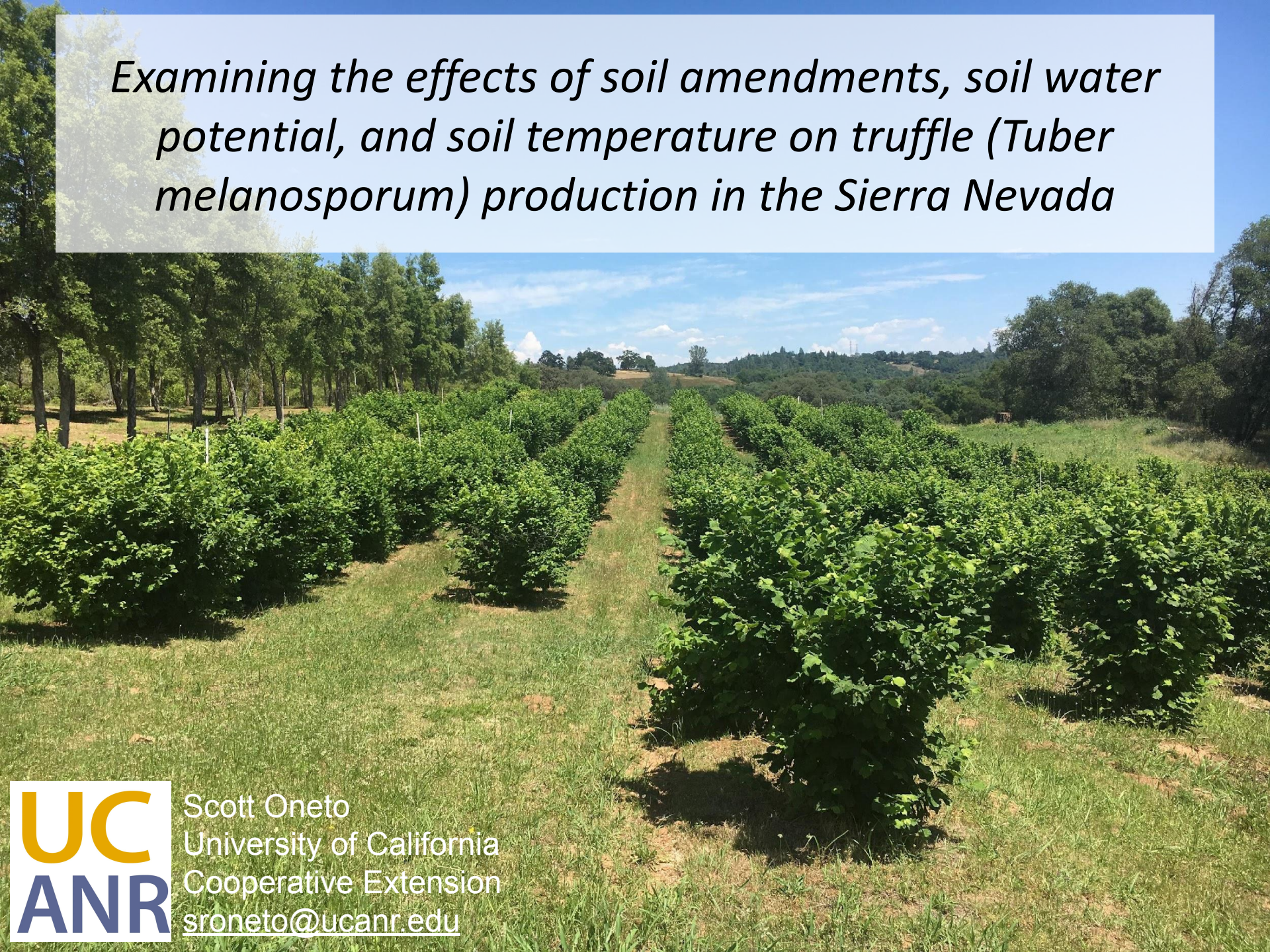
Examining the effects of soil amendments, soil water potential, and soil temperature on truffle (Tuber melanosporum) production in the Sierra Nevada



UC ANR

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A little about me…..

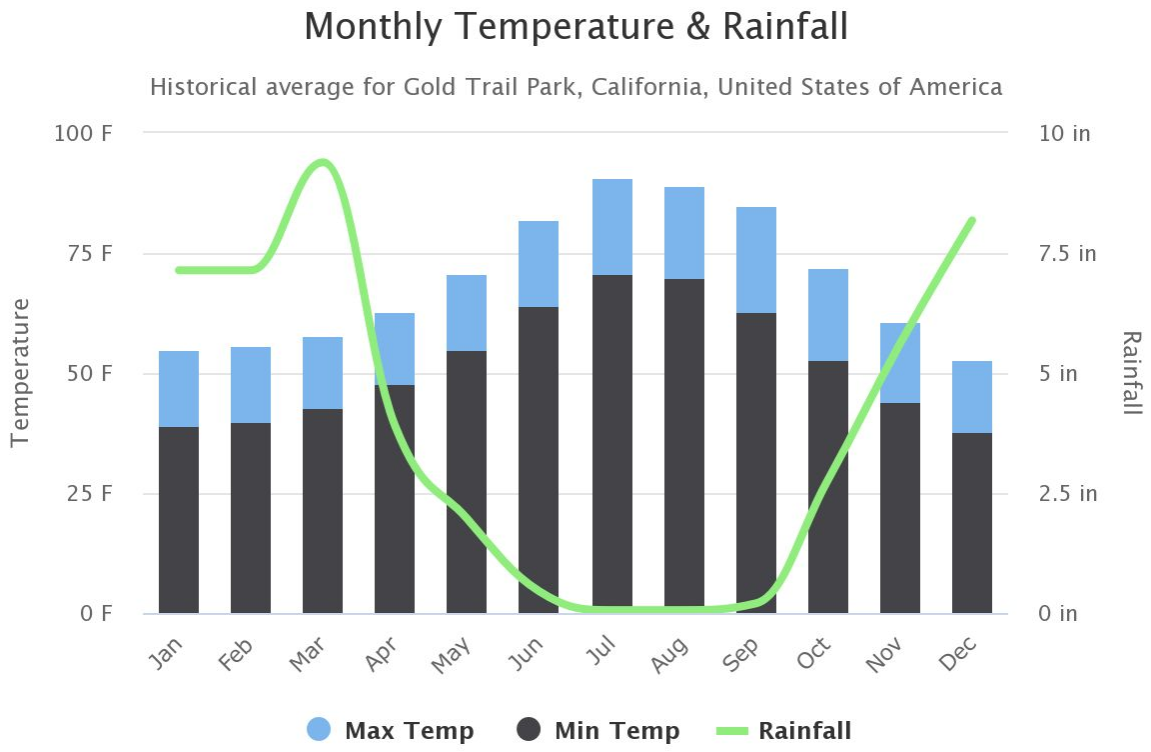
- Farm Advisor – University of California Cooperative Extension
  - Assist farmers, ranchers, agriculturists, govt. agencies, NGO's, private businesses with agricultural questions
  - Conduct research
  - Extend research based information to local clientele
- 5th generation Californian. Ancestors emigrated from Italy in the 1860's as farmers
- Strong interest in fungi
- Visited first truffle orchard in 2016, El Dorado Co.

Need for Research!

- 2019 revisited truffle orchard and began to collaborate with Staci O'Toole of Tesoro Mio Truffle Ranch to establish a research project at her El Dorado County orchard.
  - Soil properties
    - pH
    - Organic matter
    - Nutrients
  - Soil Amendments
    - Lime, compost, biochar
  - Soil temperature
  - Irrigation

Site Characteristics

- Hazelnut orchard planted in 2005
- Trees inoculated with *Tuber melanosporum*
- Soil series: Auberry course sandy loam
    - Derived from weathered acid intrusive igneous rock



Research

- Research questions:
  - Does the addition of organic matter influence truffle production?
  - Does shading the soil effect brûlé initiation and truffle production?
  - Does soil temperature impact truffle production?
  - Does water soil potential impact truffle production?

Experiments

Amendment

- Lime only (1.5 tons/acre)
- Compost – incorporated (67 yards/acre)
- Compost – top dressed (67 yards/acre)
- Biochar & compost – incorporated (50 & 67 yards/acre)

Shading

- Shade cloth in each of the four amendment treatments

Soil temperature

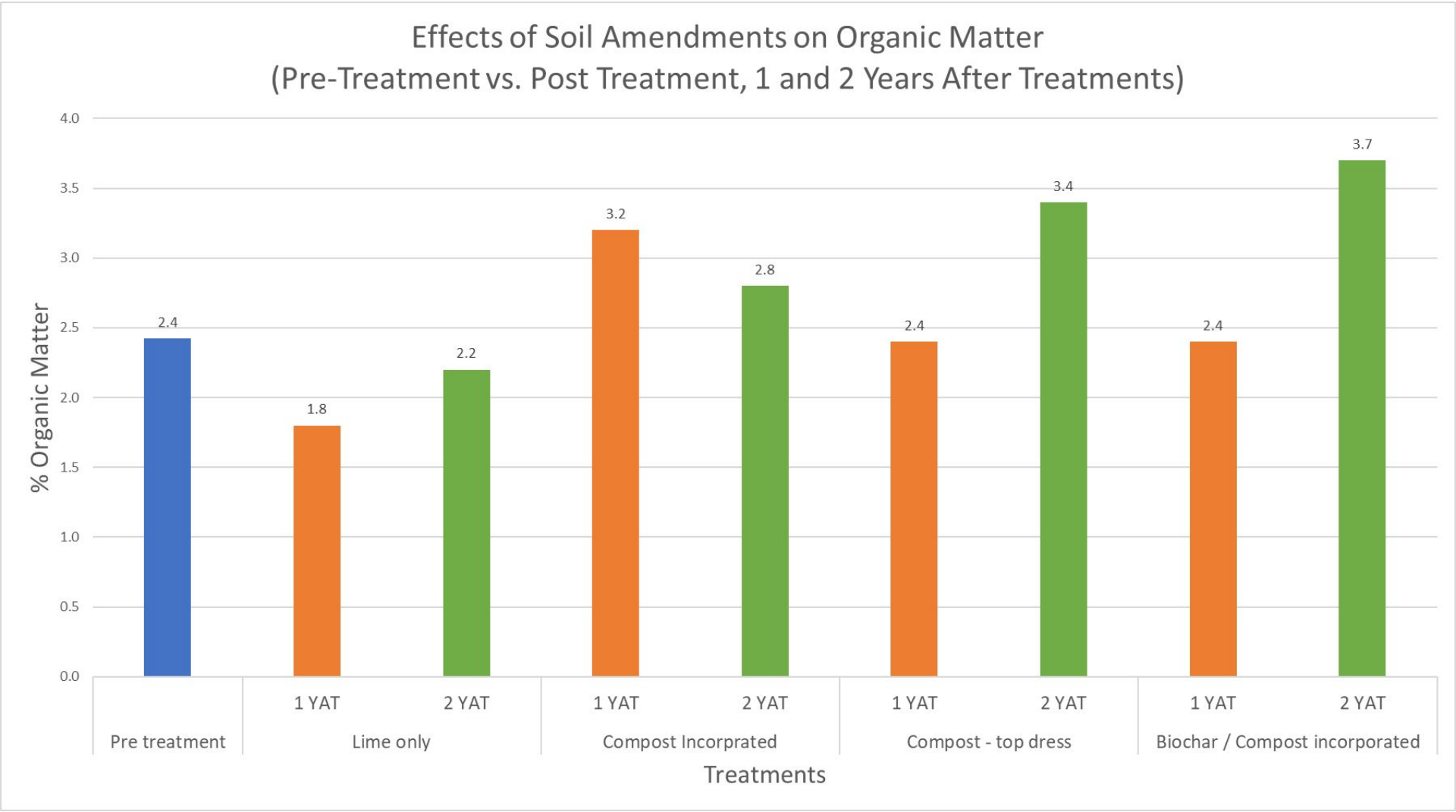
- Soil temperature probes in shade and no shade treatments

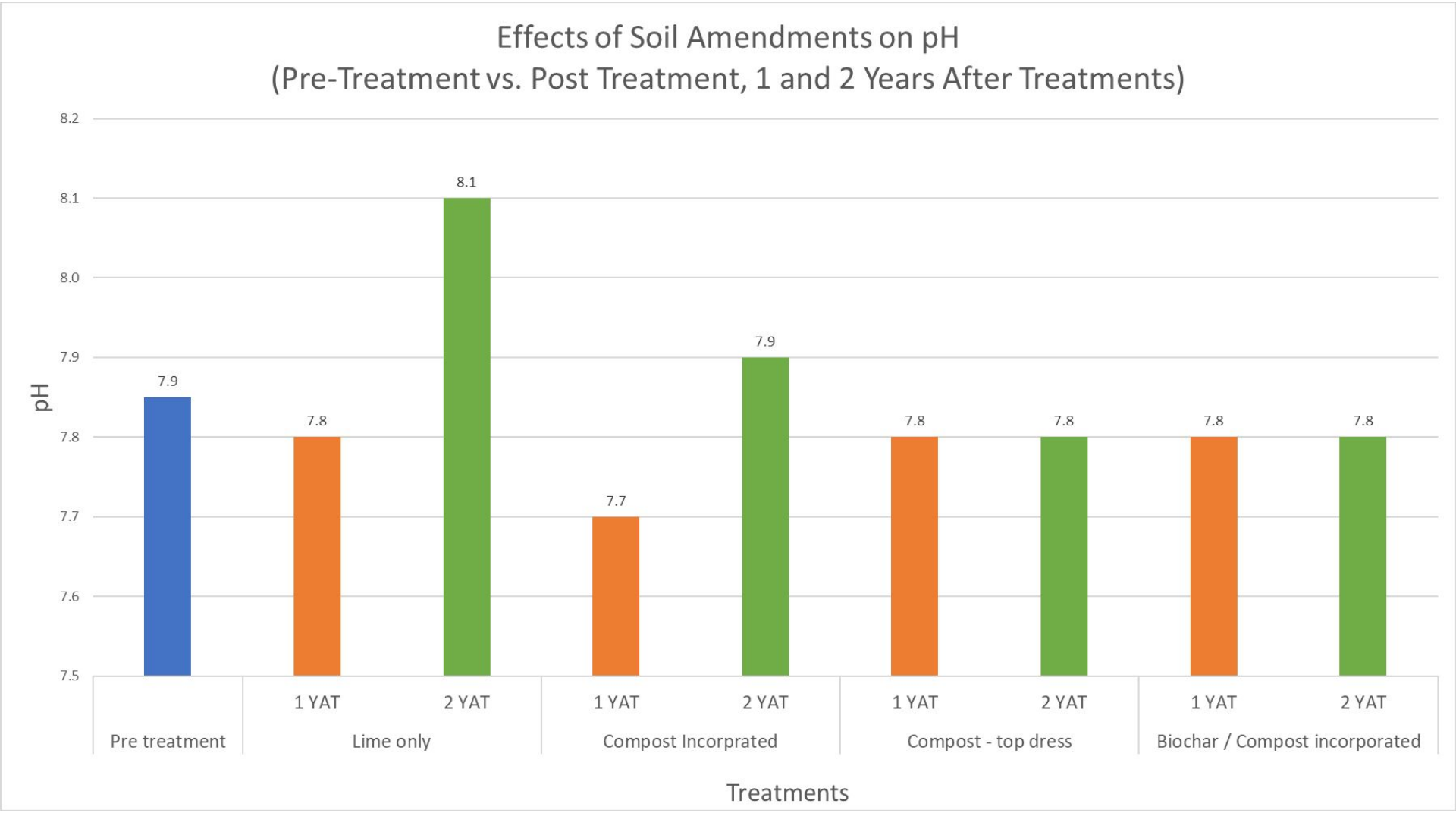
Soil water potential

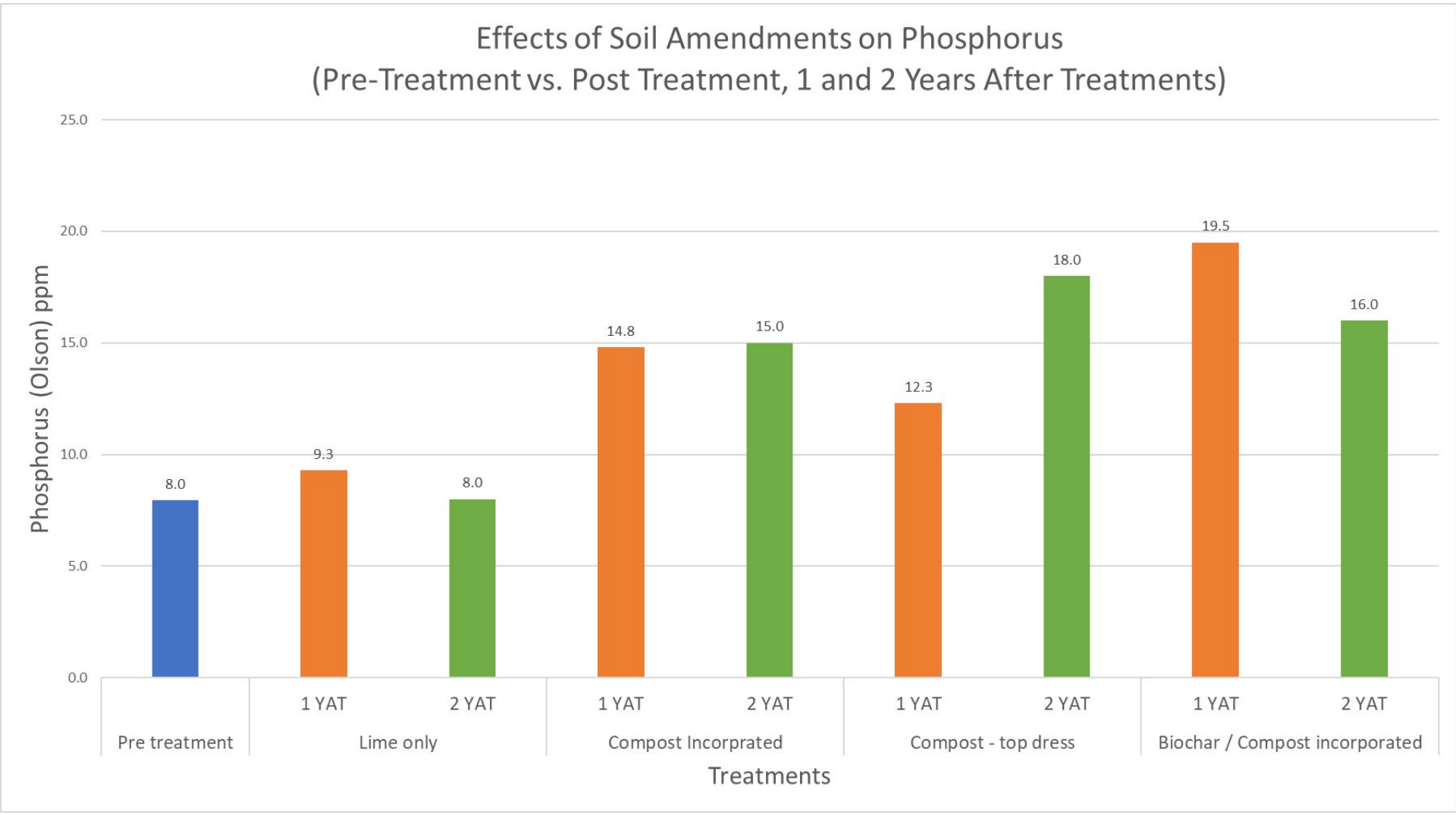
- Water potential probes in shade and no shade treatments

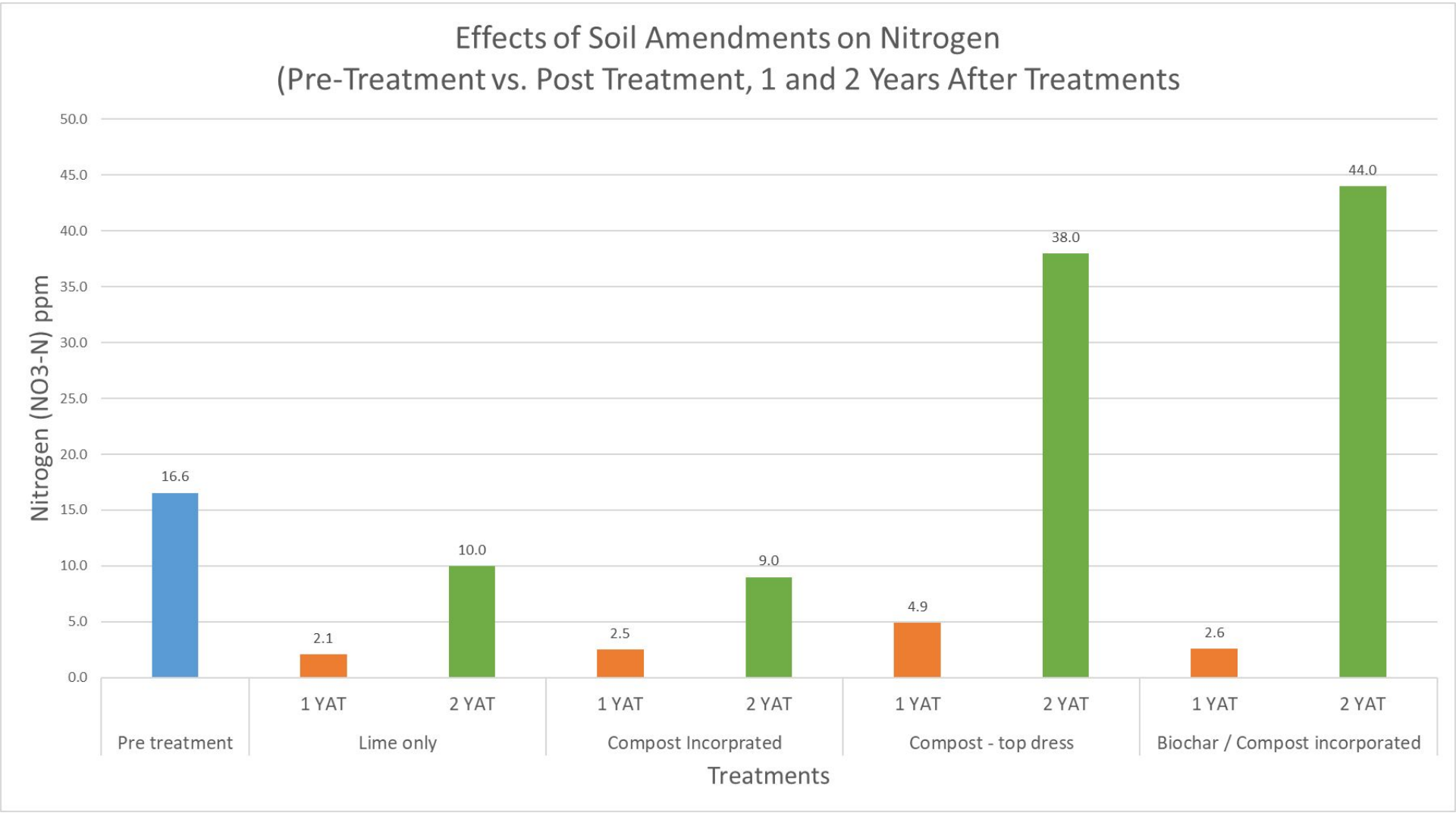

A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
COMPOST INCORPORATED
BIOCHAR & COMPOST INCORPORATED
COMPOST—NOT INCORPORATED
UNTREATED
Legend
Lime
Compost—incorporated
Biochar—incorporated
Compost—not incorporated
Untreated
Shade Treatment
Logger Station
Soil Water Potential /Temp Sensor
Soil Water Volume Sensor
Temperature Sensor

Amendments applied June 2019


Effects of Soil Amendments on Organic Matter
(Pre-Treatment vs. Post Treatment, 1 and 2 Years After Treatments)
% Organic Matter
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2.4
1.8
2.2
3.2
2.8
2.4
3.4
2.4
3.7
1 YAT
2 YAT
1 YAT
2 YAT
1 YAT
2 YAT
1 YAT
2 YAT
Pre treatment
Lime only
Compost Incorprated
Compost - top dress
Biochar / Compost incorporated
Treatments


Effects of Soil Amendments on pH
(Pre-Treatment vs. Post Treatment, 1 and 2 Years After Treatments)
pH
8.2
8.1
8.0
7.9
7.8
7.7
7.6
7.5
7.9
7.8
8.1
7.7
7.9
7.8
7.8
7.8
7.8
1 YAT
2 YAT
1 YAT
2 YAT
1 YAT
2 YAT
1 YAT
2 YAT
Pre treatment
Lime only
Compost Incorprated
Compost - top dress
Biochar / Compost incorporated
Treatments


Effects of Soil Amendments on Phosphorus
(Pre-Treatment vs. Post Treatment, 1 and 2 Years After Treatments)
Phosphorus (Olson) ppm
25.0
20.0
15.0
10.0
5.0
0.0
8.0
9.3
8.0
14.8
15.0
12.3
18.0
19.5
16.0
1 YAT
2 YAT
1 YAT
2 YAT
1 YAT
2 YAT
1 YAT
2 YAT
Pre treatment
Lime only
Compost Incorprated
Compost - top dress
Biochar / Compost incorporated
Treatments



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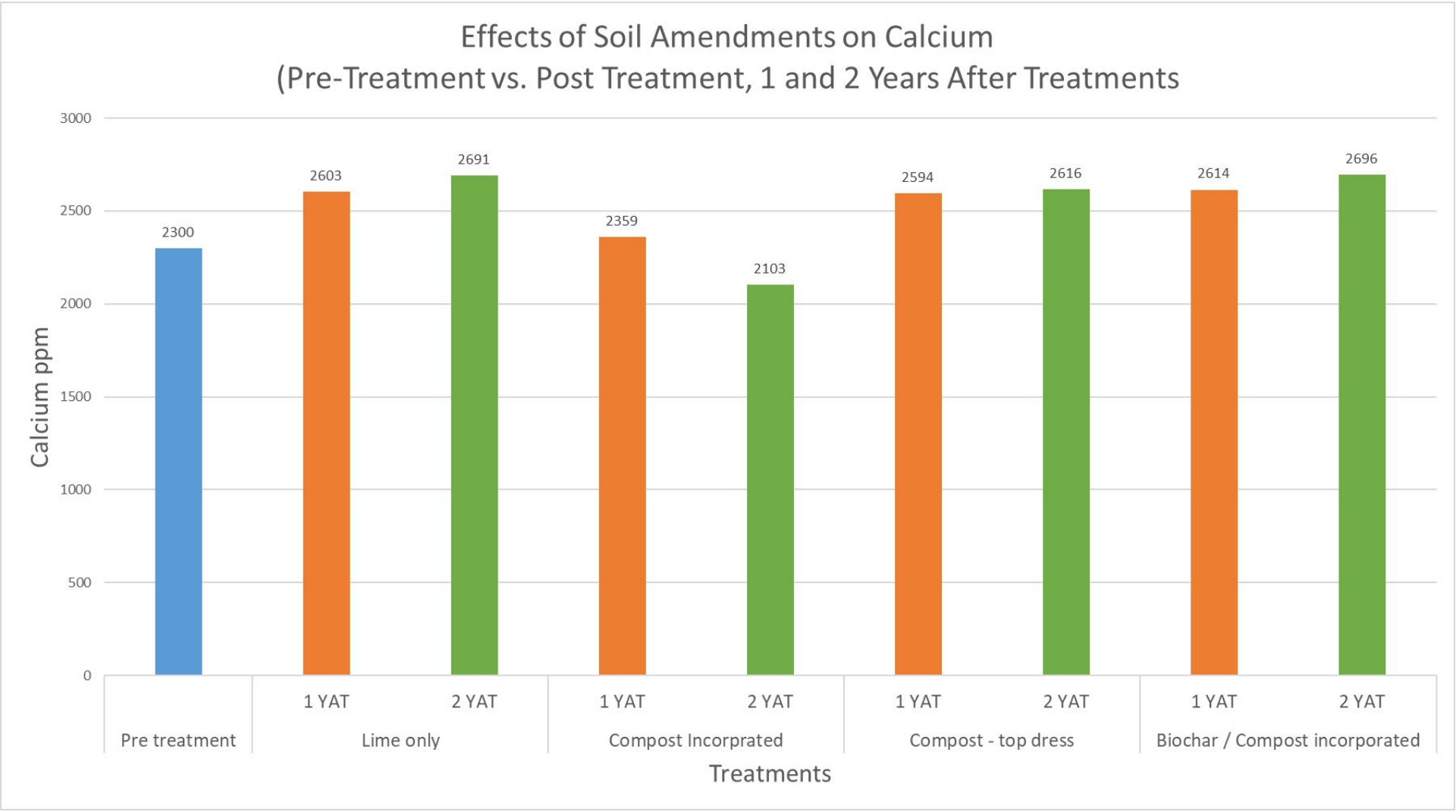
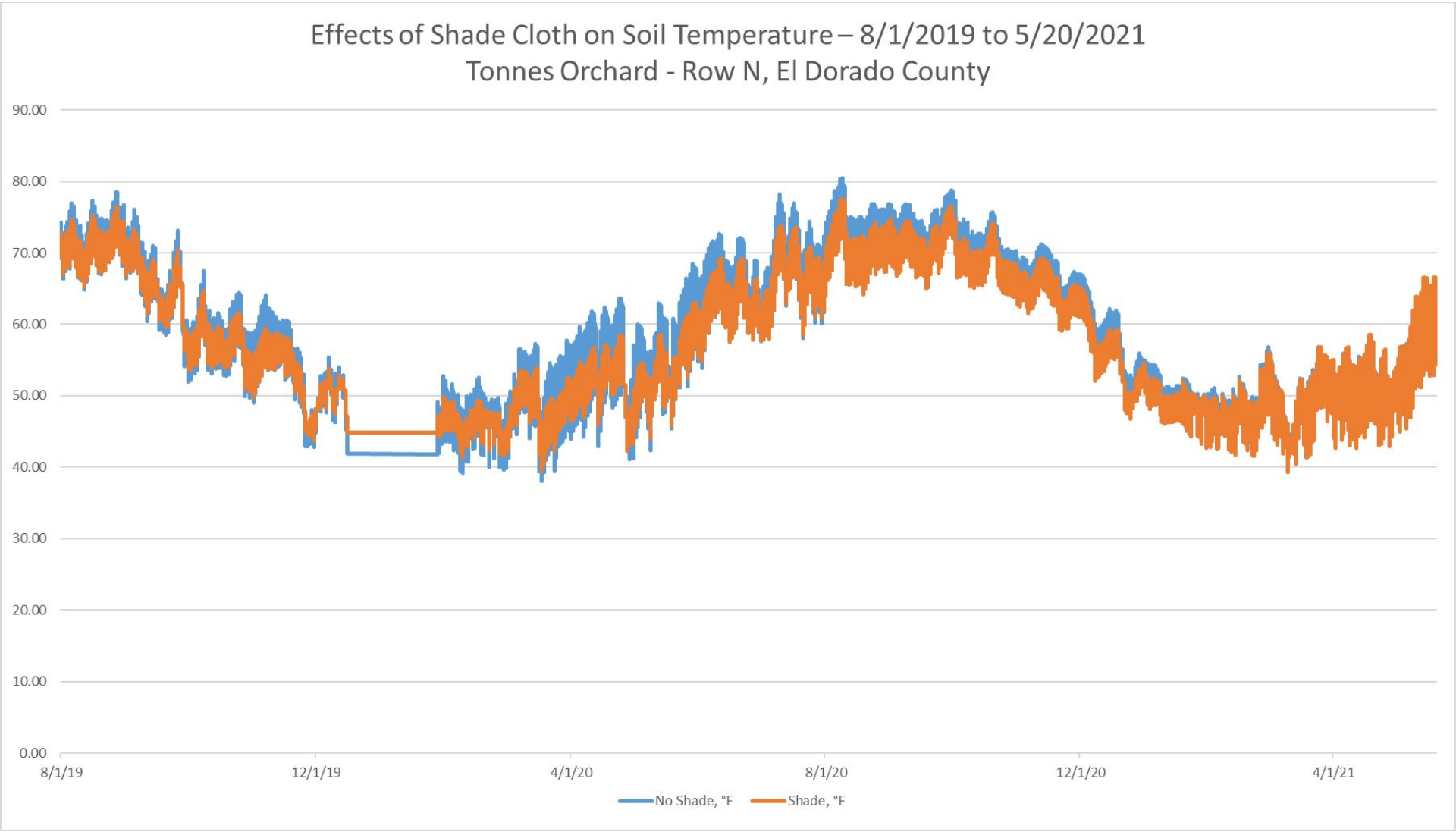
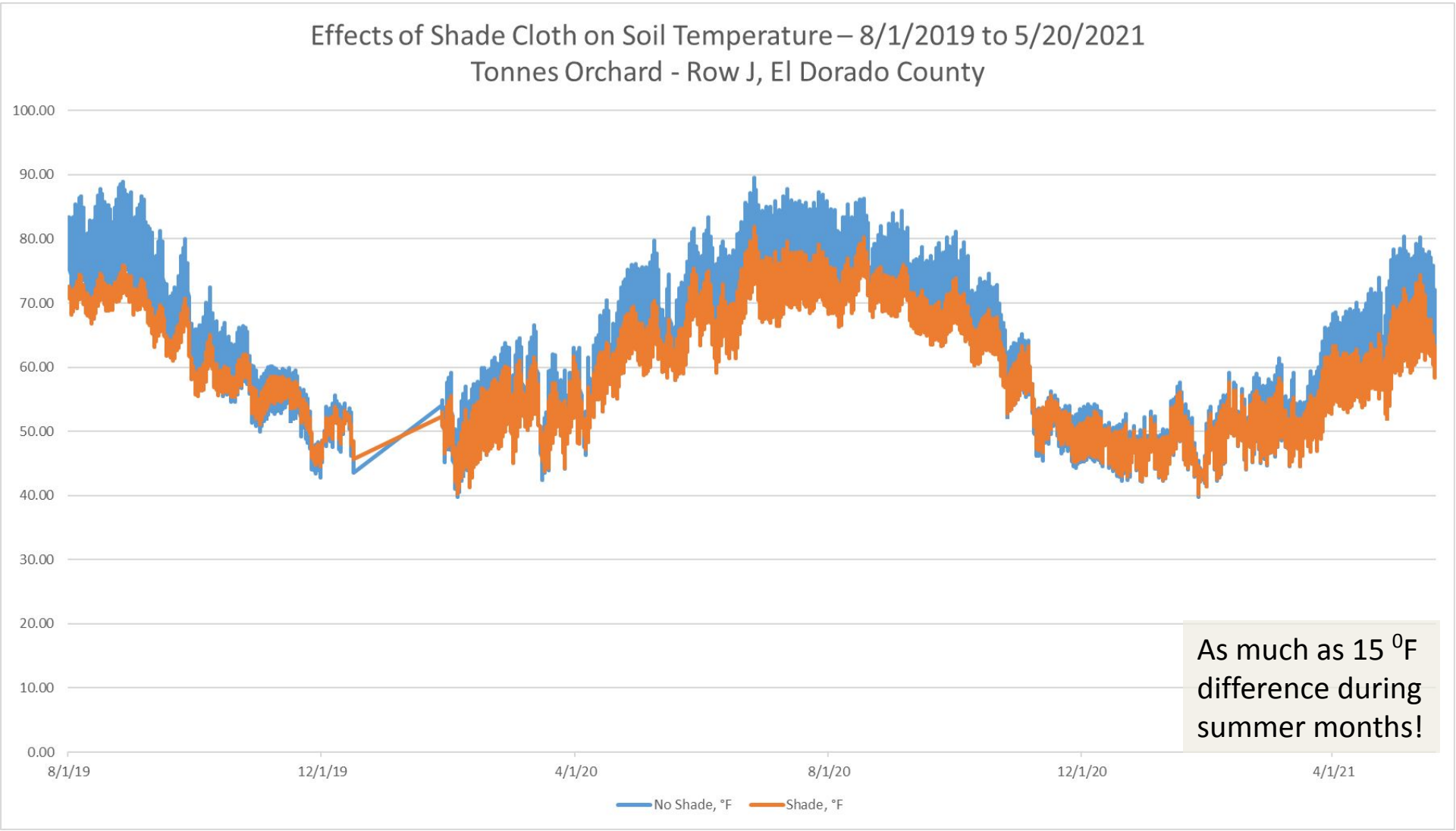

Effects of Soil Amendments on Calcium
(Pre-Treatment vs. Post Treatment, 1 and 2 Years After Treatments
Calcium ppm
3000
2500
2000
1500
1000
500
0
2300
2603
2691
2359
2103
2594
2616
2614
2696
1 YAT
2 YAT
1 YAT
2 YAT
1 YAT
2 YAT
1 YAT
2 YAT
Pre treatment
Lime only
Compost Incorprated
Compost - top dress
Biochar / Compost incorporated
Treatments


Shade cloth (70%) & soil temperature sensors installed June 2019



Treatment – Row N	Max Temp (^{0}F)	Min Temp (^{0}F)	Avg Temp (^{0}F)	Std Dev.
No Shade	80.5	38.1	58.7	9.8
Shade	77.5	39.2	57.6	9.2

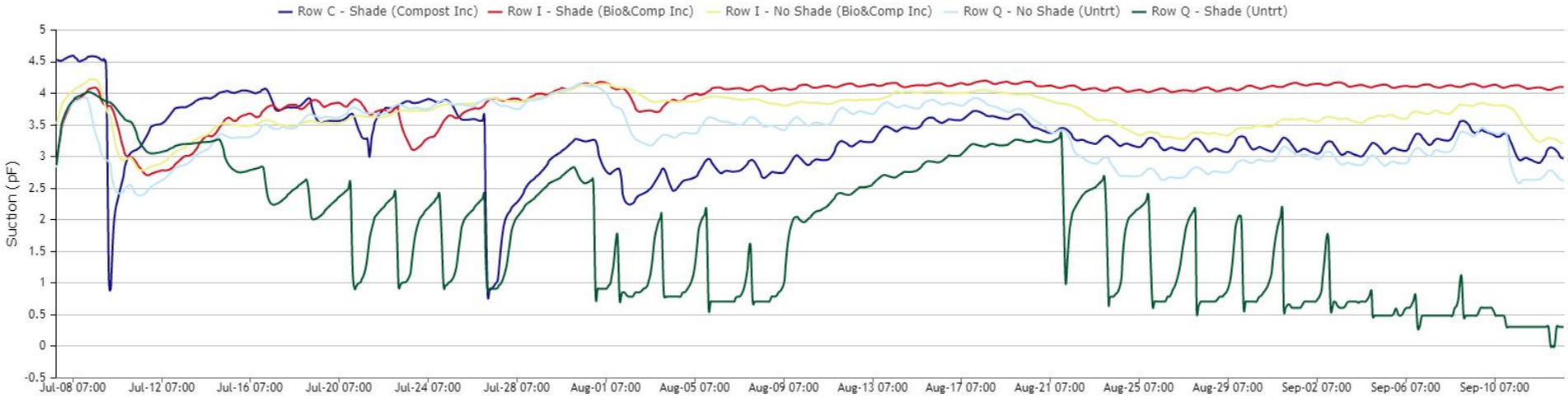


Treatment – Row J	Max Temp (^{0}F)	Min Temp (^{0}F)	Avg Temp (^{0}F)	Std Dev.
No Shade	89.5	39.7	61.9	11.4
Shade	81.9	40.2	59.4	9.3

Grower reported more brûlé formation under the shade cloth

Installed water potential sensors in two orchards June 2021

Soil water potential

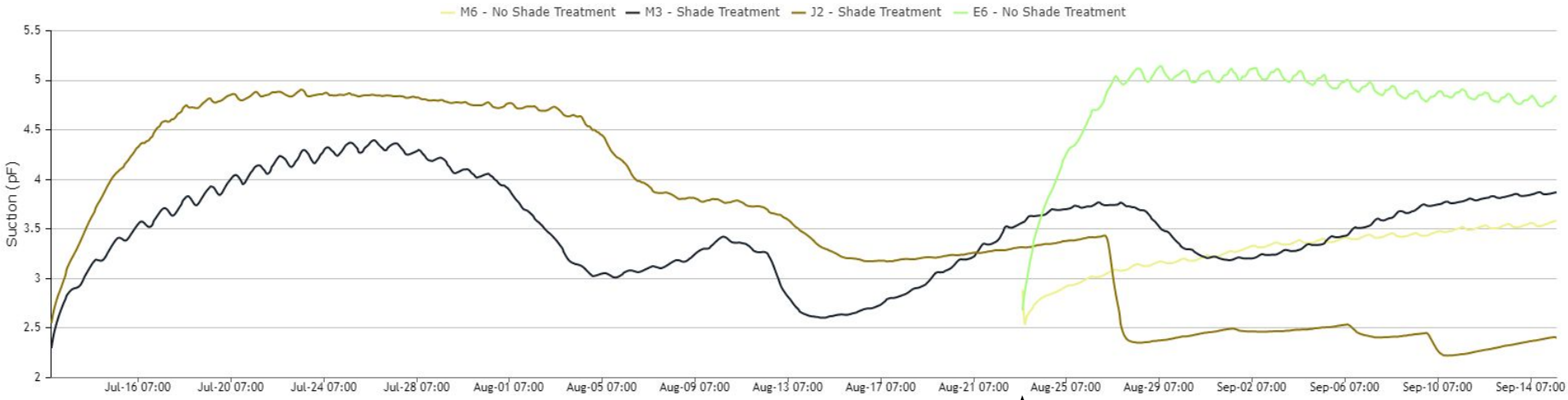


Tonnes orchard, El Dorado County

MAX	MIN
0.708 pF	4.597 pF
Row C - Shade (Compost Inc)	
2.704 pF	4.204 pF
Row I - Shade (Bio&Comp Inc)	
2.78 pF	4.224 pF
Row I - No Shade (Bio&Comp Inc)	
2.384 pF	4.147 pF
Row Q - No Shade (Untrt)	
0.009 pF	4.023 pF
Row Q - Shade (Untrt)	

AVERAGE
3.579 pF
Row C - Shade (Compost Inc)
3.997 pF
Row I - Shade (Bio&Comp Inc)
3.78 pF
Row I - No Shade (Bio&Comp Inc)
3.541 pF
Row Q - No Shade (Untrt)
2.827 pF
Row Q - Shade (Untrt)

Soil water potential



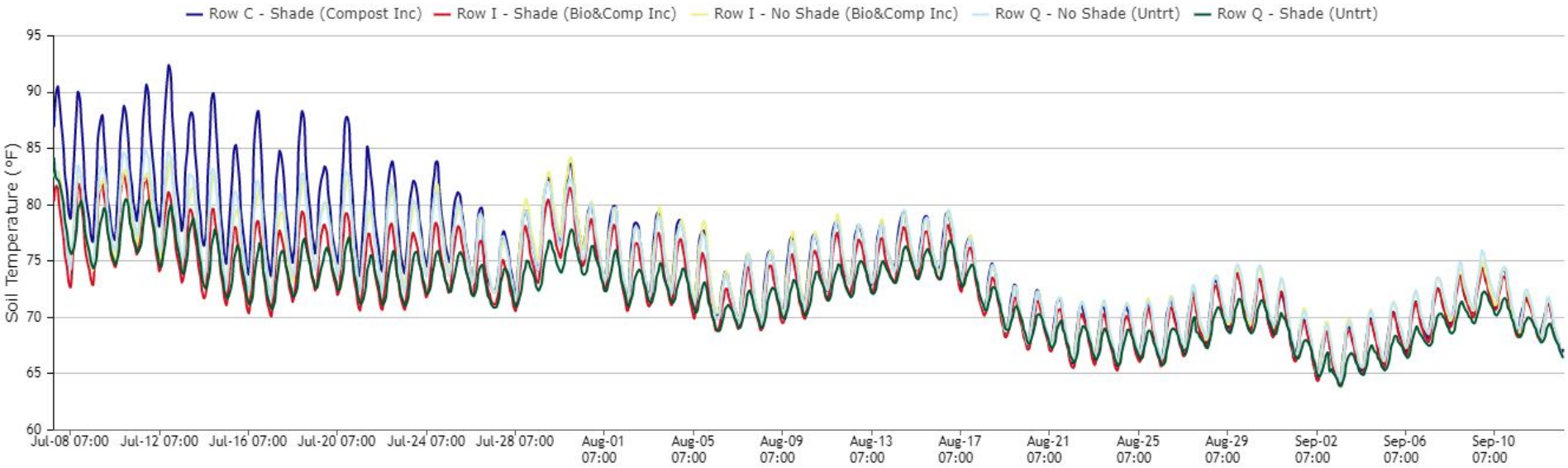
Shade Cloth installed

Wilmshurst orchard, Amador County

MAX	MIN
2.188 pF M3 - Shade Treatment	4.398 pF
2.223 pF J2 - Shade Treatment	4.911 pF
2.318 pF M6 - No Shade Treatment	3.632 pF
2.48 pF E6 - No Shade Treatment	5.153 pF

AVERAGE
3.735 pF M3 - Shade Treatment
4.304 pF J2 - Shade Treatment
3.332 pF M6 - No Shade Treatment
4.905 pF E6 - No Shade Treatment

Soil temperature

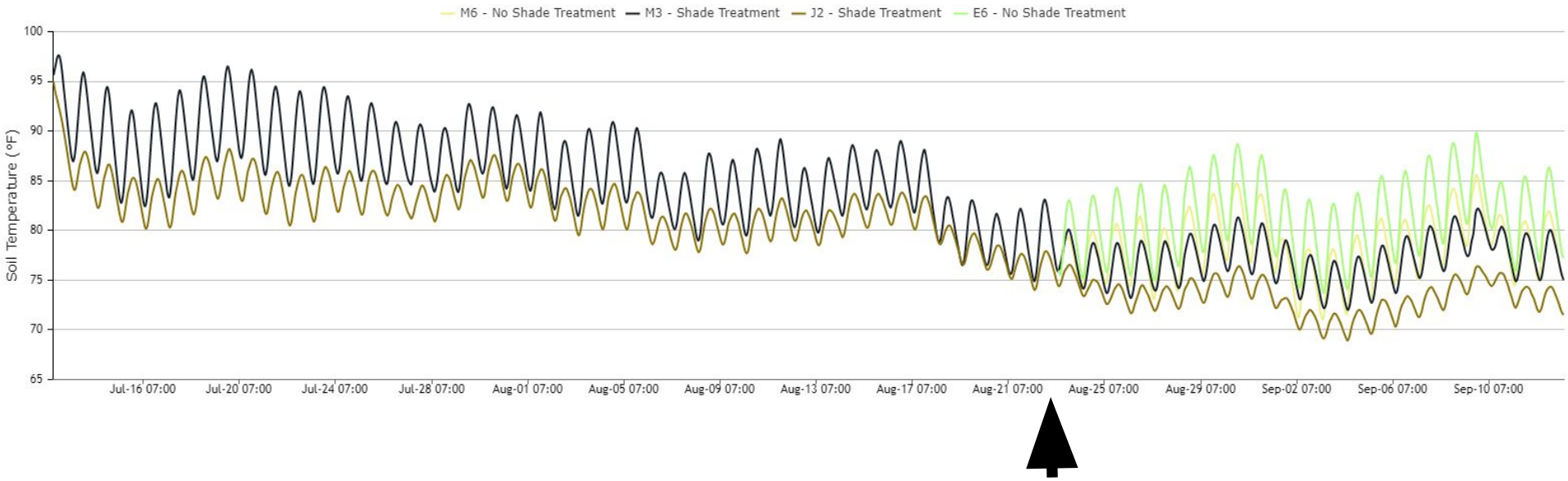


Tonnes orchard, El Dorado County

MAX	MIN
92.5 °F	64.2 °F
Row C - Shade (Compost Inc)	
82.8 °F	63.9 °F
Row I - Shade (Bio&Comp Inc)	
84.2 °F	64.4 °F
Row I - No Shade (Bio&Comp Inc)	
84.9 °F	64.2 °F
Row Q - No Shade (Untrt)	
85.7 °F	63.9 °F
Row Q - Shade (Untrt)	

AVERAGE
74.9 °F
Row C - Shade (Compost Inc)
72.7 °F
Row I - Shade (Bio&Comp Inc)
74.1 °F
Row I - No Shade (Bio&Comp Inc)
74.1 °F
Row Q - No Shade (Untrt)
71.9 °F
Row Q - Shade (Untrt)

Soil temperature



Shade Cloth installed

Wilmshurst orchard, Amador County

MAX	MIN	AVERAGE
97.7 °F M3 - Shade Treatment	72 °F	83.3 °F M3 - Shade Treatment
95.6 °F J2 - Shade Treatment	68.9 °F	79.4 °F J2 - Shade Treatment
85.6 °F M6 - No Shade Treatment	70.9 °F	78.4 °F M6 - No Shade Treatment
89.8 °F E6 - No Shade Treatment	73.6 °F	81.3 °F E6 - No Shade Treatment

Conclusions

- The addition of biochar & compost resulted in the highest increase in SOM.
- Increase in soil pH was only seen in the lime only treatment (2YAT).
- Compost (top dress) and compost & biochar treatments increased soil nitrogen.
- At this point we are still unsure what effects soil amendments have on truffle production.
- The presence of brûlé seems to be more predominant in shade treatments.
- Shade treatments are keeping soil temperatures cooler in the summer and perhaps providing some insulation in the winter.
- During summer months, temperatures were as much as 15^0F cooler in shade treatments.
- To early to tell what influence soil water potential may have on truffle production.

Acknowledgements

- Staci O'Toole, Tesoro Mio Truffle Orchard
- Ricky Wilmshurst, Wilmshurst Truffles
- NATGA