



Vertical-Point Injection: Improving Drought Resilience with a Novel Soil Architecture Modification Method using Biochar

August 2026

Overview

•WHO:

- Michael Lobato, Matrix Resource Technologies/Small Farm Owner/CSU AES Research Associate
 - B.S. Colorado Mesa University - Geology, PSM Colorado School of Mines – Mineral Exploration
- Holly Stanley, Matrix Resource Technologies/Organic Association of Kentucky
 - B.S. Colorado Mesa University – Enviro. Science
- Gerald “Jerry” Nelson, Professor Emeritus University of Illinois
 - PhD Stanford University – Ag Econ.

•WHAT:

- Funded by:
 - Colorado Ag Water Alliance [Drought Resiliency Projects | coagwater](#)
 - LOR Foundation [Field Work | LOR Foundation](#)
 - [Citizens for Clean Air Grand Junction](#)
- Pistachio shell biochar - VGrid Energy Systems, Camarillo, CA [Persist Biochar](#)
- 1.56 tons/acre (7 cubic yds) injected to 6-8” depth by DryJect Colorado

•WHERE:

- [CSU Grand Valley Research Station 1910 L Rd Fruita, CO 81521](#)
- Crop: Dahurian Wildrye, Ryegrass, Amazon Orchardgrass, Intermediate Wheatgrass, Smooth Brome, Russian Wildrye

•WHEN:

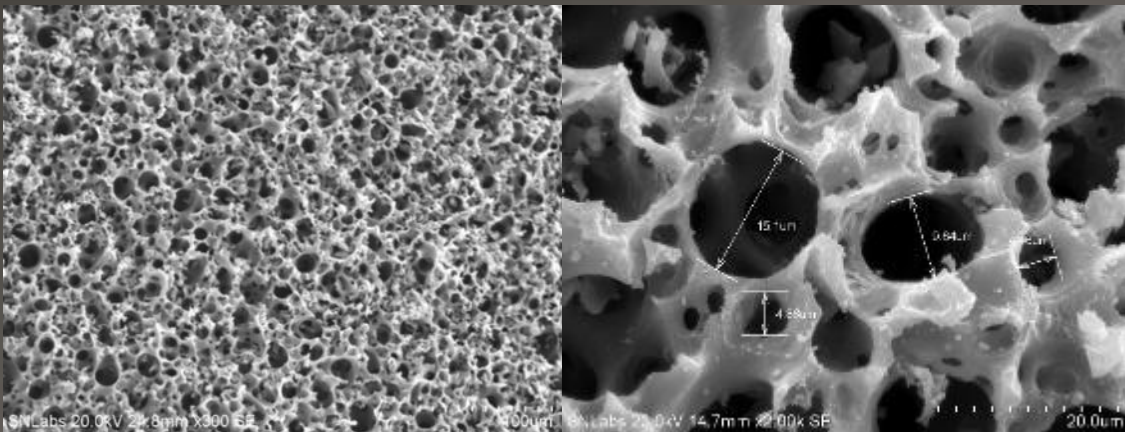
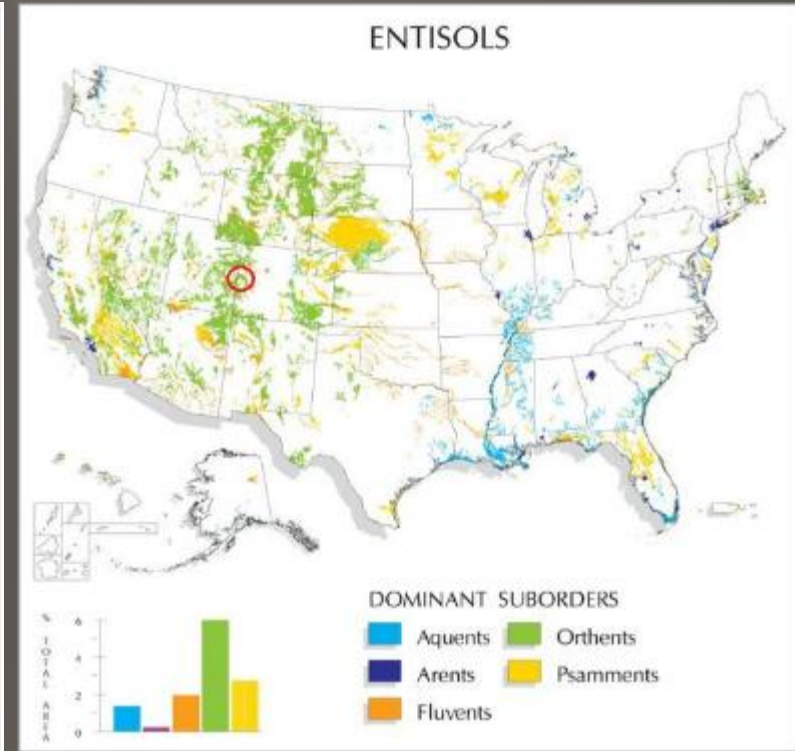
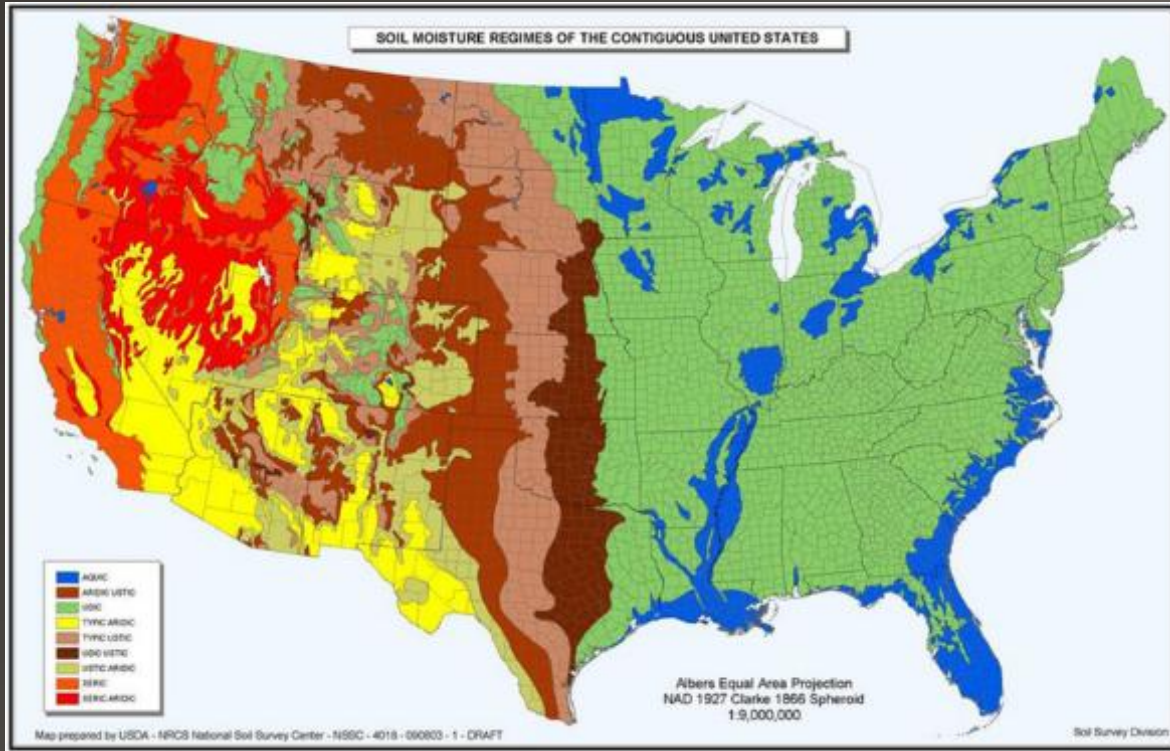
- Concept Fall of 2022
- Applied May 9, 2023

•WHY:

- Without mass disturbance/tillage**, can soil be **quickly modified** to hold more water and improve biology making it further drought resilient?



Why Biochar in Western U.S. Soils?



Scanning Electron Microscope images of VGrid's biochar

- Western Soils: Low in Organic Matter & Water Limited
- What is biochar? – Extremely Porous Carbon
 - 1 gram >300 m² of surface area
 - 1 lb = 25 football fields
- What can biochar do? Absorb/adsorb water and nutrients

The beginning of this journey:

"How do I apply biochar"?

- Most common is broadcast followed by:
 - No tillage – subject to wind blowing it away
 - Minimal tillage – shallow depths may have minimal effects
 - Heavy tillage (plow) – deeper root zone depths
- Why not just till it in?
 - Heavy tillage is most logical for annual cropping systems
 - Not an option for min/no-till, perennial systems, orchards/vineyards or similar
 - A solution must:
 - Apply minimal amount of material to reduce costs, while optimizing effects
 - Apply material to root zone depths
 - Minimize disturbance to existing crop/soil

Vertical-Point Injection Conceptual Image

Microsites
“Hotspots”



An AI-generated image portraying the concept of vertical-point injection.

Using Golf Turf Technology to Test the Concept



Trial Map

Strip	1	2	3	4
Treatment	Biochar	Control	Biochar	Control
Irrigations per Month	1	1	2	2
Treatment Abbreviation	BC50	CON50	BC100	CON100



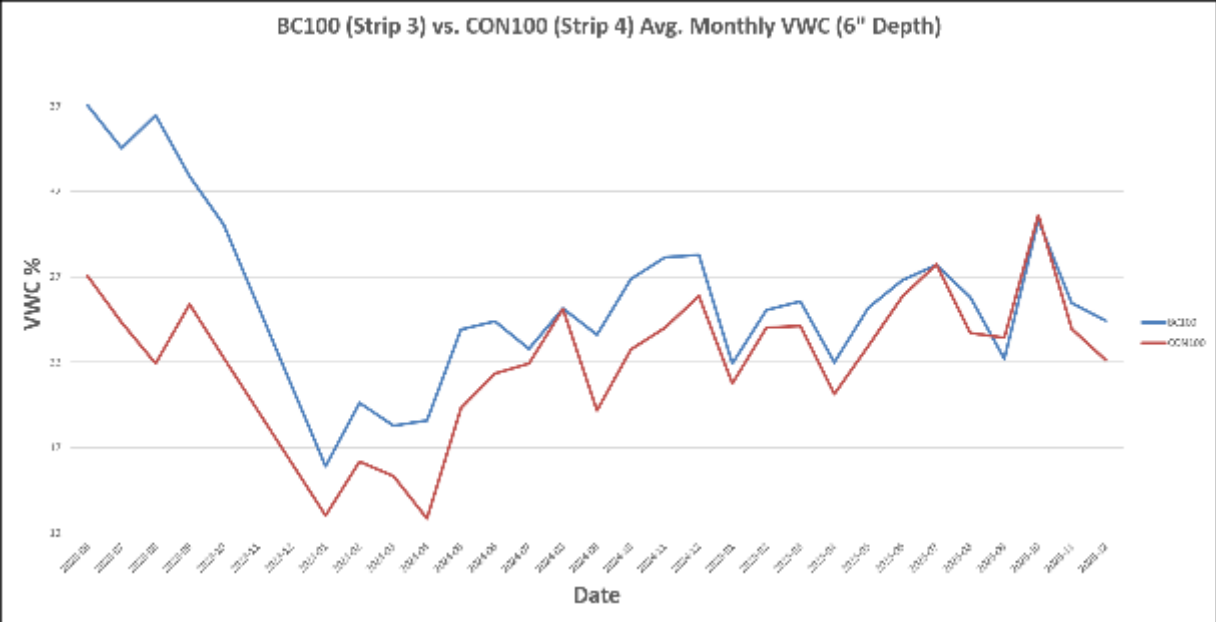
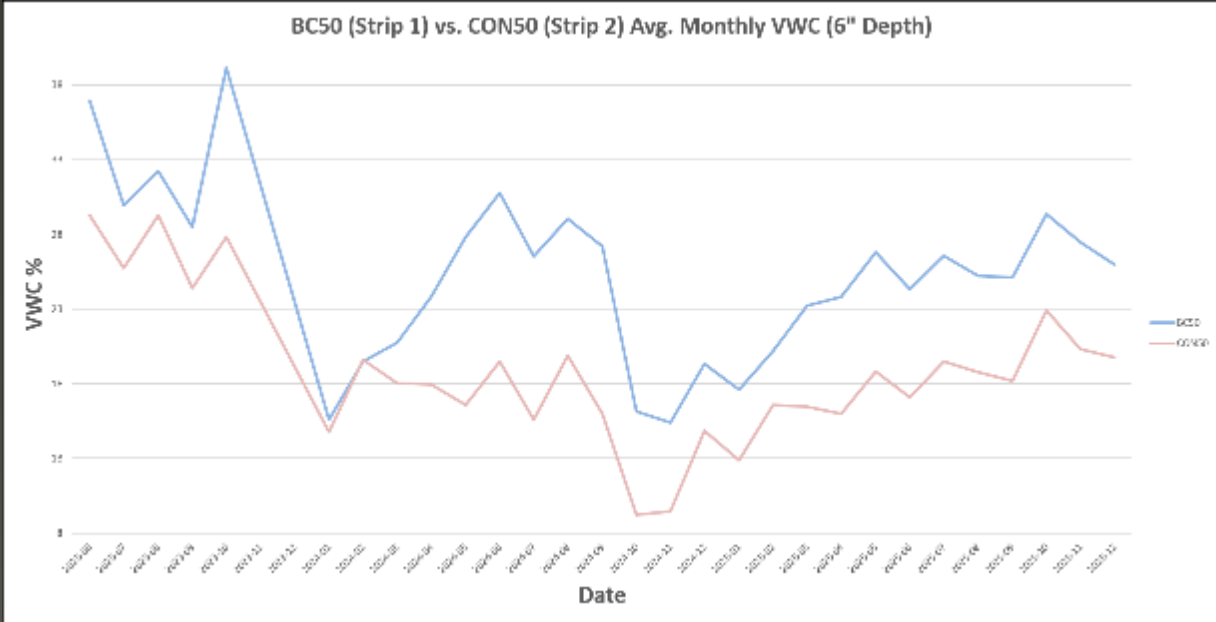
Sensors & Data Equipment



Jerry Nelson downloading data.

Does Biochar increase soil moisture (VWC %)?

VWC % Gain April 1-Oct 31, 2023-2025					
	Strip	1	2	3	4
Depth (in)	Treatment	BC50	CON50	BC100	CON100
6	Mean	27.8	20.1	27.1	23.0
	% Gain	38.5%		17.7%	
12	Mean	28.2	24.9	28.6	28.5
	% Gain	13.1%		0.2%	
18	Mean	32.2	29.3	34.0	31.7
	% Gain	9.8%		7.0%	



Yes.

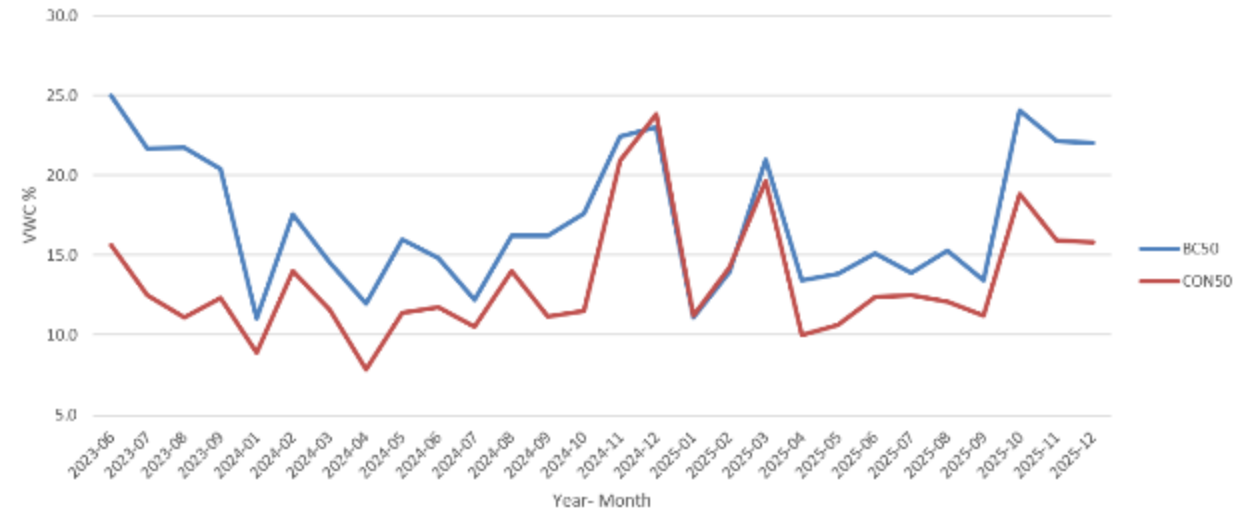
VWC Minima (Extreme Drought)

VWC % Gain 10th pct. Minima April 1-Oct 31, 2023-2025					
	Strip	1	2	3	4
Depth (in)	Treatment	BC50	CON50	BC100	CON100
6	Mean	14.0	9.9	16.8	12.1
	% Gain	41.5%		39.3%	
12	Mean	16.7	12.3	22.3	16.5
	% Gain	35.9%		34.6%	
18	Mean	20.7	16.4	26.1	24.1
	% Gain	26.6%		8.3%	

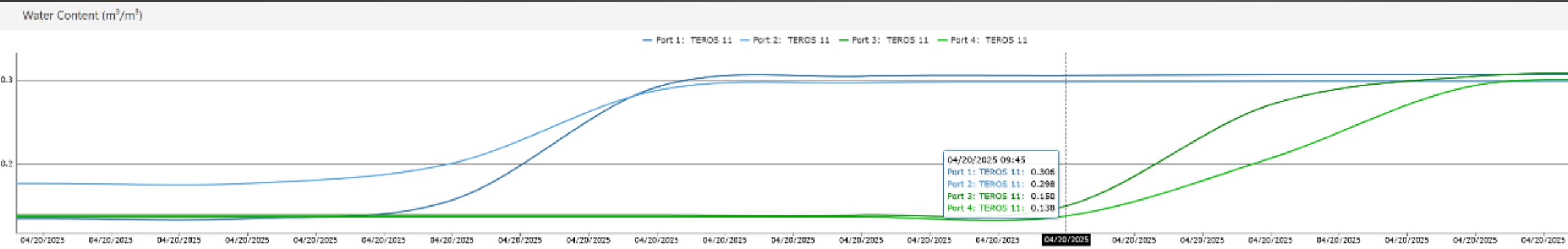
BC50 vs. CON50 VWC 10th Percentile Monthly Minima Avg. 2023-2025 (6" Depth)



BC100 vs. CON100 VWC 10th Percentile Monthly Minima Avg. 2023-2025 (6" Depth)



Infiltration & Bulk Density



- Soil profile is filled about 1-1.5 hours quicker based on what we see with the sensor network.
 - Blue is Strip 3 (BC100)
 - Green is Strip 4 (CON100)

Bulk Density (g/cm^3)				
Strip	1	2	3	4
Treatment	BC50	CON50	BC100	CON100
Sample 1	1.36	1.48	1.56	1.49
Sample 2	1.28	1.44	1.47	1.52
Sample 3			1.37	1.41
Sample 4			1.40	1.46
Sample 5			1.39	1.50
B.D.	1.32	1.46	1.44	1.48
% Δ	-9.4%		-2.6%	

Hay/Forage Yield

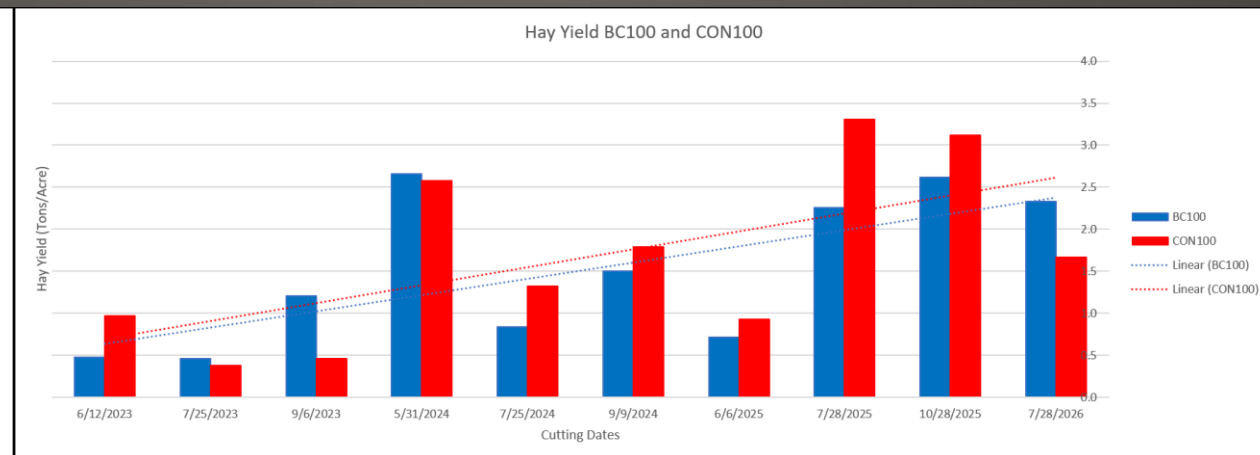
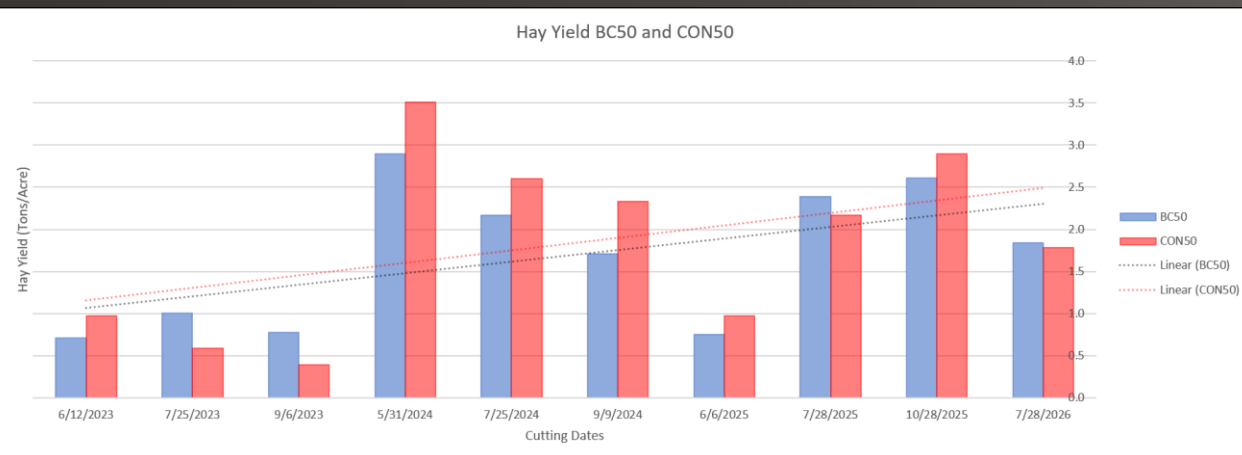
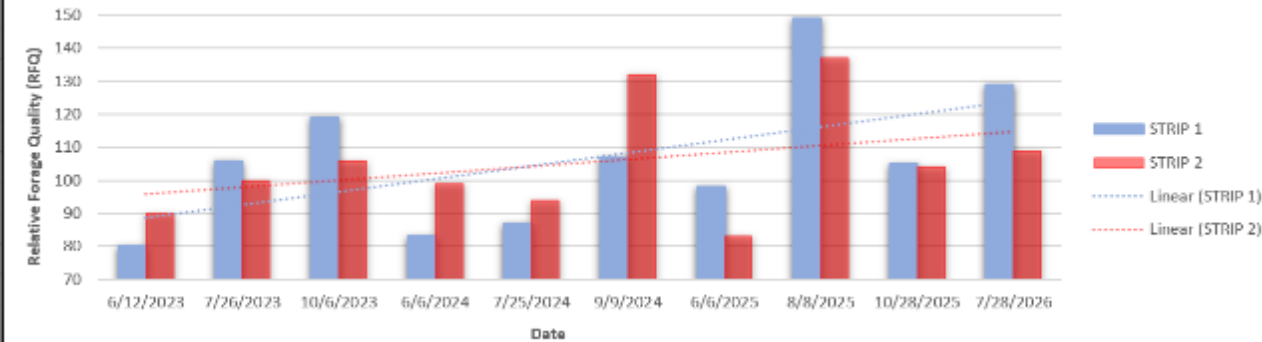


Photo taken June 20, 2023

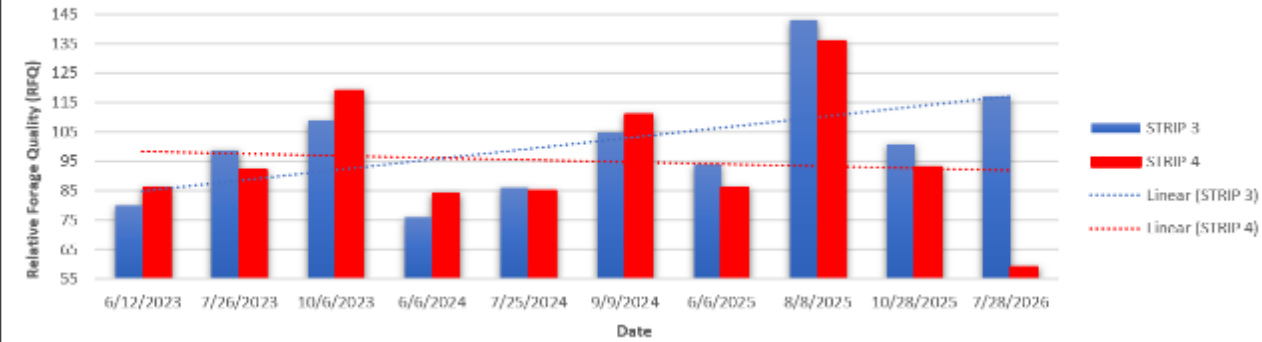
Hay Yield (tons·acre-1) 2023-2026		
Yield Ratio	BC50/CON50	BC100/CON100
%	92.2%	90.9%
BC Yield Delta Δ	-7.8%	-9.1%

Forage/Hay Quality

Relative Forage Quality (RFQ) - Strip 1 (BC50) vs. Strip 2 (CON50)



Relative Forage Quality (RFQ) - Strip 3 (BC100) vs. Strip 4 (CON100)



RFQ = fiber quality and digestibility



Holly Stanley collecting grass samples.

Fertilizer Recommendations

2023-2026 Nutrient Totals (lb/acre)	N	P	K	Mn
Biochar Strips	90.0	137.5	115.0	27.0
Control Strips	130.0	147.5	157.5	24.0
Biochar Strips Fertilizer Delta Δ	-31%	-7%	-27%	13%

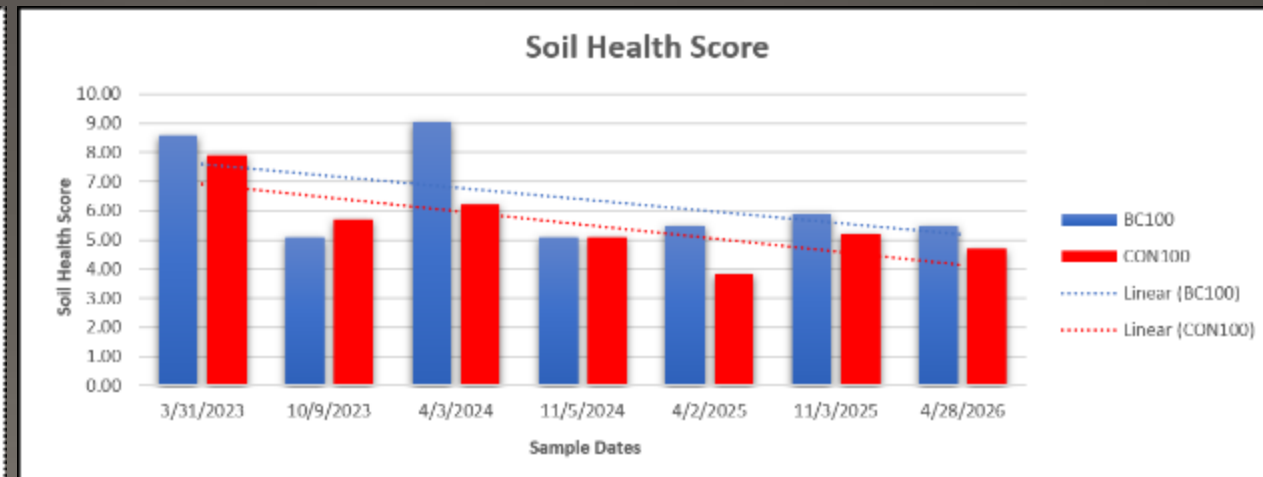
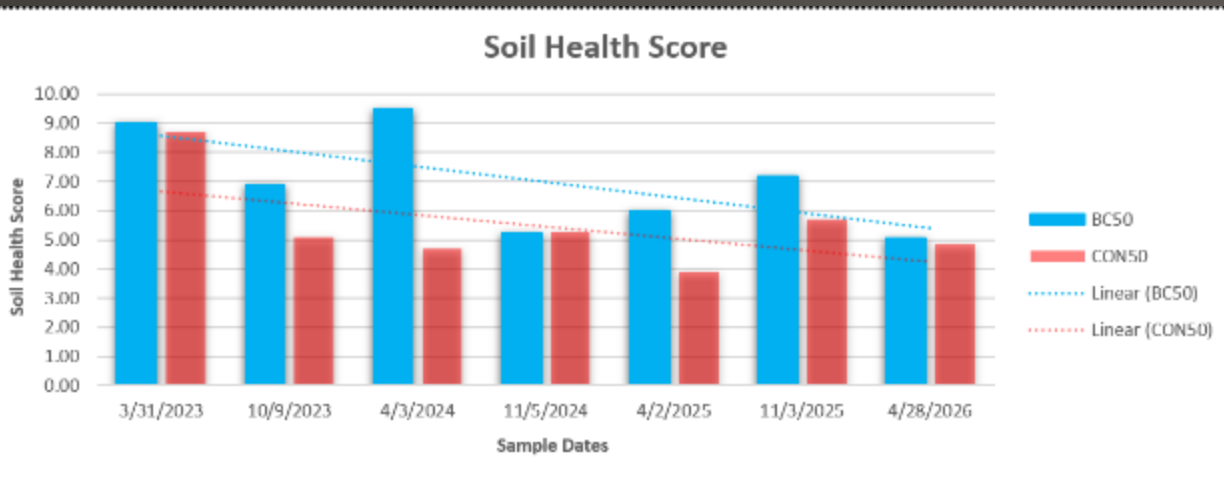
Partial Factor Productivity of Nitrogen (PFPN)						
Strip	1	2	3	4	BC (tons/lb N)	CON (tons/lb N)
Treatment	BC50	CON50	BC100	CON100		
Total Yield (tons/ac)	16.8	18.2	15.0	16.5	0.35	0.27
Total N Applied (lb/ac)	47.5	70.0	42.5	60.0		
PFPN (tons hay per lb N)	0.35	0.26	0.35	0.28		

Total Yield/Total N Applied Over 4-Years

Soil Health 2023-2026

Primary Group	Variable	Primary Driver
Chemical Environment	1:1 Soil pH	Irrigation
	CEC/Sum of Cations (me/100g)	Irrigation
Ionic Balance / Salinity	%Ca Sat	Interaction
	%Mg Sat	Interaction
	%Na Sat	Interaction
	1:1 Salts (mmho/cm)	Interaction
	Sodium (ppm)	Interaction
Nutrient Retention & Storage	Potassium (ppm)	Biochar
	Total N H ₂ O (ppm)	Biochar
Organic Matter / Nutrient Cycling	Organic C:N H ₂ O (ppm)	Biochar
	Organic N H ₂ O (ppm)	Interaction
Soluble Nutrient Dynamics	%K Sat	Irrigation
	Calcium (ppm)	Irrigation
	Iron (ppm)	Irrigation
	Magnesium (ppm)	Irrigation
	Manganese (ppm)	Interaction
	NO ₃ -N H ₂ O (ppm)	Irrigation
	Olsen P (ppm)	Irrigation
	Sulfate (ppm)	Interaction

- To fairly compare metrics: use standardization as well as 2-way ANOVAs.
 - The first soil test of trial is prior to amendment.
- 1:1 Salts and Sodium **ONLY** decreased in BC100
 - Suggests strong interaction effects of biochar + irrigation
- N & K retained

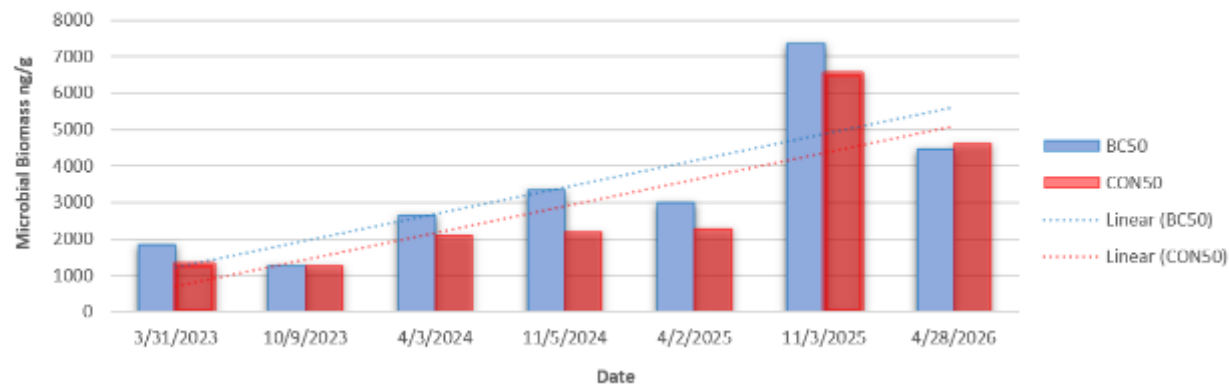


Soil Biology (PLFA) 2023-2025

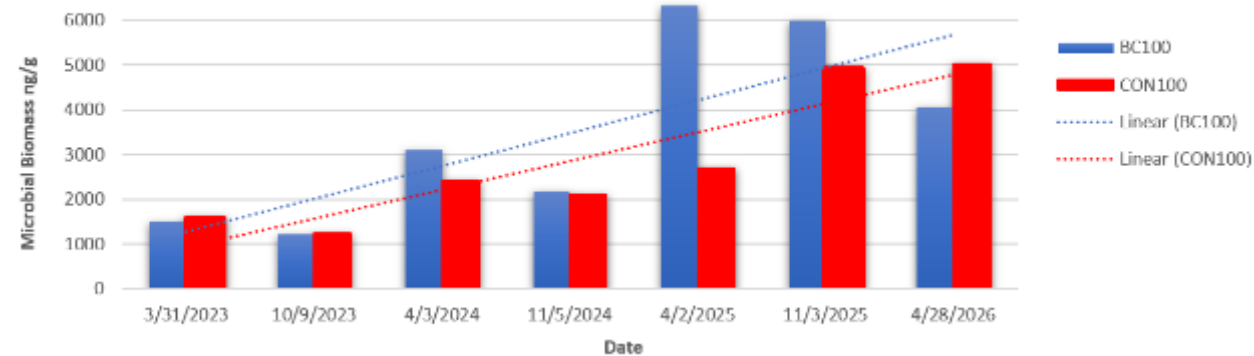
Primary Group	Variable	Primary Driver
Community Balance	Fungi:Bacteria	Interaction
Community Structure	Gram (-) %	Irrigation
	Gram(+):Gram(-)	Biochar
Stress / Membrane Dynamics	Pre 16:1w7c:cy17:0	Biochar
	Pre 18:1w7c:cy19:0	Biochar
	Sat:Unsat	Biochar

- BC plots show a decrease in stress markers
- Controls show an increase
- Suggests BC soils experience less physiological stress on microbial community.

Total Living Microbial Biomass



Total Living Microbial Biomass



Economics

Cost = \$6,000/acre, obviously not practical. Most of cost is reflected in the golf turf industry (application)

ARIES makes this process possible for apx. \$500/acre (once prototype is refined)

NOT limited to biochar; other materials, minerals or combinations could be used

Consider savings of water, fertilizer, tractor passes, labor, incentives, carbon credits

Hedge or insurance against crop failure (drought) for high value crops

For: perennial, min. or no-till systems, rangeland, pasture, vineyards, orchards, reclamation, remediation, forestry, urban green belts...

One & Done: Only 1 application is expected to be needed

Data Summary

38% more VWC at 6" depth, modified quickly, without tillage or need to replant.

VWC 10th percentile minima increased by apx. 40% over controls – buffering against extreme drought stress!

Hay/forage yield decreased 8-9% but RFQ improved

Increased soil health metrics, meaningful increase in soil biology activity = Decrease in microbial stress

Decreased nitrogen and fertilizer inputs thereby increasing Nitrogen Use Efficiency by 29.6%

ARIES Soil Modification System Mk1 Prototype (patent pending)

ARIES Mk1 in Operation



Media & Links

- [Field Trial Plan](#)
- WWW.BIOCHARRESEARCH.ORG
- [Instagram Reel of Field Application](#)
- [GJ Sentinel](#)
- [NBC 11 News](#)
- [Rocky Mtn. PBS](#)
- [USDA Fresh Growth Podcast](#)

THANKYOU