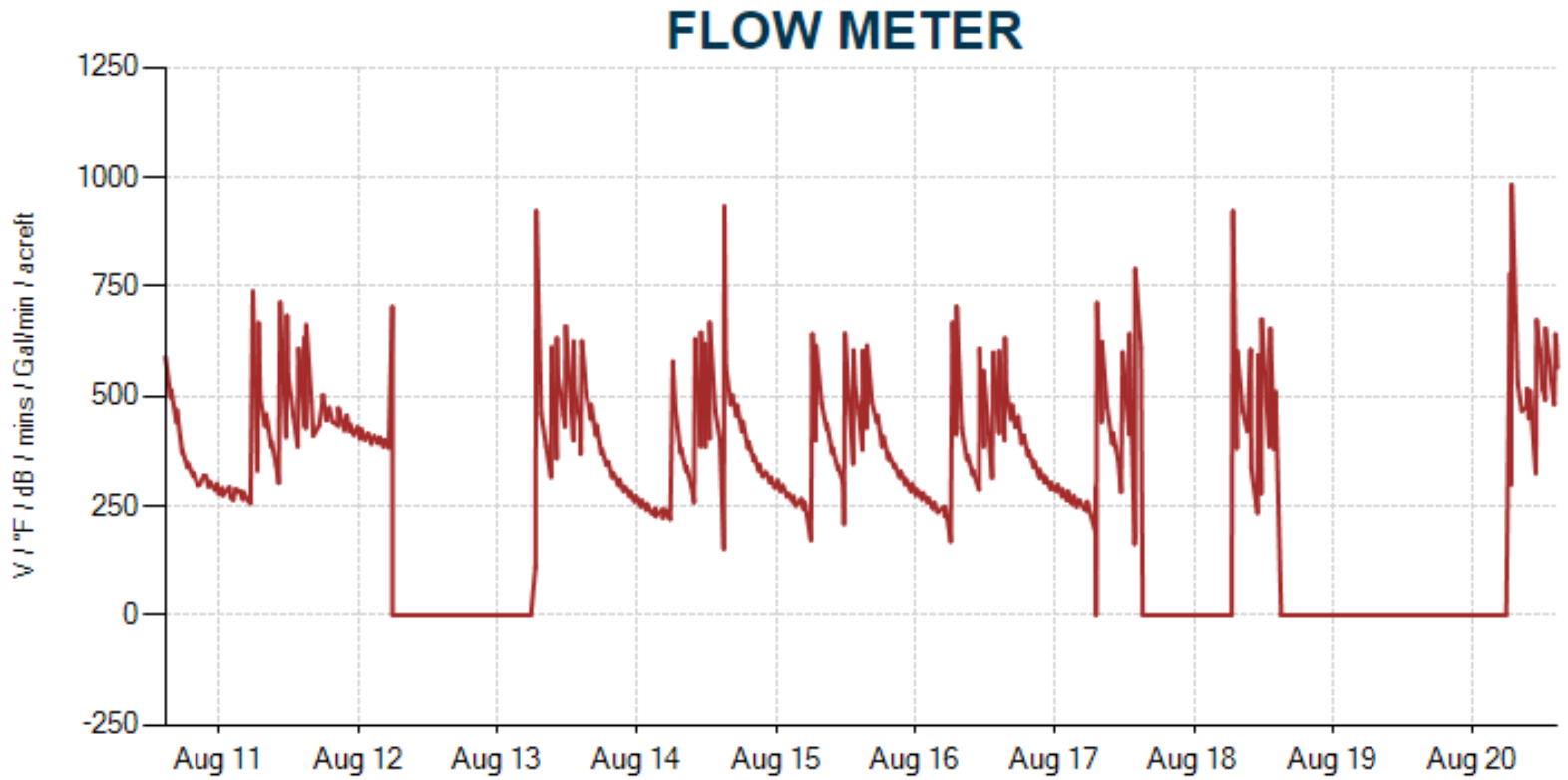
$$\text{GPM/ac} = \frac{0.00883\ \text{GPM} \times 2}{12' \times 2'} \times \frac{43560\ \text{sq. ft}}{1\ \text{ac}} = 32.05\ \text{GPM per acre}$$

West Irrigation Set @ 16.75 acres = 536 GPM

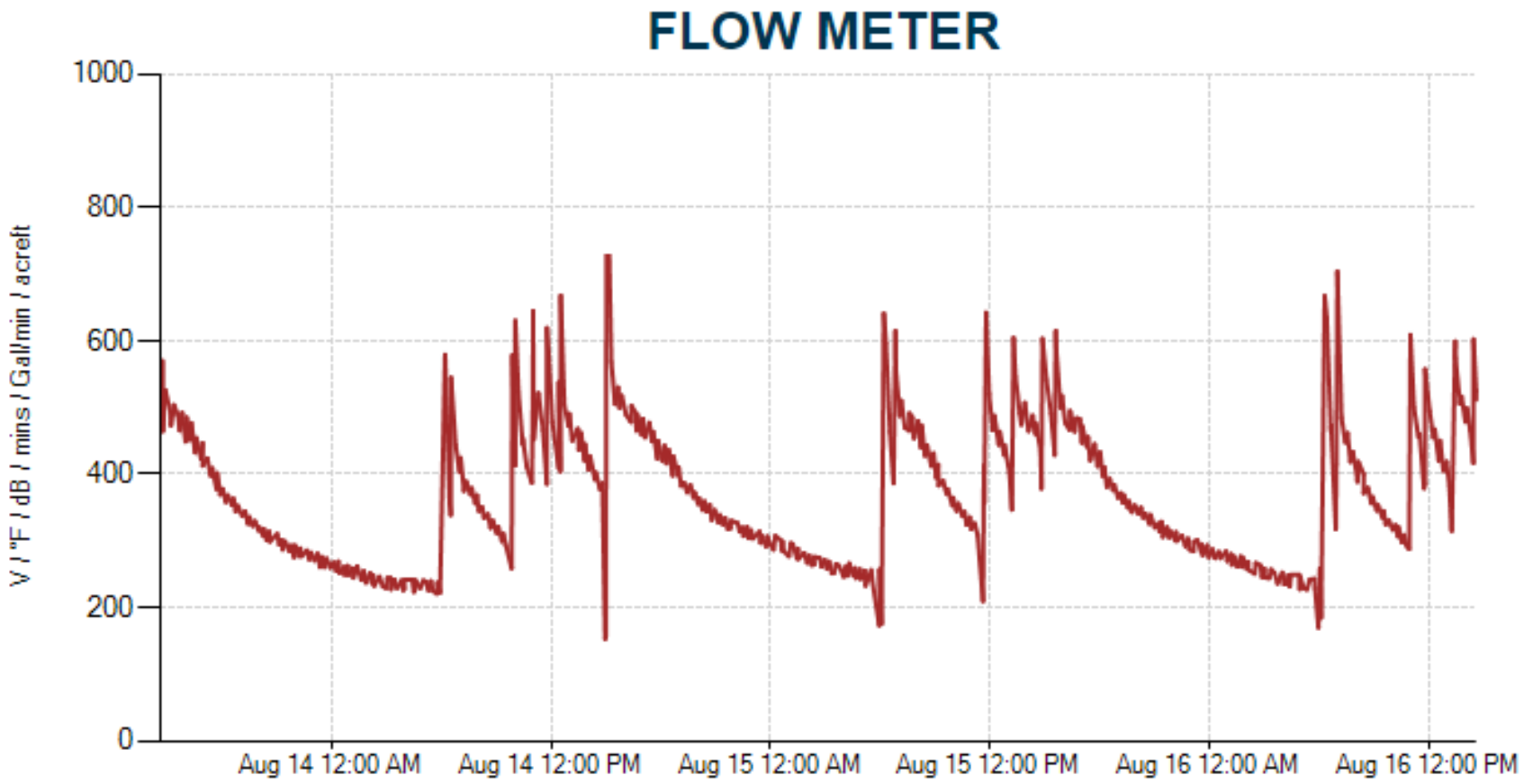
Easter Irrigation Set @ 17 acres = 544 GPM

Pump Output estimate: 600 GPM @ 40 psi

What is my pump capacity?



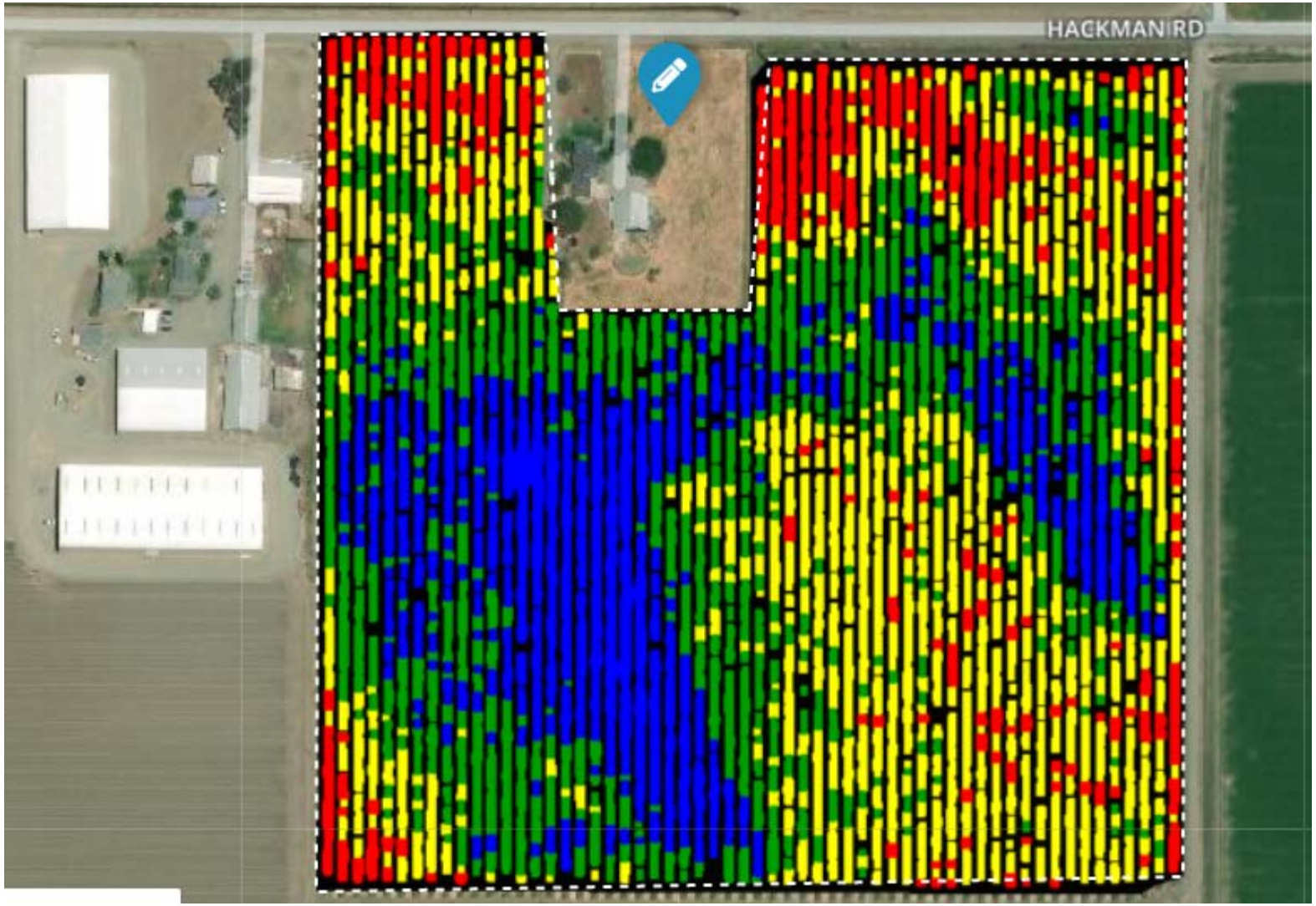
Can my filters keep up in the summer?



Flushing Irrigation Lines

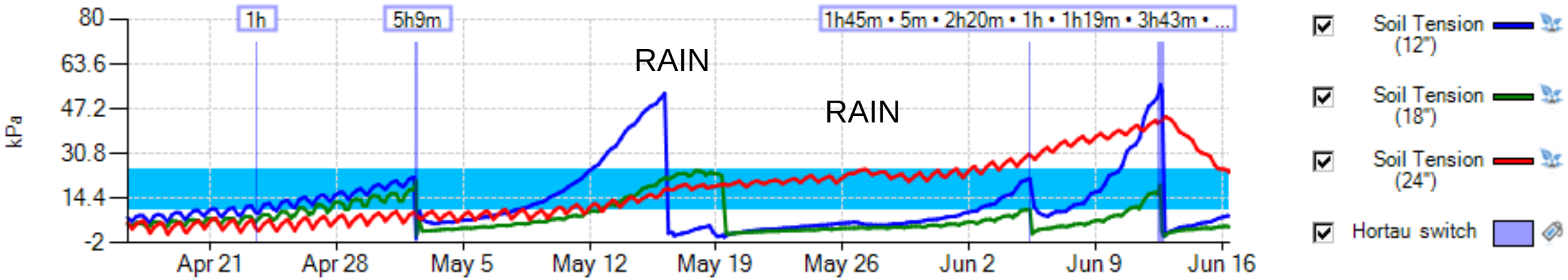
Distribution Uniformity is critical

Water Quality and irrigation efficiency



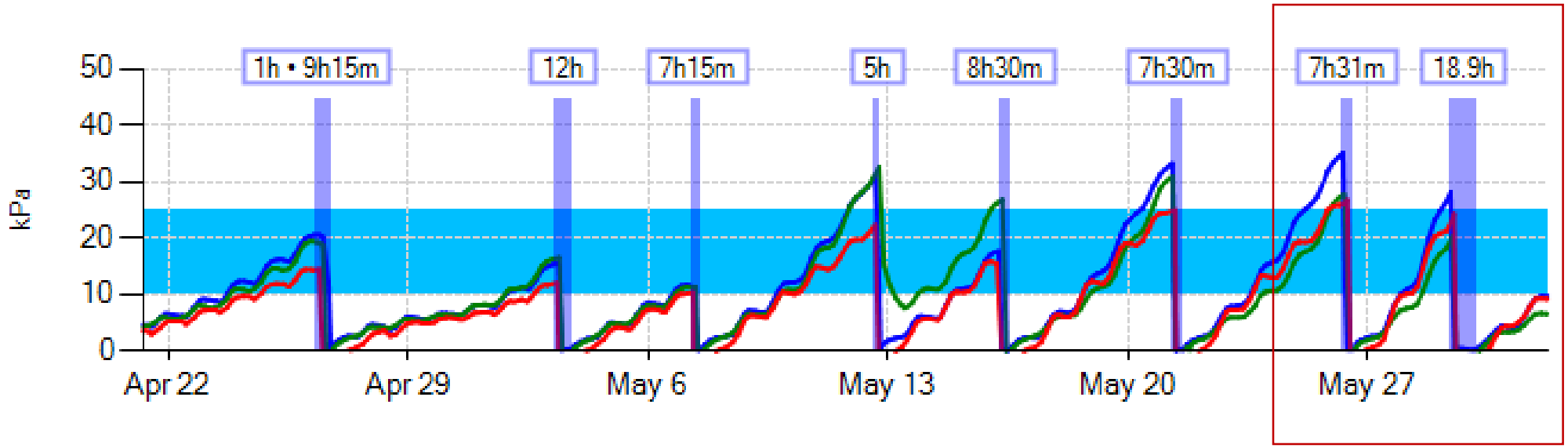
Early Vegetative Bine Regrowth

- Manage the root zone to optimize nutritional uptake (10 kPa to 20 kPa)
- Eliminate excessive watering to limit anaerobic downtime
- What's the weather forecast? (Irrigate or hold off)



April-June 2018

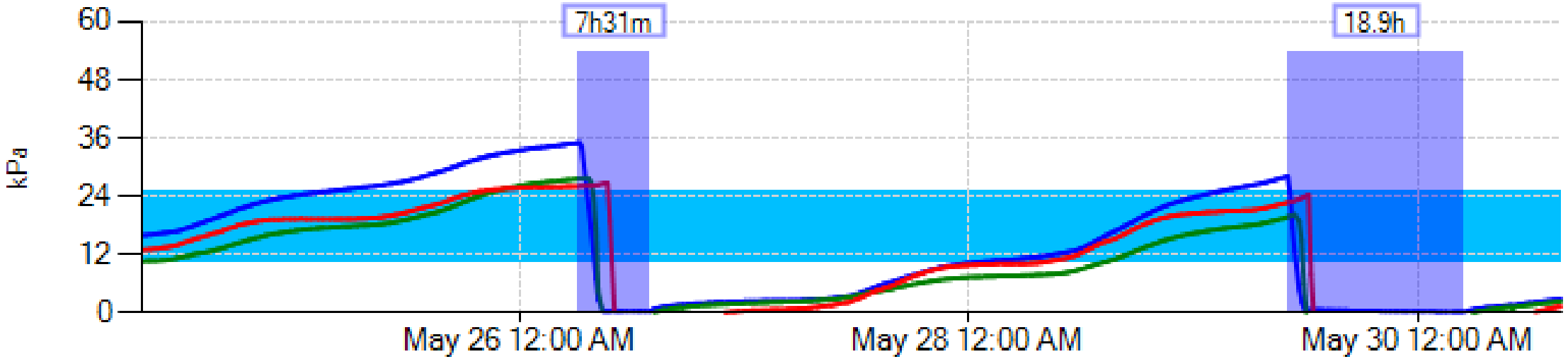
Not every year is the same

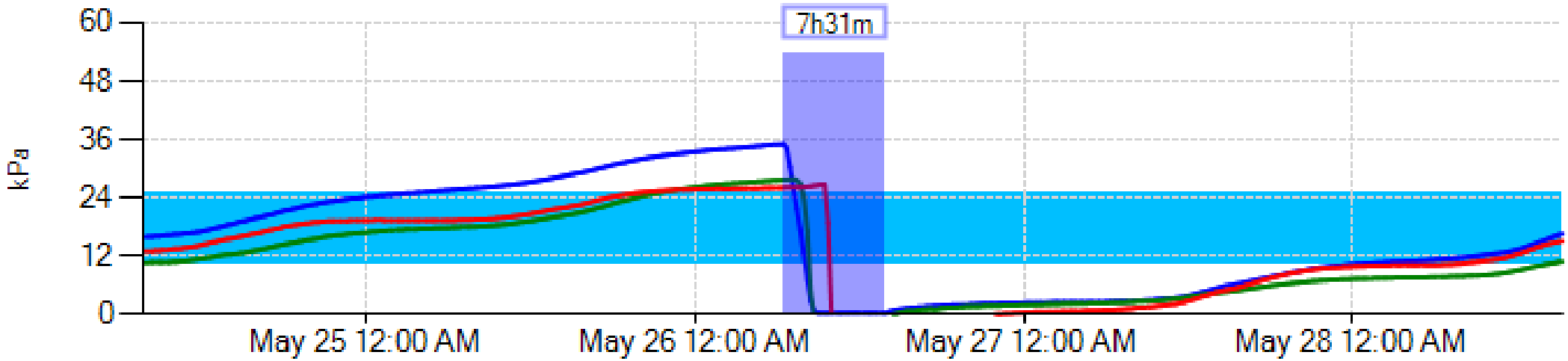


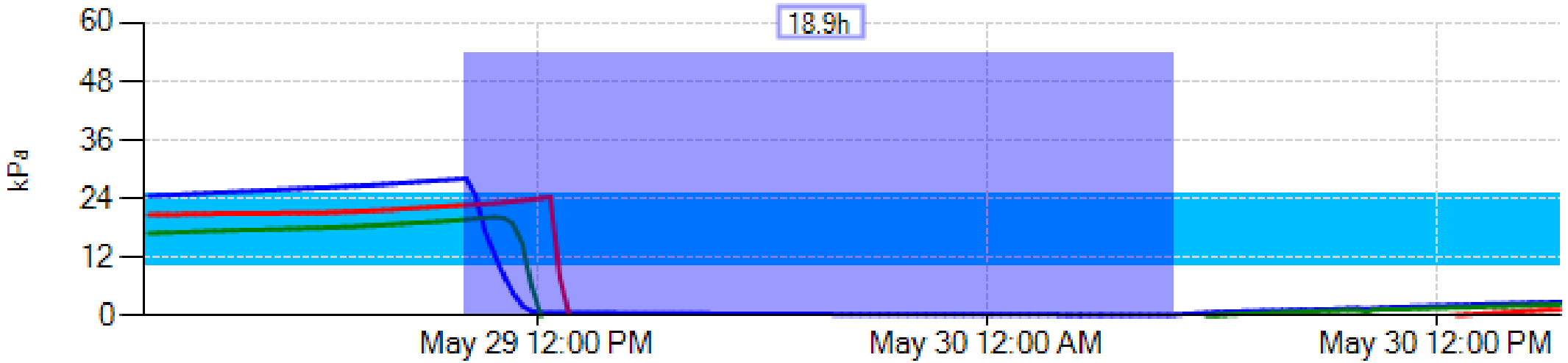
April-May 2019


as seen in IDIOCRACY
IT'S GOT ELECTROLYTES
BRAWNDO
THE THIRST MUTILATOR
BRAWNDO.COM

Fertigation: Where is my Nitrogen?



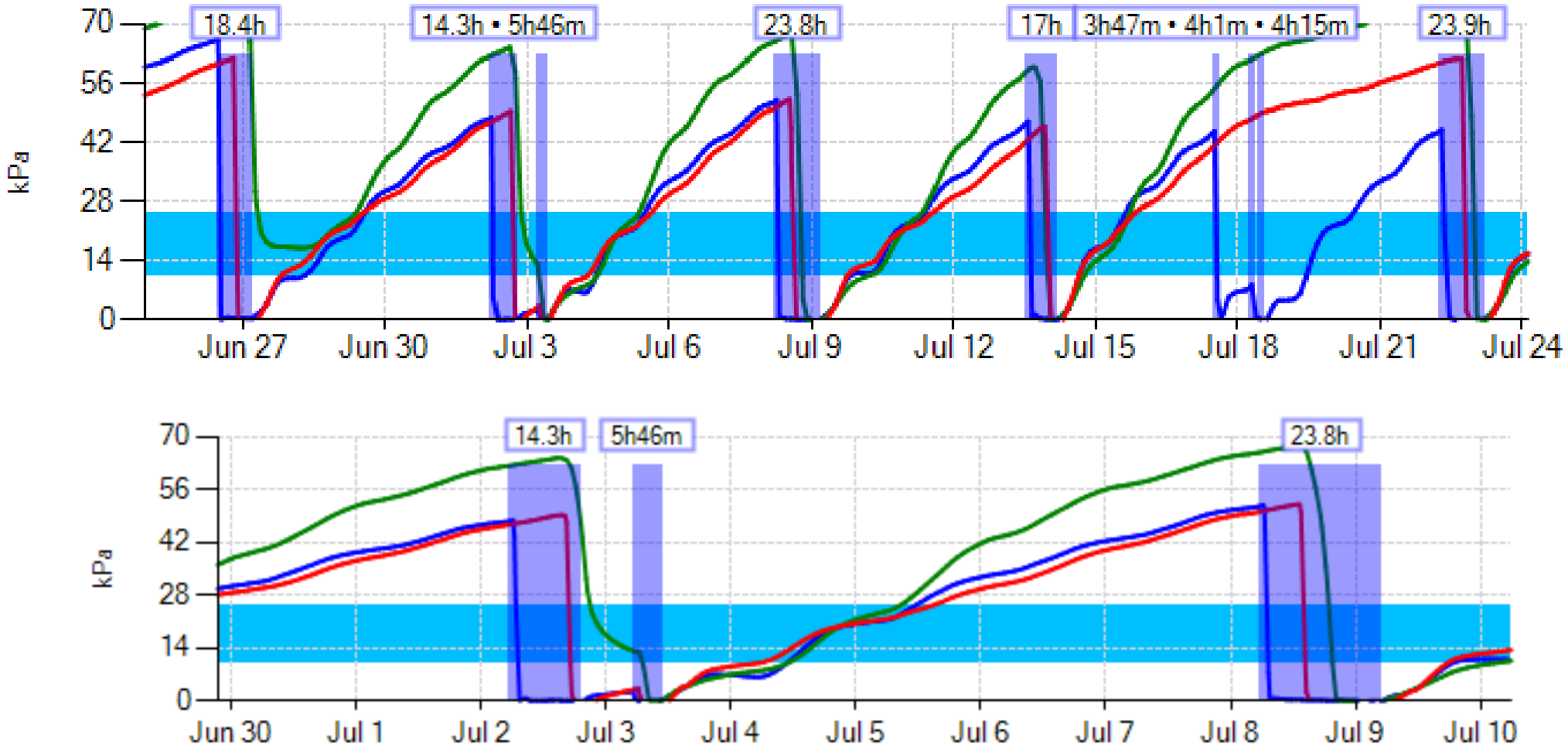

7h31m
60
48
36
24
12
0
kPa
May 25 12:00 AM
May 26 12:00 AM
May 27 12:00 AM
May 28 12:00 AM


18.9h
60
48
36
24
12
0
kPa
May 29 12:00 PM
May 30 12:00 AM
May 30 12:00 PM

jasonjessee

Vegetative (10-25 kPa)

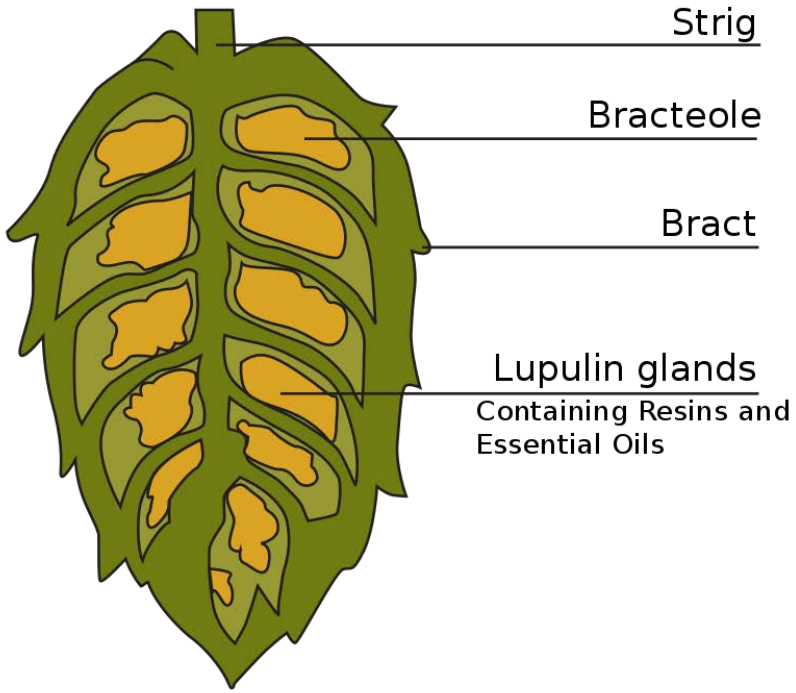
Vegetative Production (10-25 kPa)



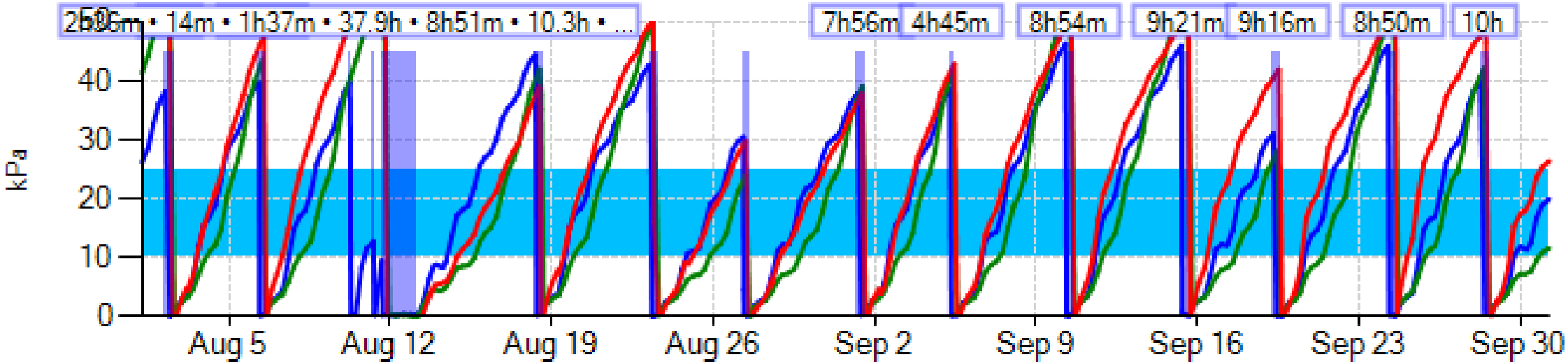
Flowers are expensive

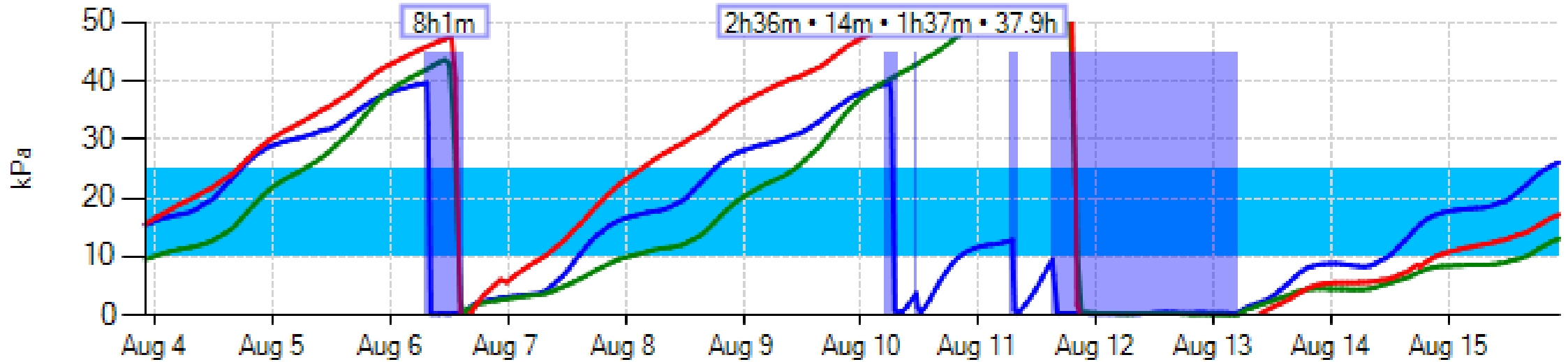
Flower Production (10-25 kPa)

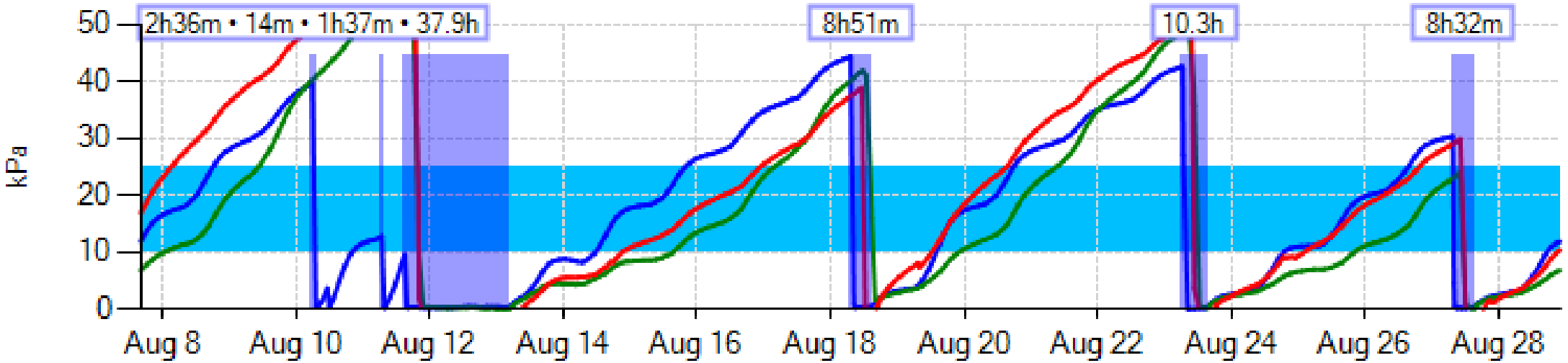
Minimize stress as much as possible



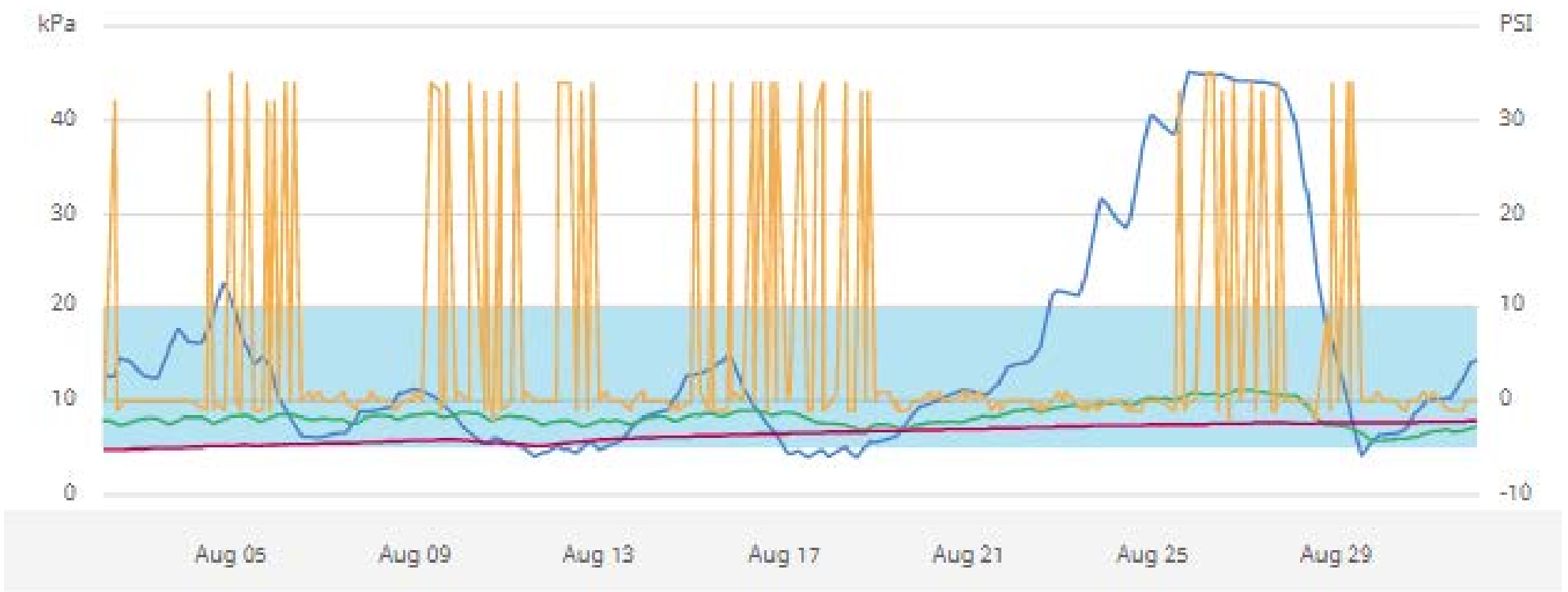
Flower Production (10-25 kPa)

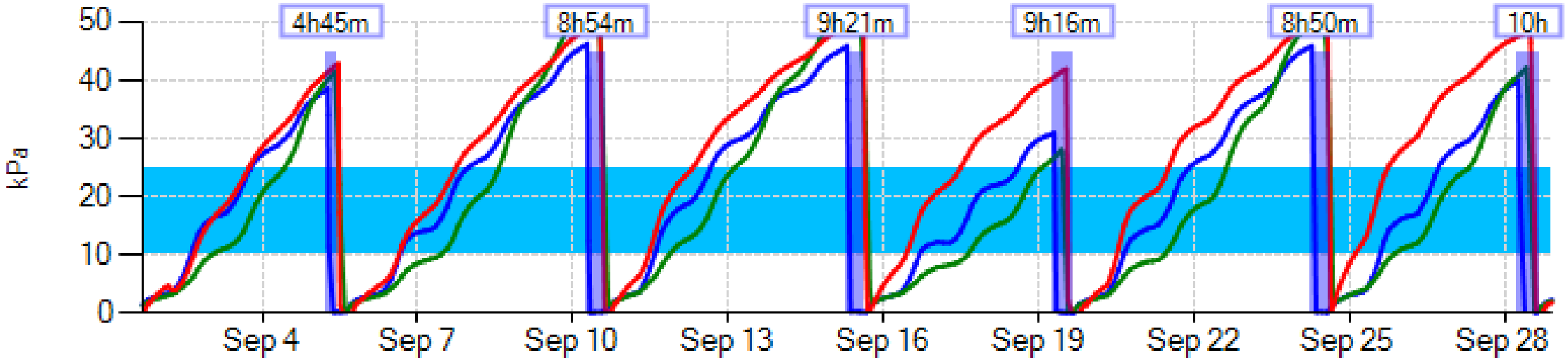


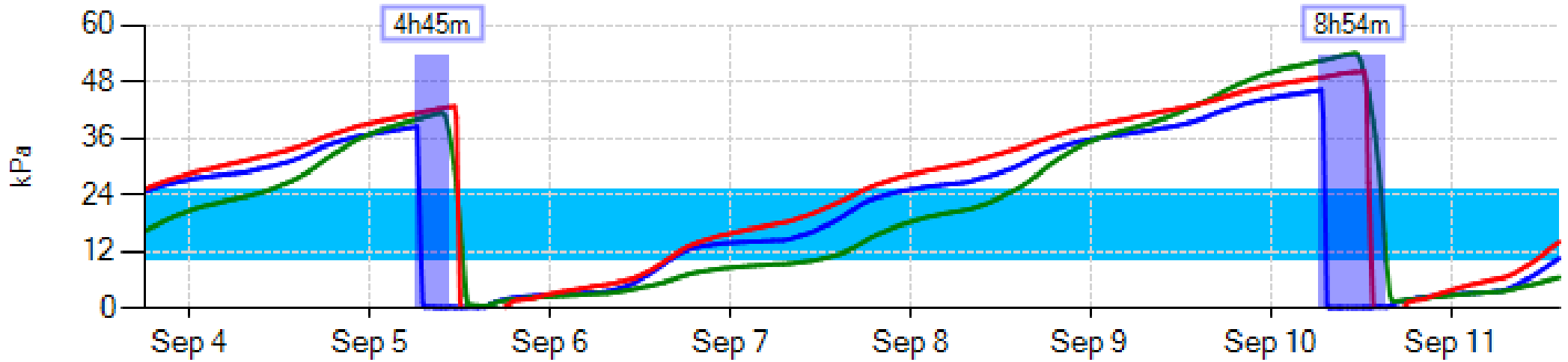

8h1m
2h36m • 14m • 1h37m • 37.9h
kPa
50
40
30
20
10
0
Aug 4
Aug 5
Aug 6
Aug 7
Aug 8
Aug 9
Aug 10
Aug 11
Aug 12
Aug 13
Aug 14
Aug 15


2h36m • 14m • 1h37m • 37.9h
8h51m
10.3h
8h32m
kPa
50
40
30
20
10
0
Aug 8
Aug 10
Aug 12
Aug 14
Aug 16
Aug 18
Aug 20
Aug 22
Aug 24
Aug 26
Aug 28

Pulse Irrigation through automation

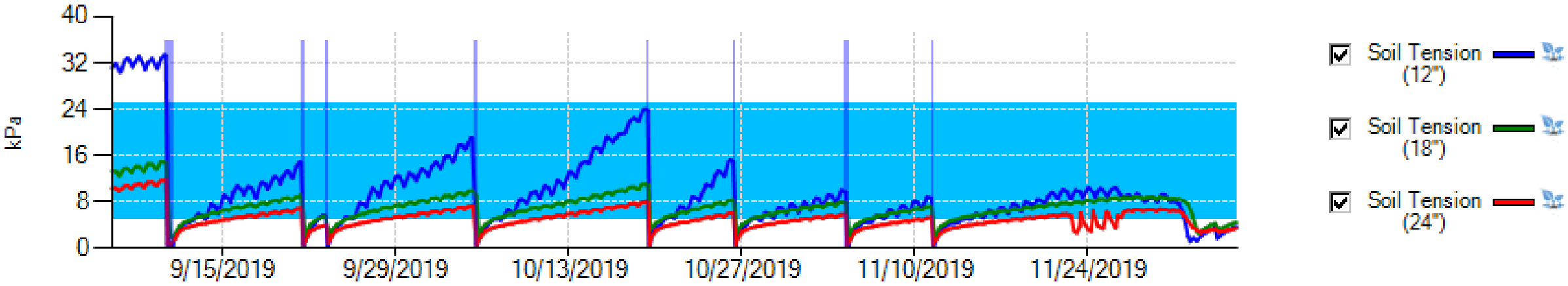



4h45m
8h54m
9h21m
9h16m
8h50m
10h
50
40
30
20
10
0
kPa
Sep 4
Sep 7
Sep 10
Sep 13
Sep 16
Sep 19
Sep 22
Sep 25
Sep 28

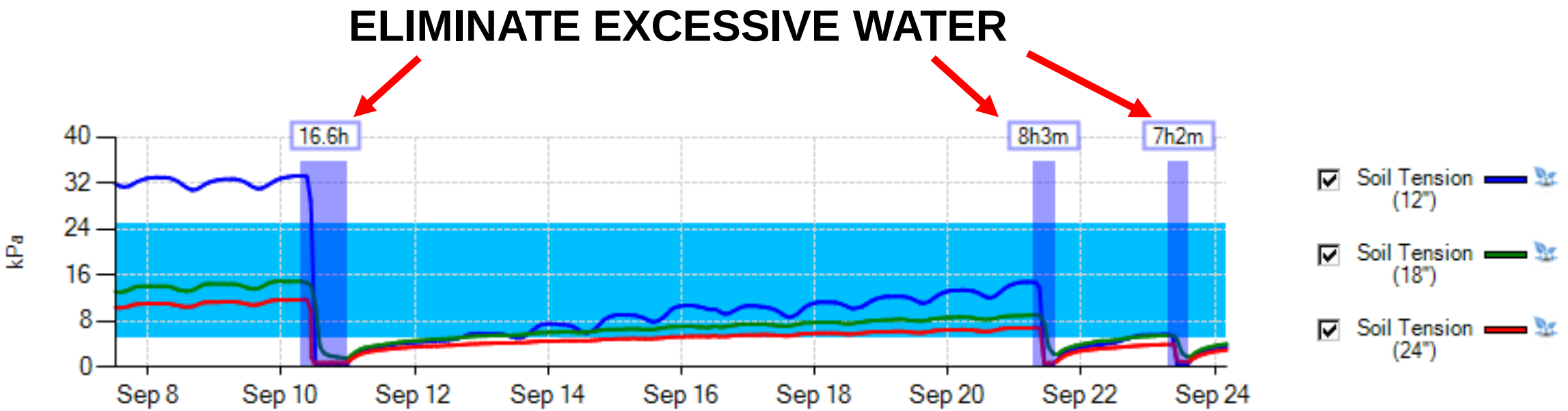

4h45m
8h54m
60
48
36
24
12
0
kPa
Sep 4
Sep 5
Sep 6
Sep 7
Sep 8
Sep 9
Sep 10
Sep 11

Post Harvest Irrigation Management

- Manage the root zone to optimize carbohydrate sequestration and root flush (10 kPa to 25 kPa)
- Eliminate excessive watering and leaching fractions until dormancy

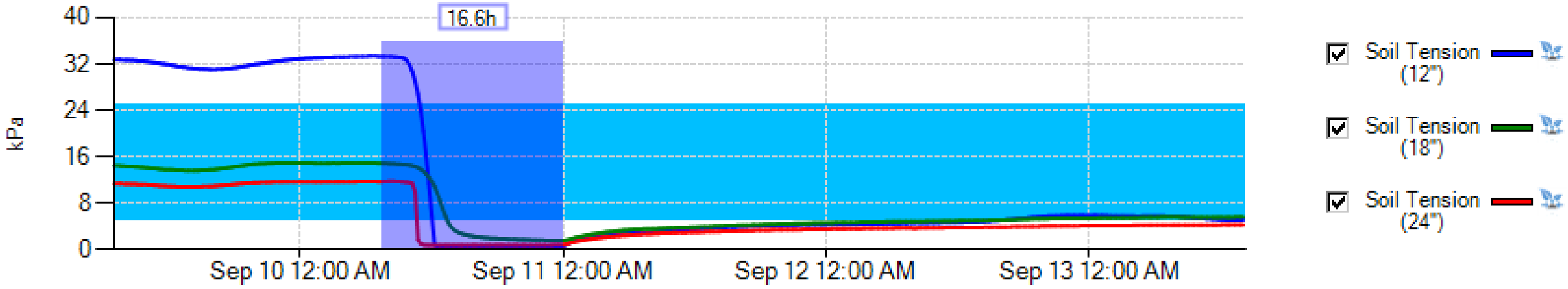


Post Harvest Irrigation Strategy

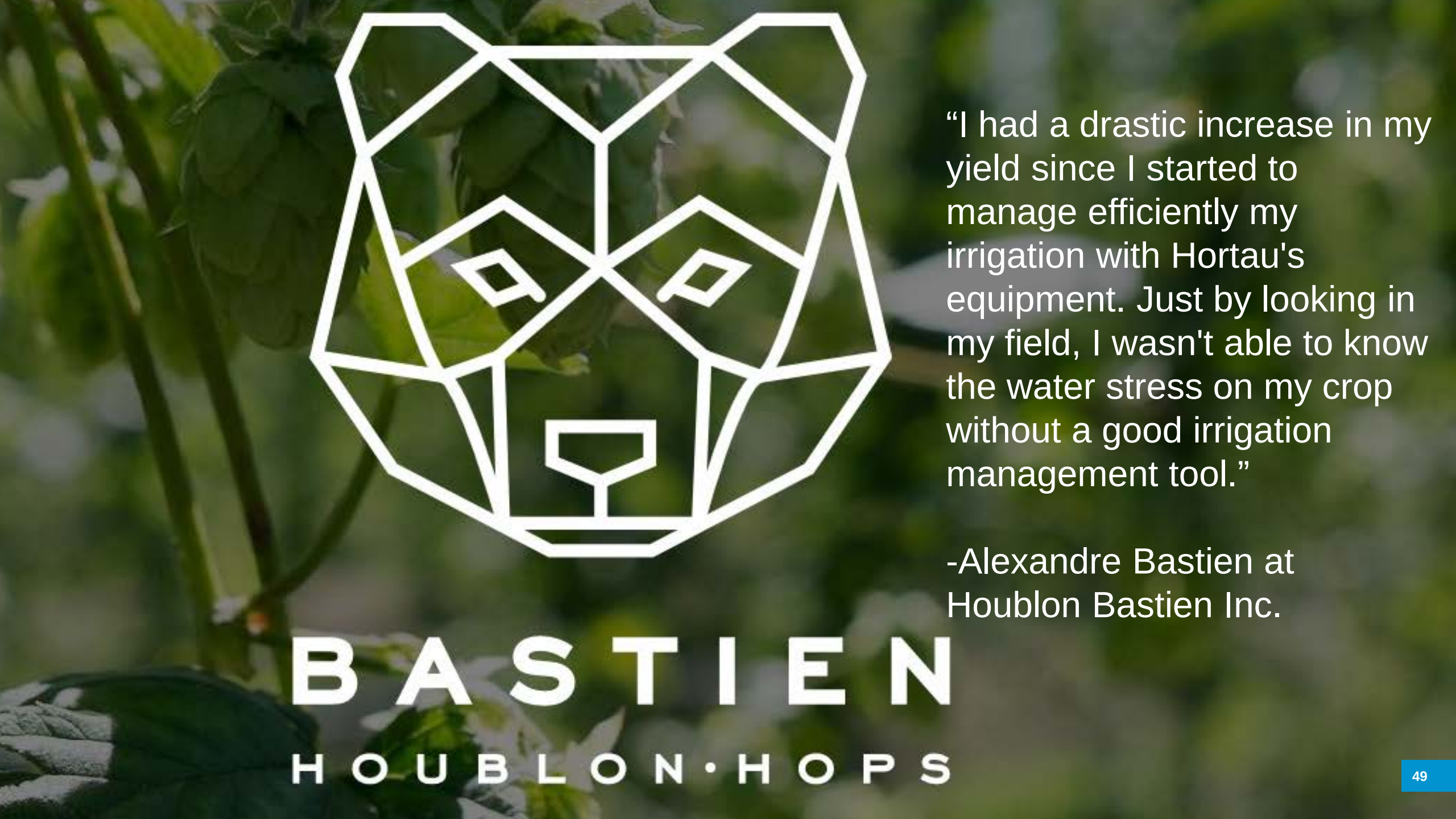


1st Irrigation after harvest

100% soil rehydration @ 7 hours



25% Depletion estimate by grower with ET @ 1.667”
AR @ 0.071”/hr
Wetting Pattern AR @ 0.107”/hr
Total water applied: 16.6 hrs x 0.107”/hr = 1.77” of water
Hortau Projection @ 7 hours = 0.75” of water
Root zone was overwatered by 1” of water



“I had a drastic increase in my yield since I started to manage efficiently my irrigation with Hortau's equipment. Just by looking in my field, I wasn't able to know the water stress on my crop without a good irrigation management tool.”

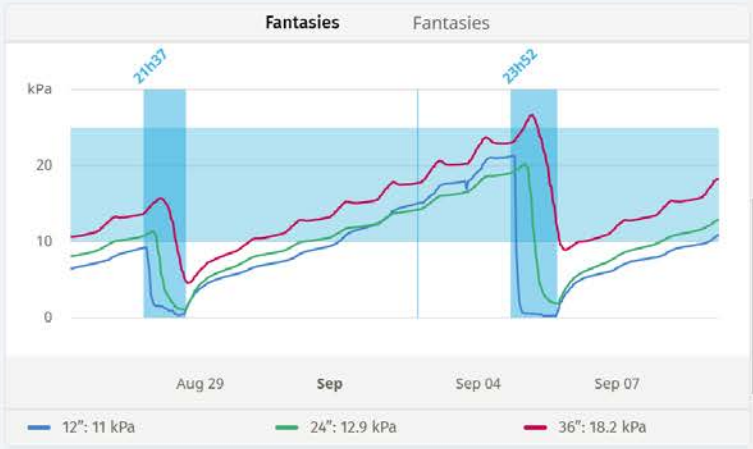
-Alexandre Bastien at Houblon Bastien Inc.

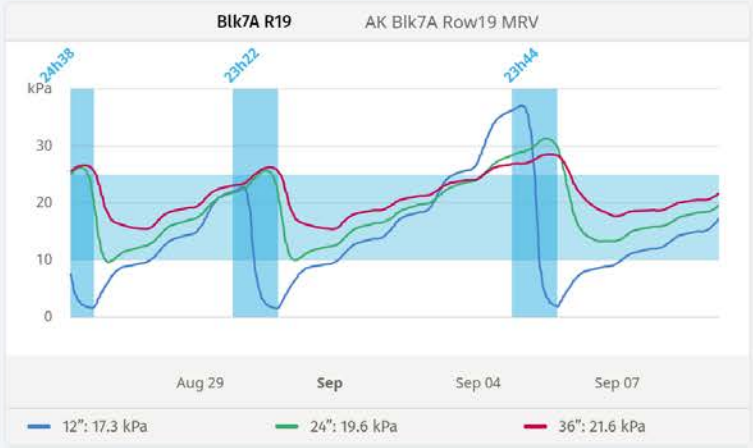
RMV / Schedule

1 WEEK | 2 WEEKS | 1 MONTH

WEEK VIEW | DAY VIEW

Advanced Mode

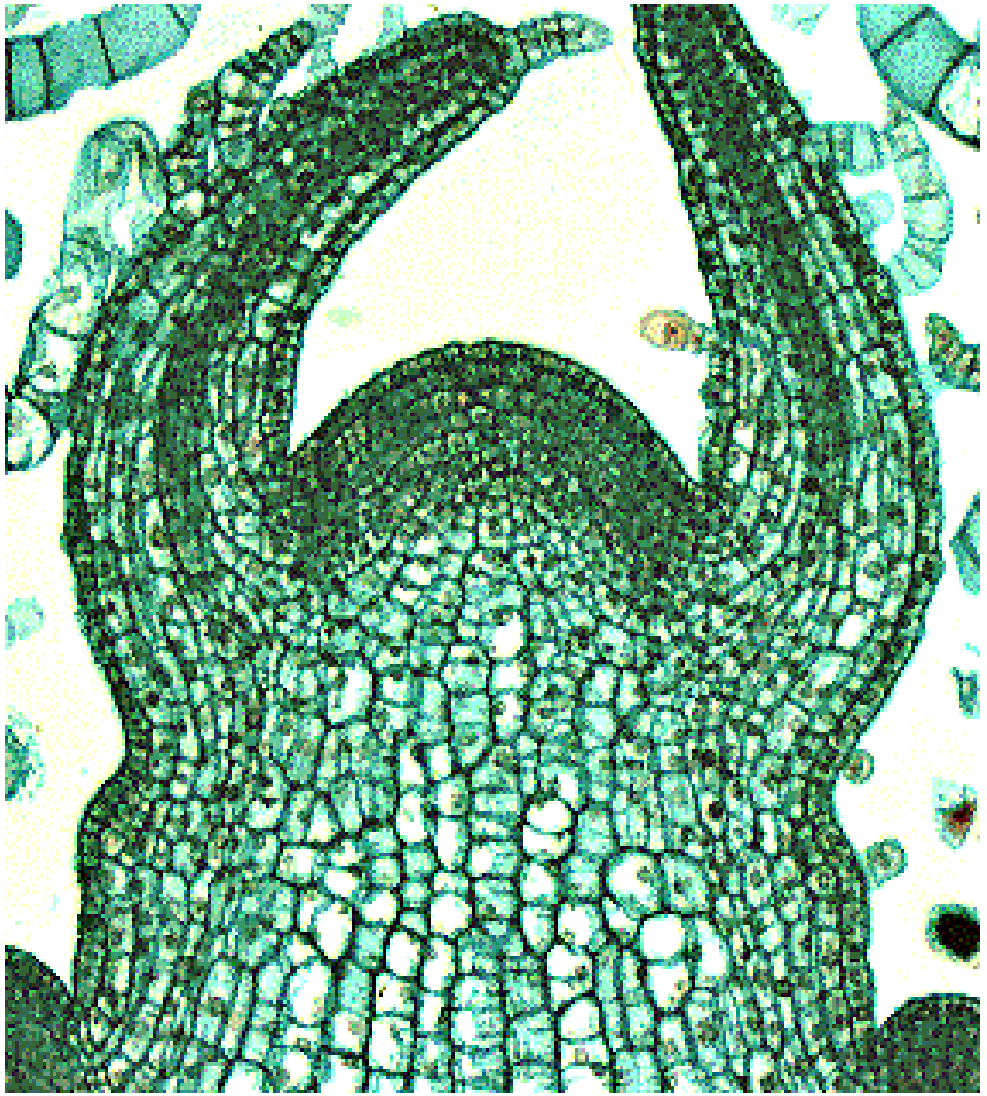




SCHEDULE
9 Sep - 15 Sep

Name	M 9	T 10	W 11	T 12	F 13	S 14	S 15	NOTES
Thompson Blk 3A — Blk 3 A	3h56		16h			16h		
AK Blk5A Row77 MRV — AK B5 AR77			16h			16h		
Fantasies — Fantasies			16h			16h		
AK Blk7A Row19 MRV — Blk7A R19		18h					18h	
AK Blk7B Row71 MRV — AK B7 BR71		18h					18h	
SR Blk1B Row30 MRV — SRB1B R30		18h					18h	

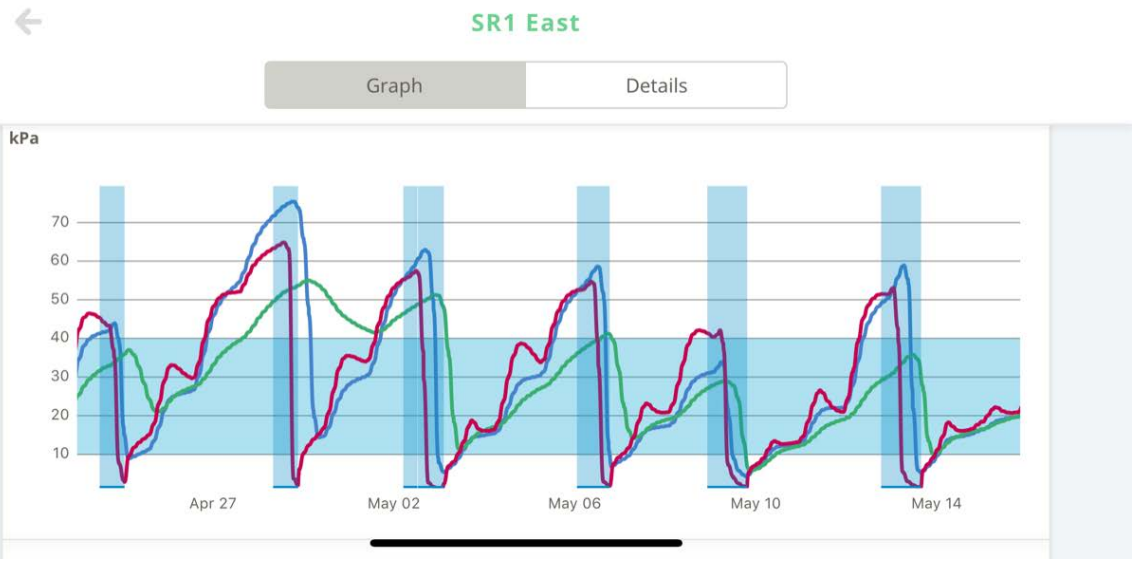
- Cells are created in meristem and nowhere else
- Most plant growth in size and mass is due to enlargement of existing cells.
- After a fruit passes from the meristem, it contains all of the cells it will ever have.



http://preuniversity.grkraj.org/html/3_PLANT_ANATOMY_files/image002.gif

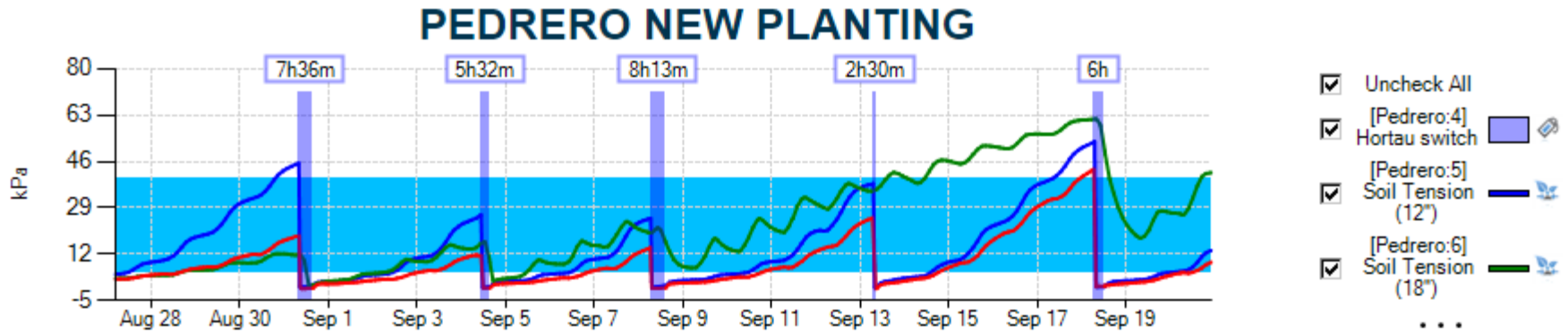
Unadvised

Advised



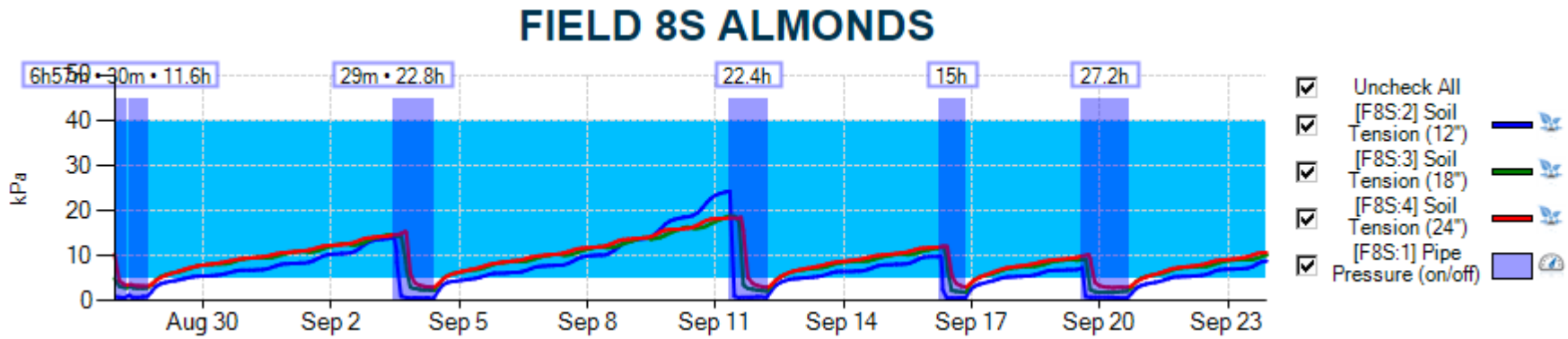
1st Year Tree Research in Nonpareil Almonds

High Compliance

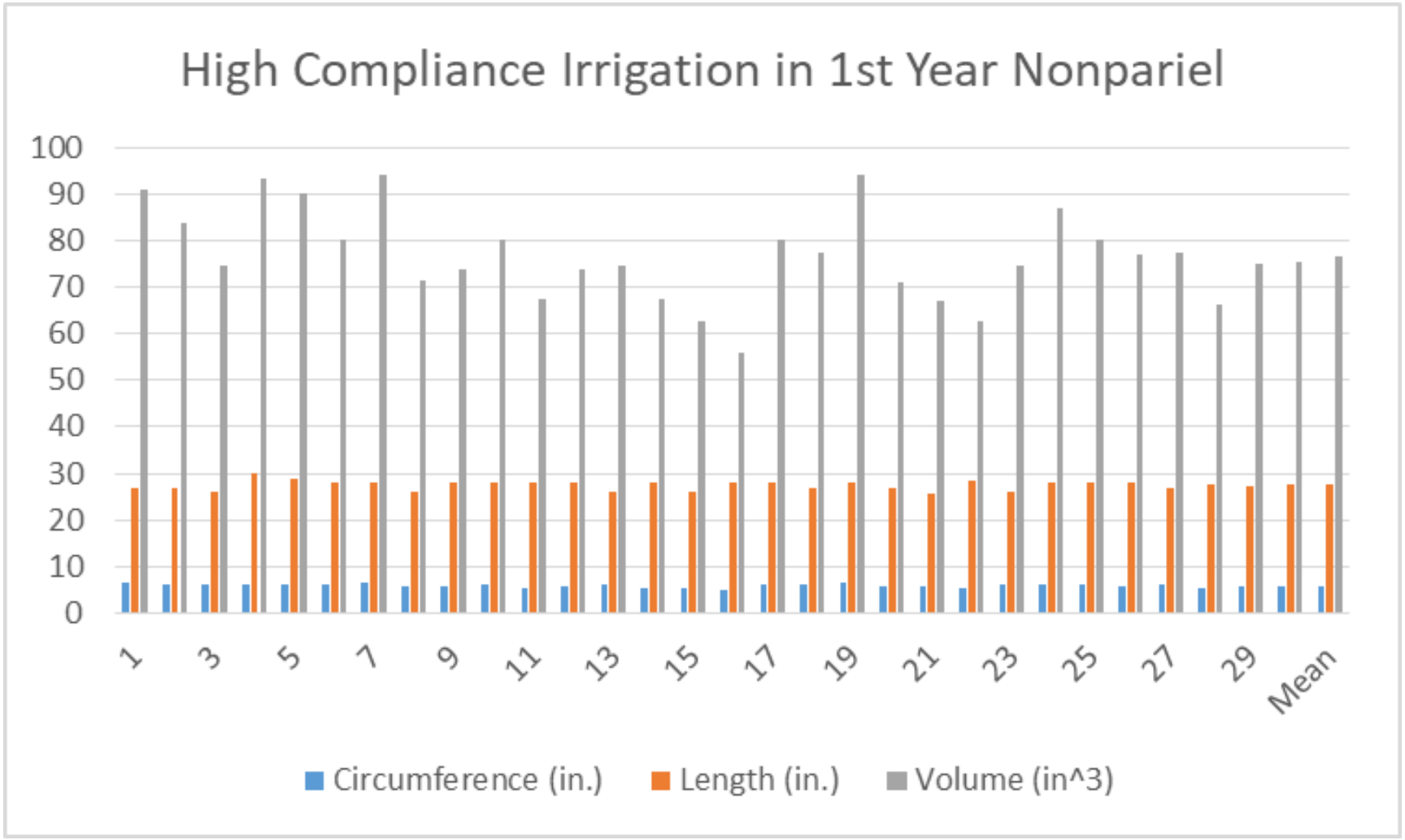


VS

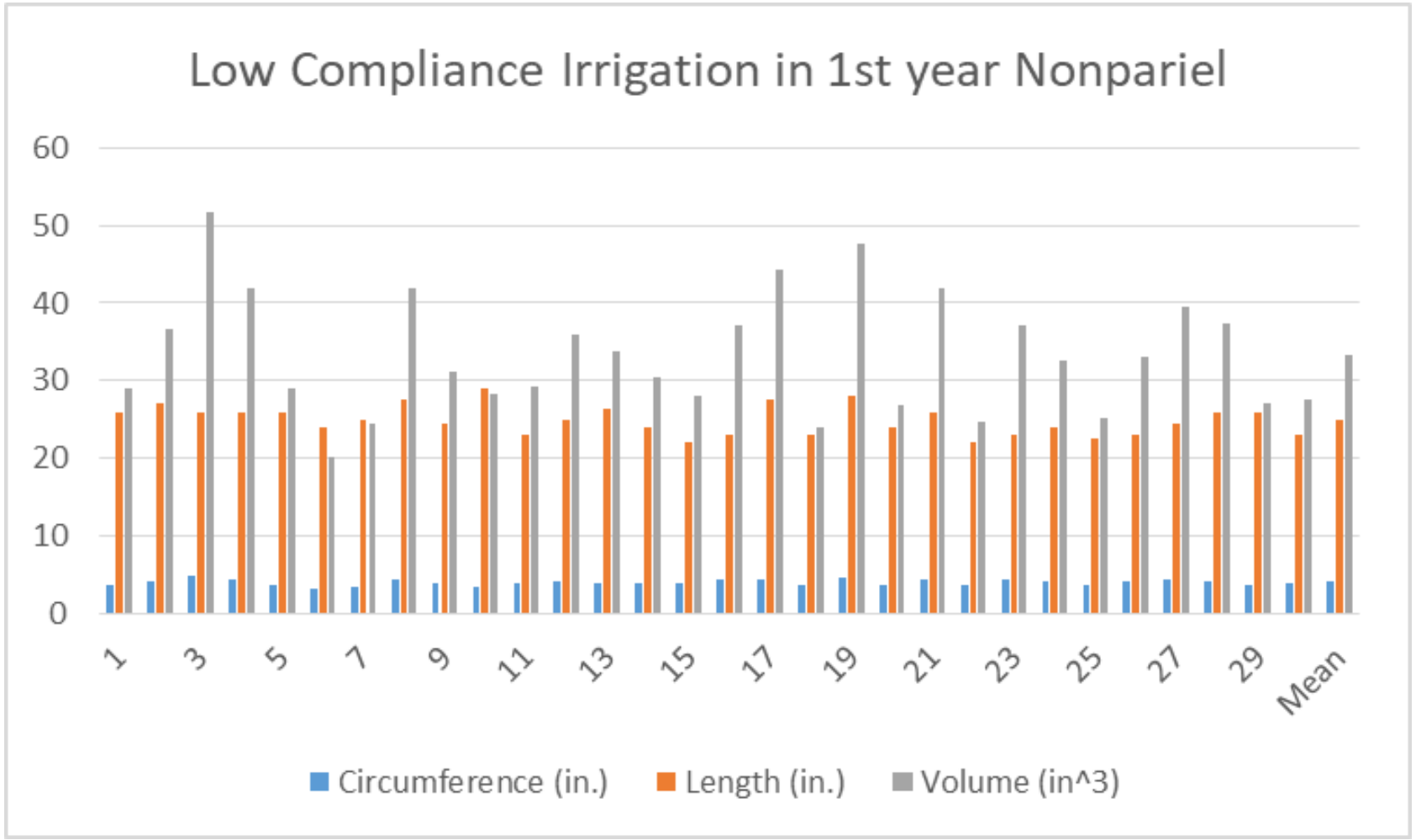
Low Compliance



High Compliance



Low Compliance



	Circumference (in.)	Length (in.)	Volume (in^3)
High Compliance Ranch (NP)	5.91	27.48	76.61
Low Compliance Ranch (NP)	4.07	24.90	33.25
% Increase in High Compliance Ranch	45%	10.40%	130%

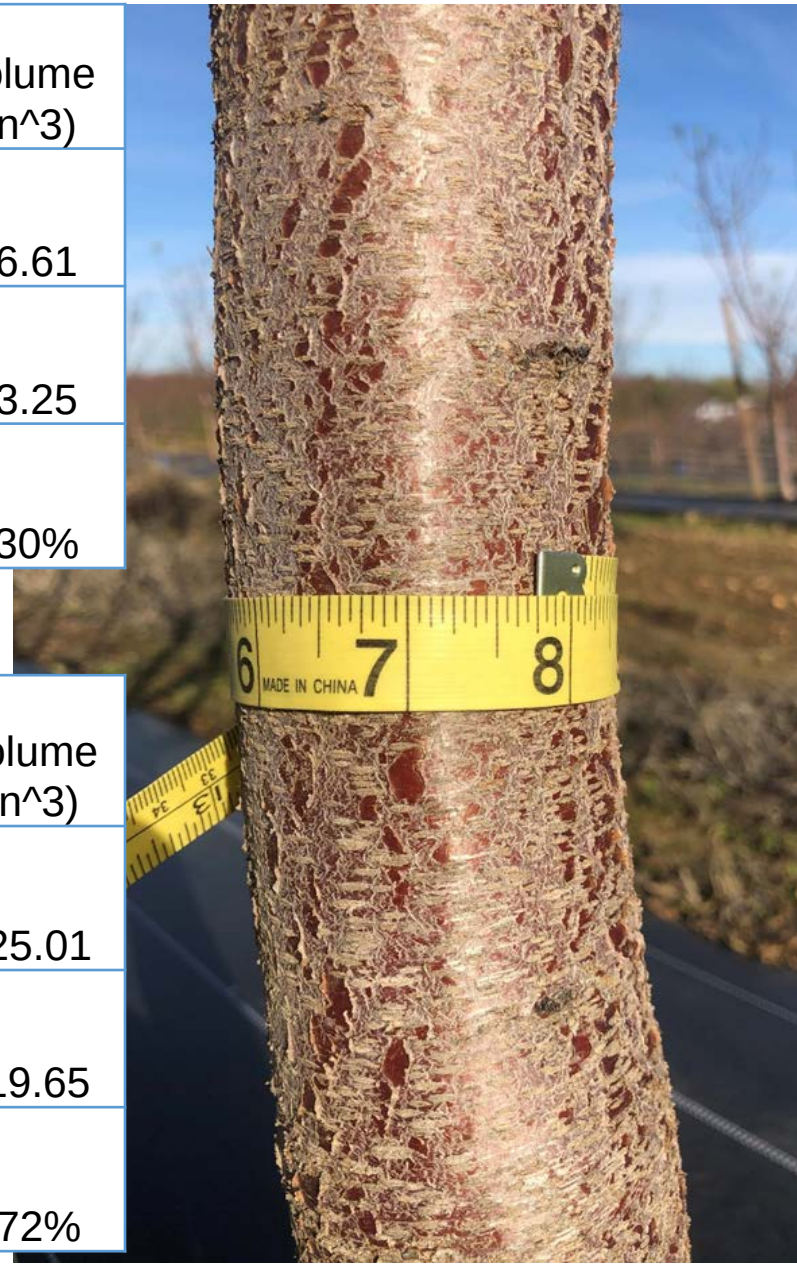
12 Months High Compliance

12 Months Low Compliance

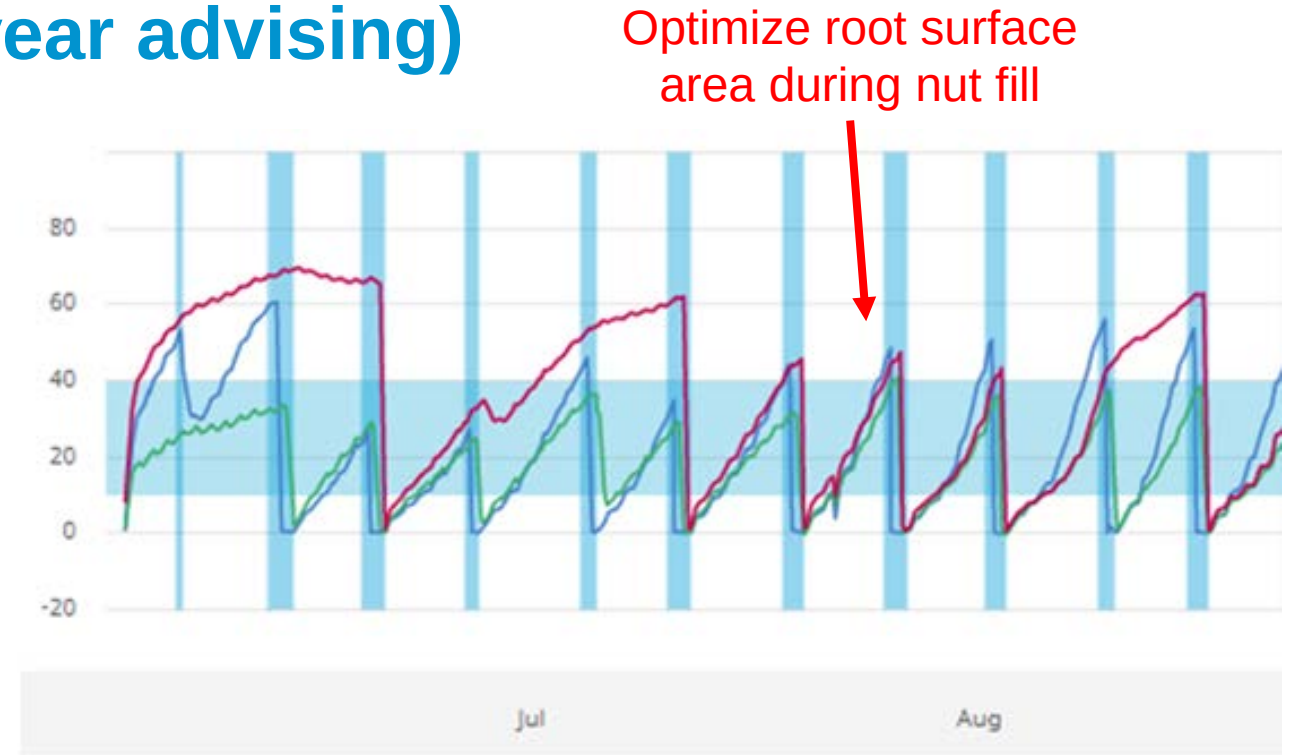
December 2019

December 2018	Circumference (in.)	Length (in.)	Volume (in^3)
High Compliance Ranch (NP)	5.91	27.48	76.61
Low Compliance Ranch (NP)	4.07	24.90	33.25
% Increase in High Compliance Ranch	45%	10.40%	130%

December 2019	Circumference (in.)	Length (in.)	Volume (in^3)
High Compliance Ranch (NP)	12.19	27.47	325.01
Low Compliance Ranch (NP)	7.71	24.89	119.65
% Increase in High Compliance Ranch	58%	10.3%	172%



Walnuts (1st year advising)



44% Increase in edible yield
6% Increase in light meat

Oakdale Almonds

Key metrics (Site averages)	2017	2018	Change	Change %
Water Applied/Acre (ac-in)	35	29	-6	-16%
Site-Wide Water Use (ac-ft)	8382	7021	-1361	-16%
Water Use Efficiency (lbs/ac-in)	21	53	32	152%
Leaching (hrs per block)	326	292	-34	-11%
Pumping Energy Costs ($/ac)	$ 257.03	$ 215.30	$ (41.73)	-16%
Water Cost ($/ac)	$ 43.30	$ 36.27	$ (7.03)	-16%
Yield (lb/ac)	732	1543	811	111%
Yield value ($/ac)*	$ 1,904	$ 4,013	$ 2,108	111%
Gross Profit Margin variation ($/ac)	$ 1,604	$ 3,761	$ 2,157	134%
	* Priced at	$ 2.60	/lb	

Site Totals	2017	2018	Change	Change %
Cost of Water	$ 872,122	$ 730,516	$ (141,606)	-16%
Crop Value	$ 4,688,017.20	$ 7,702,314.340	$ 3,014,297	64%

Gross Profit Increase	$	3,155,903.40

Your Return on Hortau solutions invested is (ROI)	25.7x

Newman Almonds

Key metrics (Site averages)	2017	2018	Change	Change %
Water Applied/Acre (ac-in)	33	37	4	11%
Site-Wide Water Use (ac-ft)	3875	4293	417	11%
Water Use Efficiency (lbs/ac-in)	28	33	5	18%
Leaching (hrs per block)	0	36	36	0%
Pumping Energy Costs ($/ac)	$ 247.21	$ 273.83	$ 26.62	11%
Water Cost ($/ac)	$ 555.21	$ 614.99	$ 59.78	11%
Yield (lb/ac)	933	1217	283	30%
Yield value ($/ac)*	$ 2,053	$ 2,677	$ 624	30%
Gross Profit Margin variation ($/ac)	$ 1,251	$ 1,788	$ 537	43%

* Priced at $ 2.20 /lb

Site Totals	2017	2018	Change	Change %
Cost of Water	$ 1,120,173	$ 1,240,792	$ 120,620	11%
Crop Value	$ 2,866,398	$ 3,736,933	$ 870,536	30%

Gross Profit Increase	$ 749,915.92

Your Return on Hortau solutions invested is (ROI)	6.2x

Bakersfield Almonds

Key metrics (Site averages)	2017	2019	Change	Change %
Water Applied/Acre (ac-in)	55	49	-6	-12%
Site-Wide Water Use (ac-ft)	5075	4479	-596	-12%
Water Use Efficiency (lbs/ac-in)	51	61	10	19%
Pumping Energy Costs ($/ac)	$ 409.68	$ 361.55	$ (48.13)	-12%
Water Cost ($/ac)	$ 502.48	$ 445.47	$ (57.00)	-11%
Yield (lb/ac)	2840	2988	148	5%
Yield value ($/ac)*	$ 7,384	$ 7,770	$ 385	5%
Gross Profit Margin variation ($/ac)	$ 6,472	$ 6,962	$ 491	8%
	* Priced at	$ 2.60	/lb	
Site Totals	**2017**	**2019**	**Change**	**Change %**
Cost of Water	$ 1,006,296	$ 890,310	$ (115,986)	-12%
Crop Value	$ 8,146,165	$ 8,571,327	$ 425,162	5%
Gross Profit Increase			**$ 541,147.90**	

ROI on Hortau's system:

6.5X

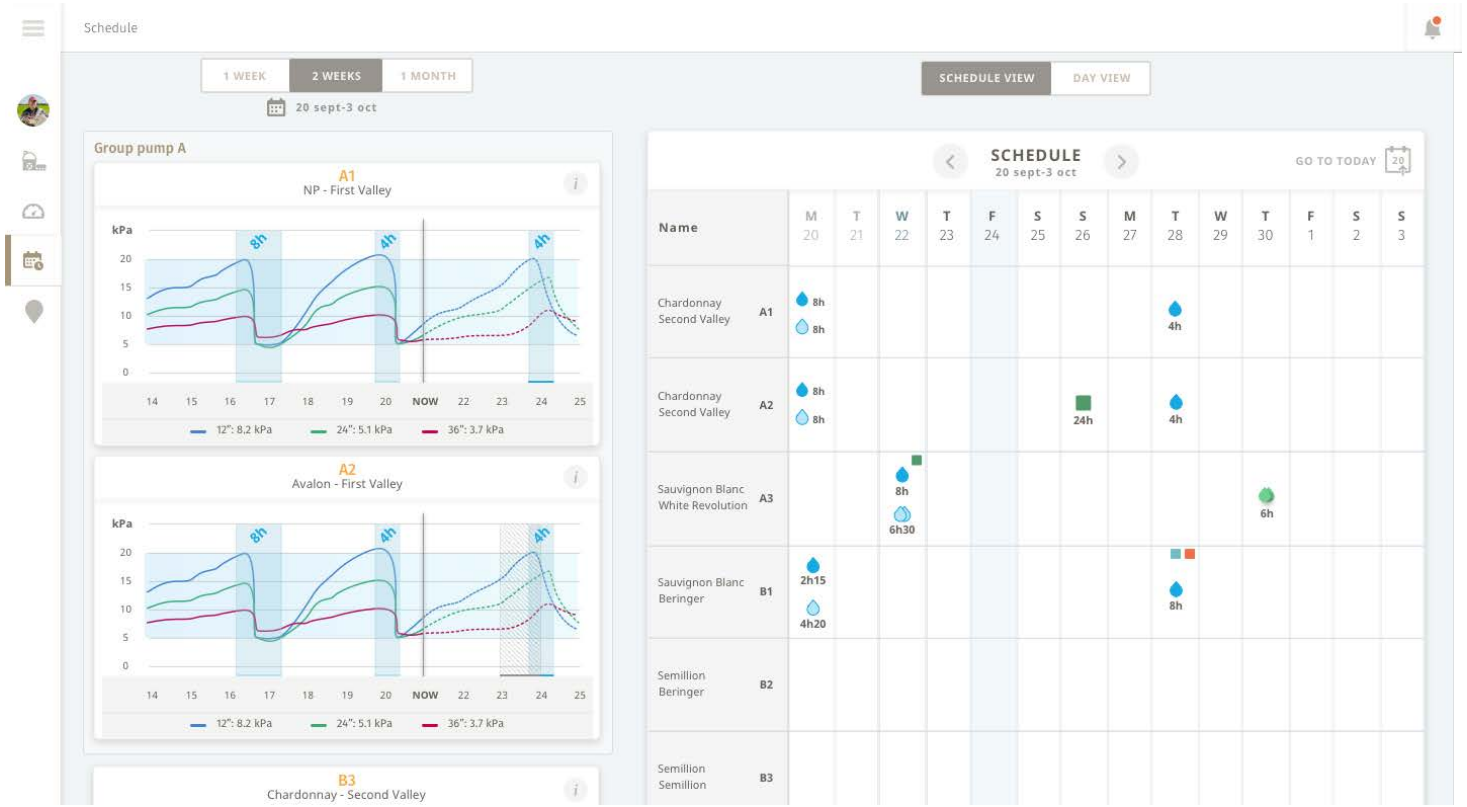
A team of Ag professionals

Hortau at a glance

- 17 years in the business
- 75 employees
- Offices in San Luis Obispo and Canada
- More than 1,000 farms being serviced
- 6500+ monitoring stations deployed
- Full service irrigation advising

For more on the entire Hortau team, visit hortau.com/staff

In-field sensing, analytics and advising to increase crop and farm input productivity



A look inside the company

Patented technology (11 patents)

- Soil sensing technologies
- Multi-variated crop stress management

Trade secrets on

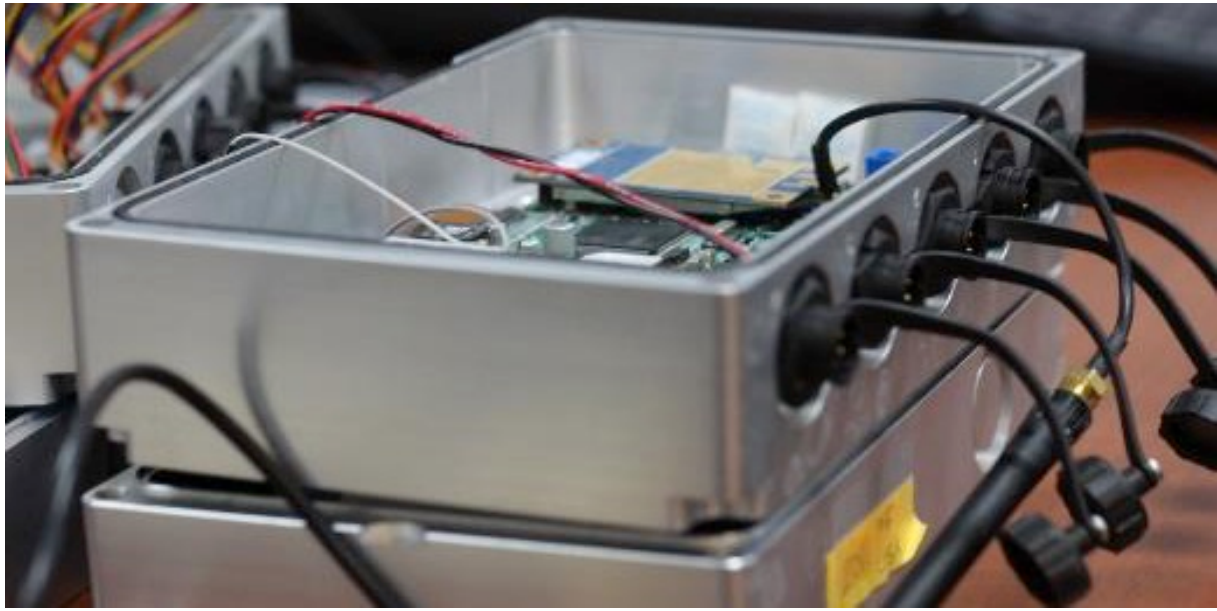
- Machine learning algorithms
- Sensing ceramics
- Polymers

Internal R&D team

- Wireless solar powered devices
- Sensor development
- Machine learning
- Add design and development

Manufacturing:

- Flexible production capacity
- In-house assembly and quality control



Anticipating and managing crop stress can lead to multiple benefits

Increased crop health

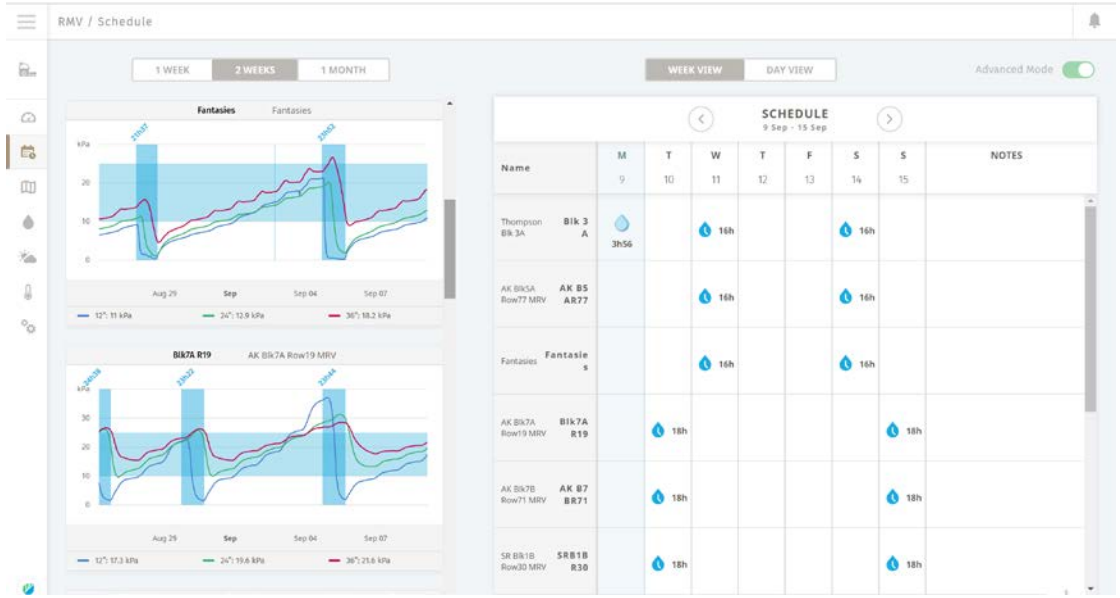
- Better quality
- Better uniformity
- Better yields

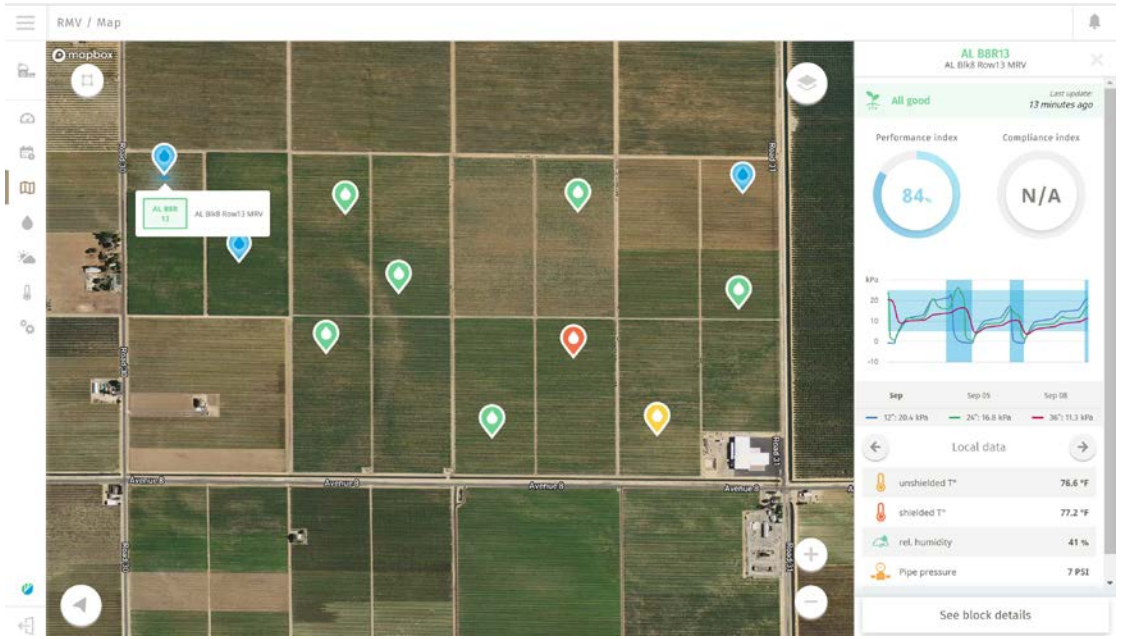
Better input efficiency

- Water
- Nutrients
- Pesticides

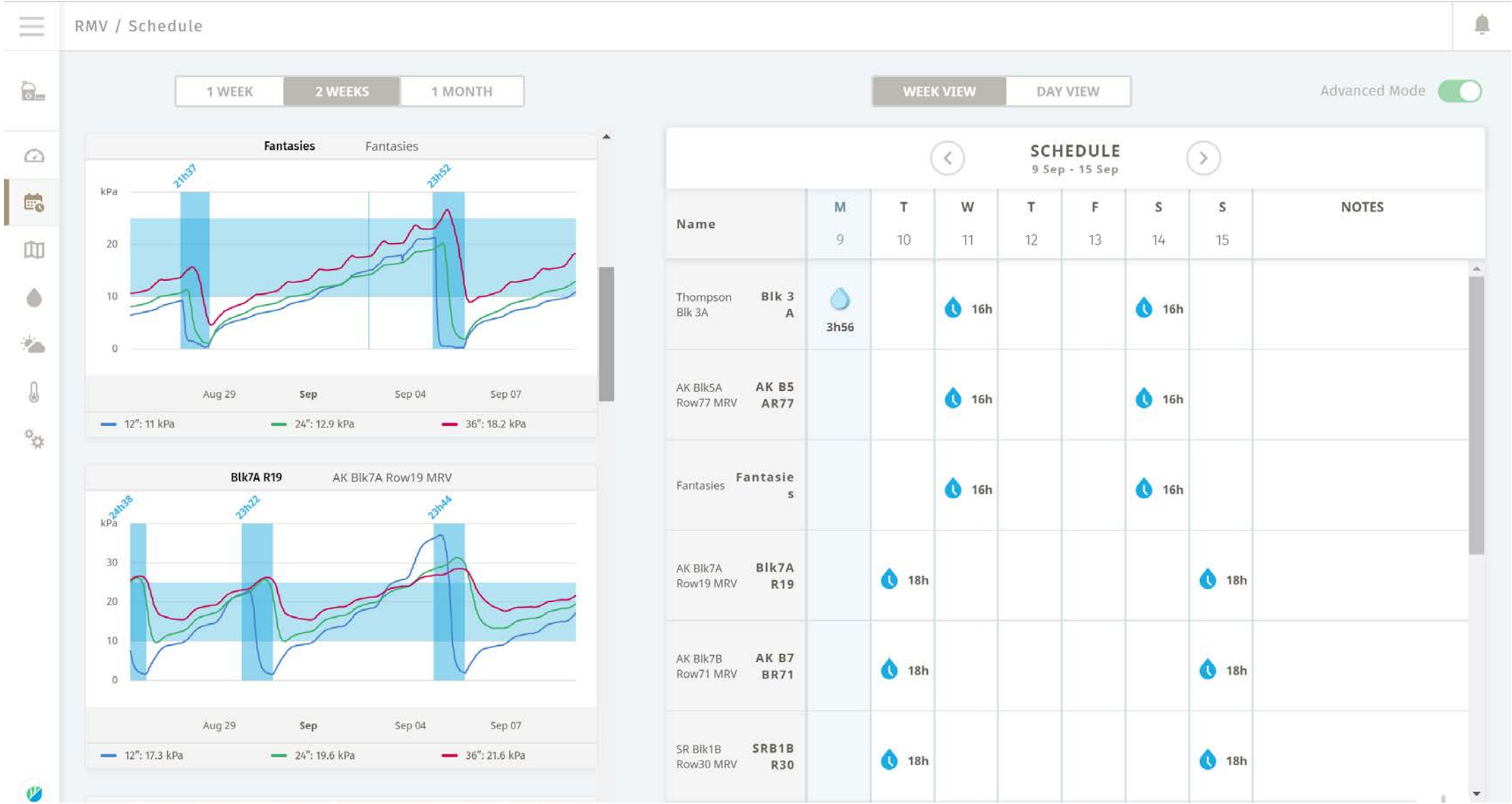
Better reporting and traceability

- SIGMA
- Repeatability of best results





Taking action: easily turn field data into irrigation schedules



Services currently offered

Irrigation Management	Autonomous Irrigation	Weather	Flowmeter Monitoring
			
On-demand, tension-based, irrigation management service including • Equipment, Wireless, Data storage, Apps and access • Crop stress anticipation with forecasted schedule a week ahead • Field tech support • Grower support	Autonomous irrigation operation and control service including • Equipment, Wireless, Data storage, Apps and access • Three automation mode: remote start, schedule and fully autonomous • Field tech support • Grower support	Local weather monitoring service including • Equipment, Wireless, Data storage, Apps and access • Access to Hortau weather network (in development) • Field tech support • Grower support	Wireless flowmeter monitoring service including • Equipment, Wireless, Data storage, Apps and access • Remote access to flowmeter data from multiple locations • Field tech support • Grower support

Soil Tension

- Monitoring soil tension allows us to know when to irrigate long before the plant shows any visible sign of stress
- Keeps Stomata open, CO2 flowing in, Vapor Transpiring out, and nutrients flowing through the plant.
- Health, yield, and growth are optimized
- Critical physiological periods can be understood and controlled

The Right Tech

- More than 15 years experience developing product
- We have gone through the paces to know what works and what does not
- Continuous R&D to further develop hardware and software

The Right Support

- Complete service package
  - We take care of it all
    - Installation
    - Maintenance
    - Updates
    - Training
    - Analysis
    - Troubleshooting
    - Irrigation Schedule

Why Hortau?

Committed partner

- 15 years in Ag business
- More than $10M invested on crop research and technology development
- In-field support specialists
- Service approach
- ROI season after season

Data

- Direct soil tension
- Integrated weather measurement
- Crop stress anticipation
- Real-time, actionable reports
- Accessible by any device
- Complete automation

Expertise

- Team of farm experts and agronomists
- Trusted advisor relationships, built by farmers for farmers
- 24/7 support, data stream reliability
- Grower support
- Tech support

Connecting the dots between Ag and tech

Agronomic support and training

Direct technical support

Precision farming made easy

Hortau's team includes graduates, M.Sc. and Ph.D in:

- Soil science
- Crop science
- Soil physics
- Soil bio-chemistry
- Ag engineering
- Ag business
- Certified Crop Advisors

Team members grew up on a farm and have many years of industry experience.

Hortau's team relentlessly help **bridge the gap** between the field and the office

Creating tangible and sustainable on-farm value

Reduce water and energy usage by **20 to 35%**

Increase yield by **10 to 50%** Increase quality and uniformity

Virtually **eliminate fertilizer losses** through leaching

Keep crops healthy, minimizing the impact of pests and diseases

Reduce pesticide usage

High ROI – 5X to 30X

Strawberry Research

- 17% yield increase
- 35% water savings
- Near-zero fertilizer leaching

Almond Research

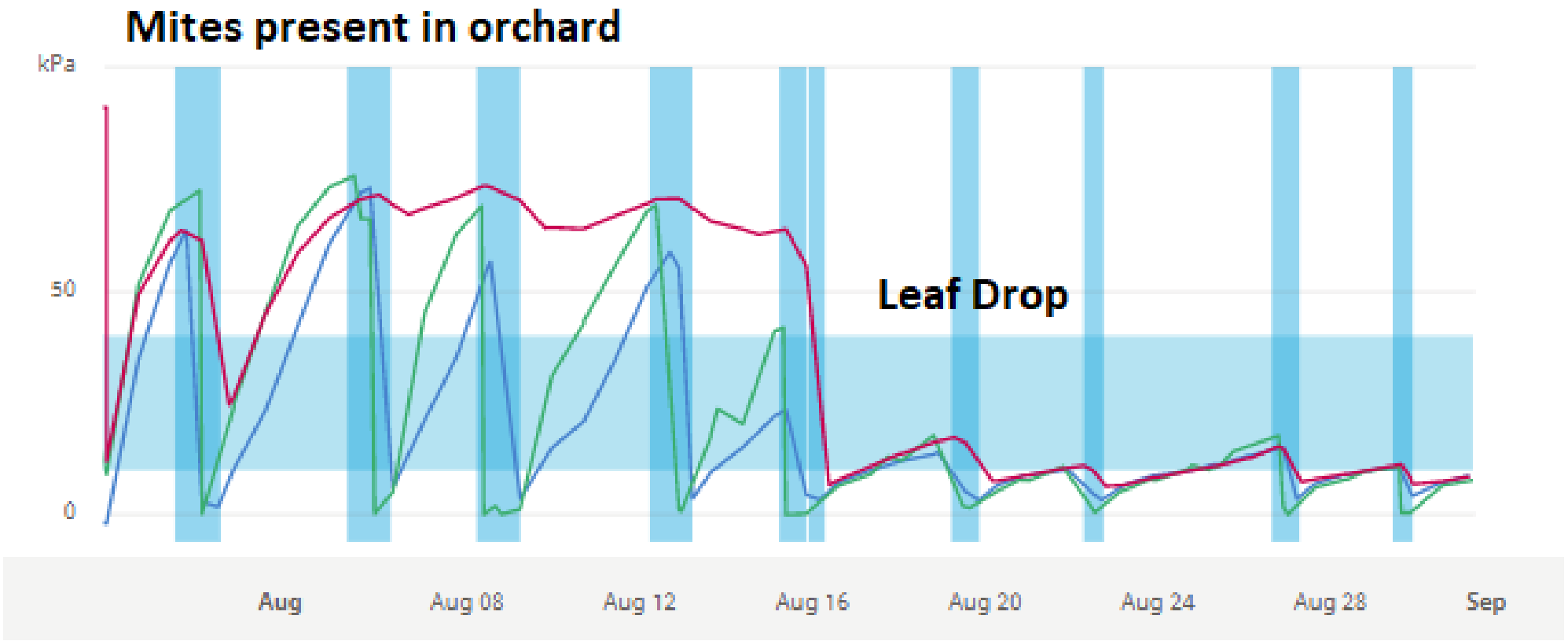
- 16% yield increase
- 24% water savings

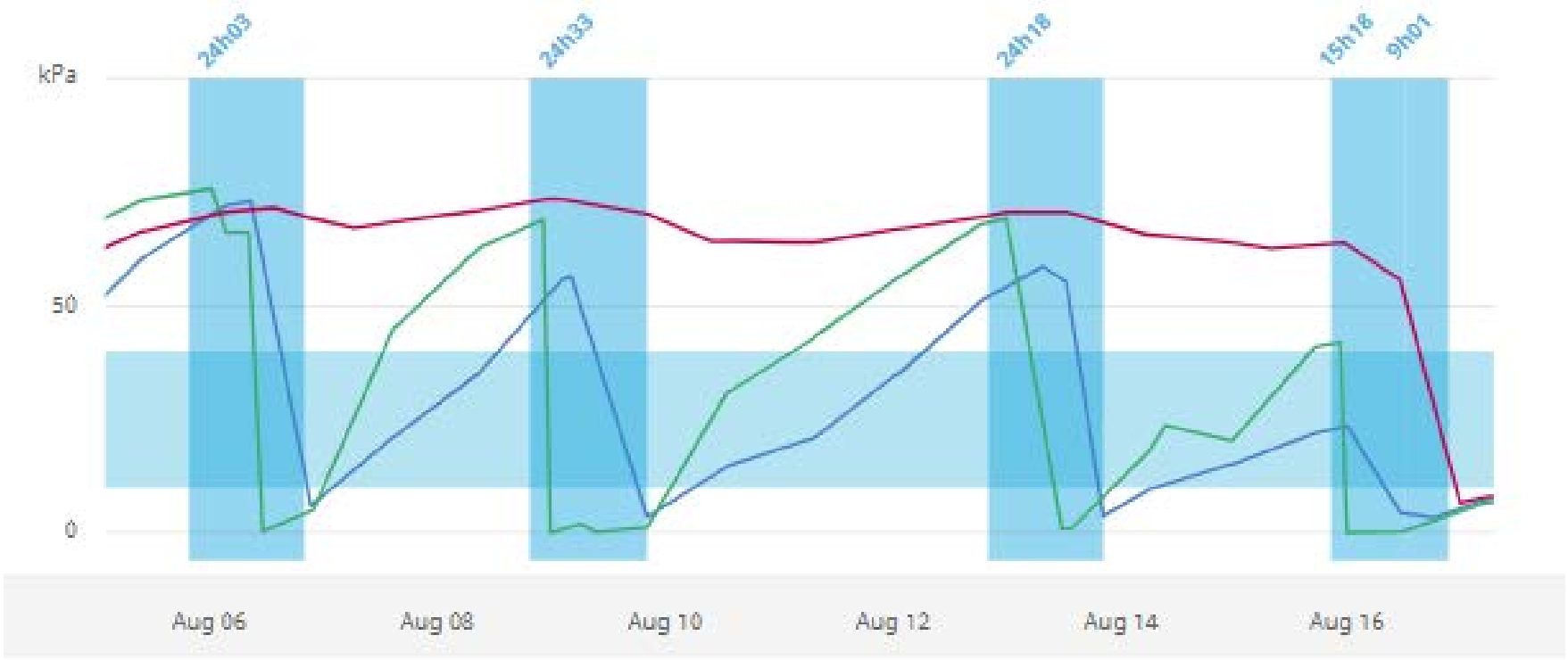
Cranberry Research

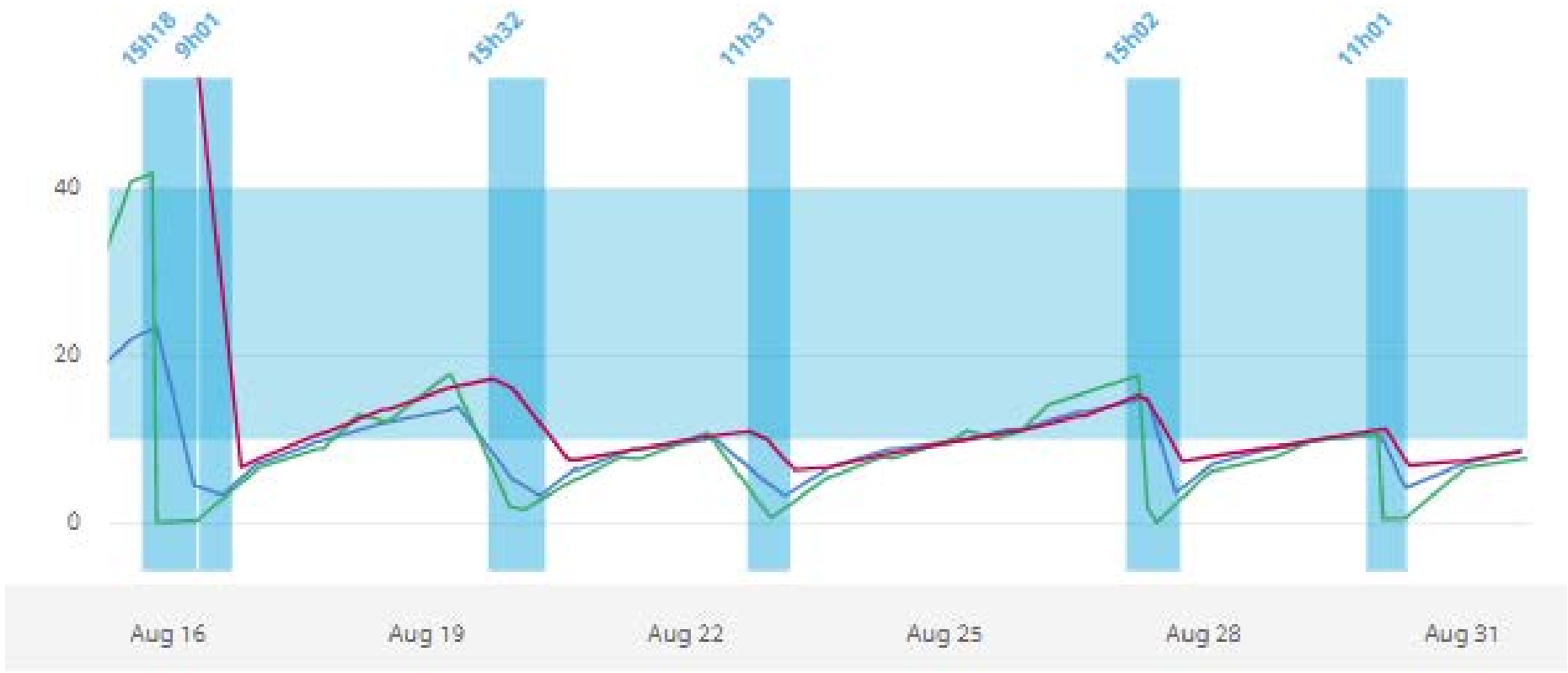
- 20% to 50% yield increase
- 5X less water consumption

Lettuce Research

- 18% yield increase
- 10% - 20% less tip burn
- Profitability $500 to $4,000 per acre


Mites present in orchard
kPa
50
0
Leaf Drop
Aug
Aug 08
Aug 12
Aug 16
Aug 20
Aug 24
Aug 28
Sep


24h03
24h33
24h18
15h18
9h01
kPa
50
0
Aug 06
Aug 08
Aug 10
Aug 12
Aug 14
Aug 16


15h18
9h01
15h32
11h31
15h02
11h01
40
20
0
Aug 16
Aug 19
Aug 22
Aug 25
Aug 28
Aug 31