

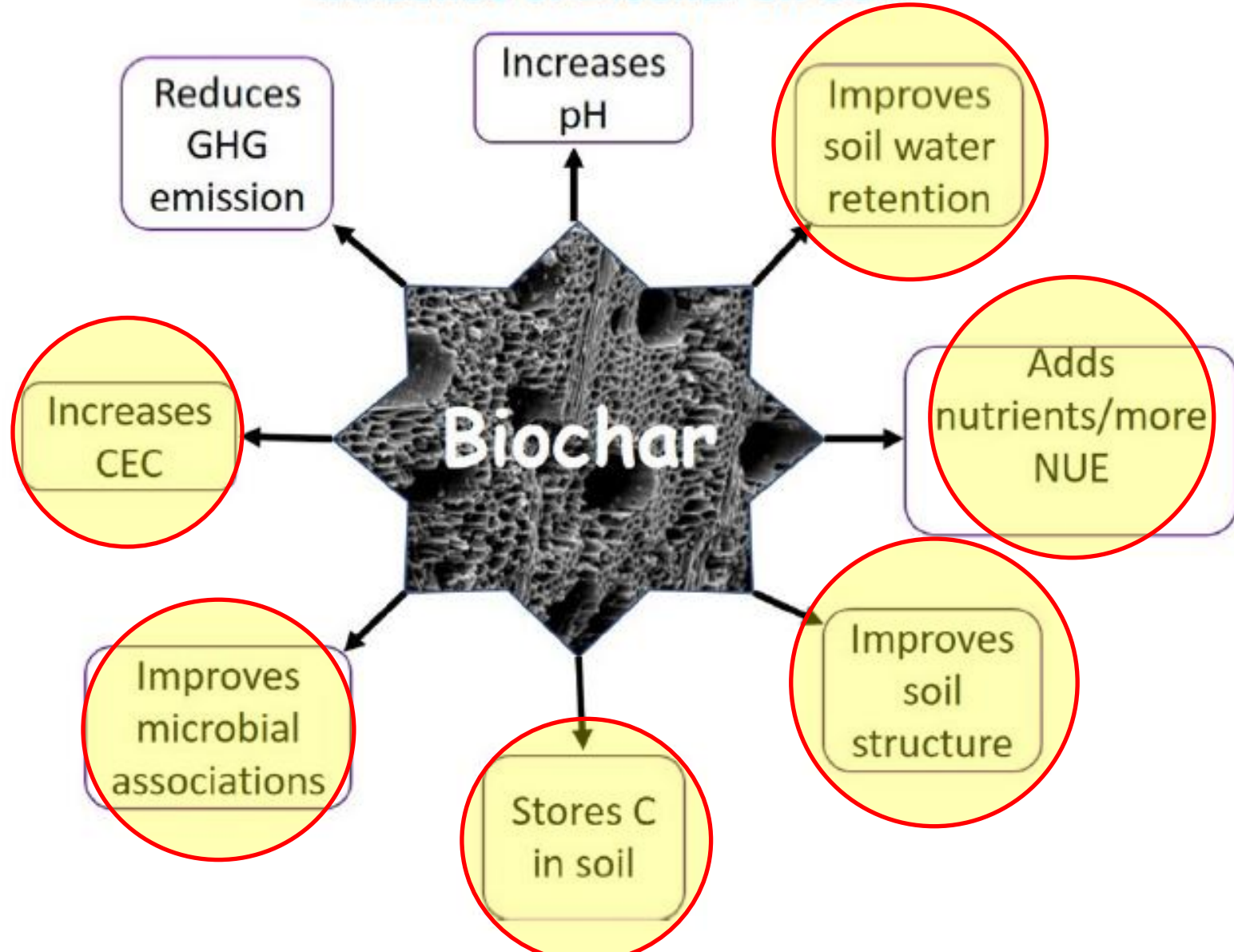
Use of Biochar as Soil Amendment Improve Reclamation Success and site Resiliency

Amir Hass
West Virginia State University

ASRS
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Why Biochar?

Influence of Biochar on Soil



Reclaimed Mine Study Sites

Farm land (2)

Reclaimed mine sites (3):

- MTRVF reclaimed in early 2000's
- PMLU wildlife habitat

Site Preparation

- Brush hogged
- Ripped (box ripper) to 6-8"
- Disked
- Fertilized (triple 19 @ 300lb acre⁻¹)
- Disked and seeded with 135 lb of wheat and 80 lb of pasture mix per acre

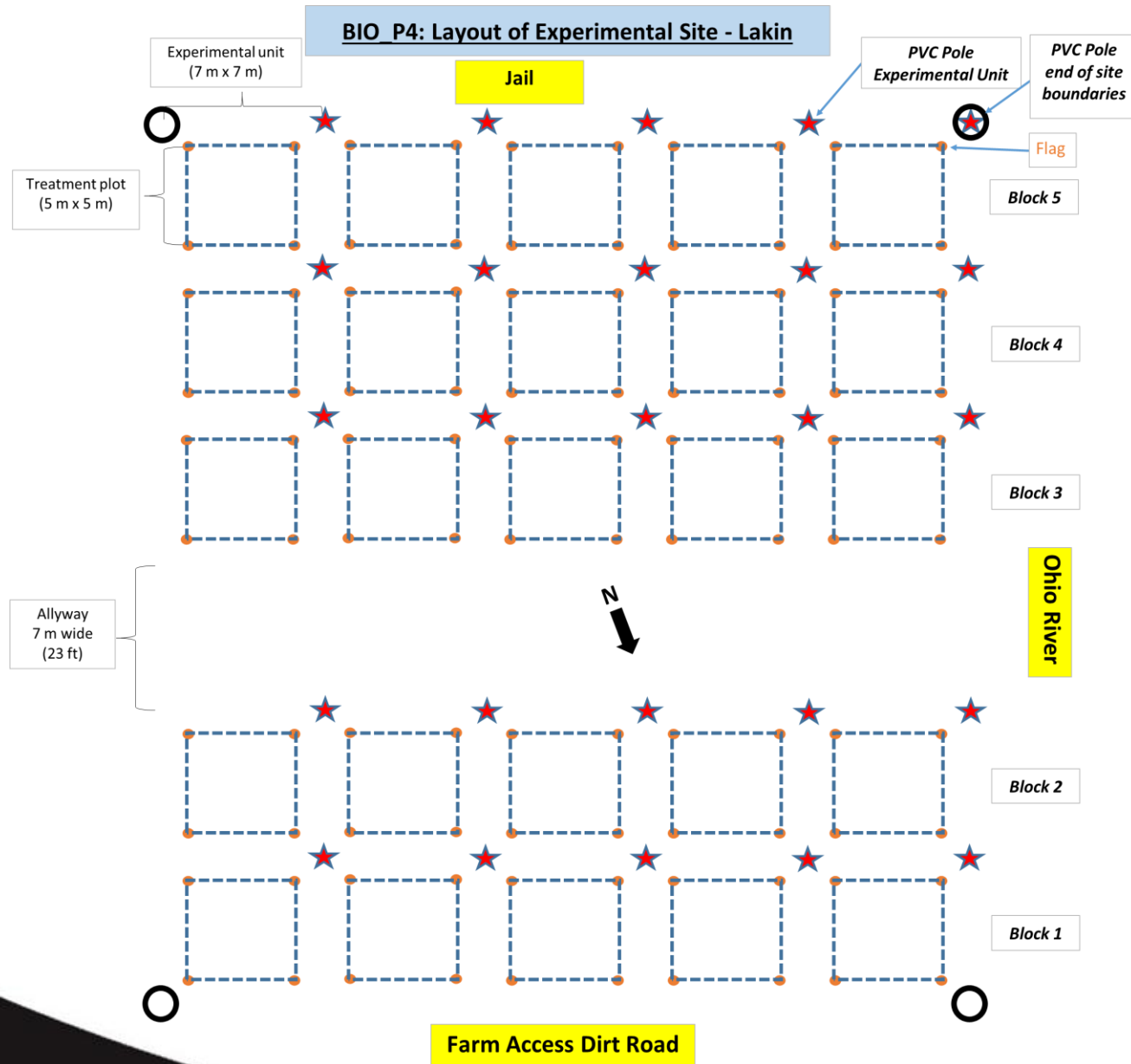
Treatments:

Biochar Application 0, 6, 12, 24, 48, 96 Mg ha⁻¹



Reclaimed Mine Study Sites

Experimental layout (RCBD)





BIO 1

Broom sage
(*Andropogon virginicus*)

pH 5.5
OM 4.0 %
P 5 ppm
K 79 ppm
NO₃⁻ 14 ppm



BIO 2

Lespedeza
(*Lespedeza cuneata*)

pH 4.6
OM 6.7 %
P 13 ppm
K 116 ppm
NO₃⁻ 27 ppm

BIO 3

pH 5.5
OM 6.5 %
P 11 ppm
K 118 ppm
NO₃⁻ 36 ppm

Autumm olive
(*Elaeagnus umbellata* Thunb.)



Biochar Treatment Instalation



Biochar Treatment Instalation

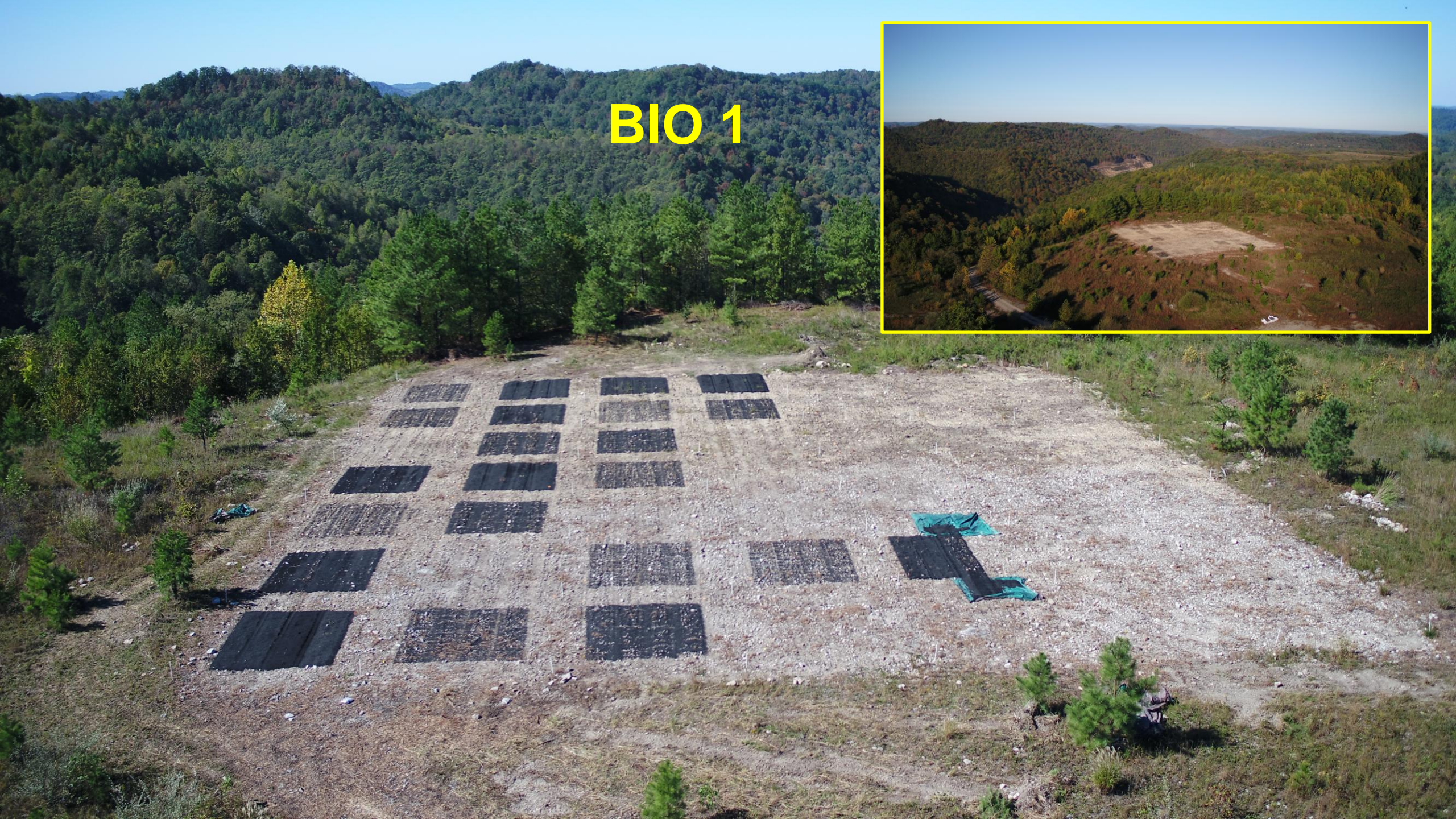








BIO 1



BIO 1



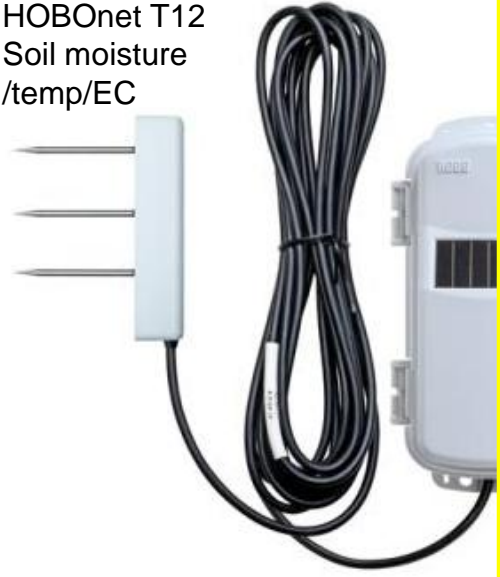




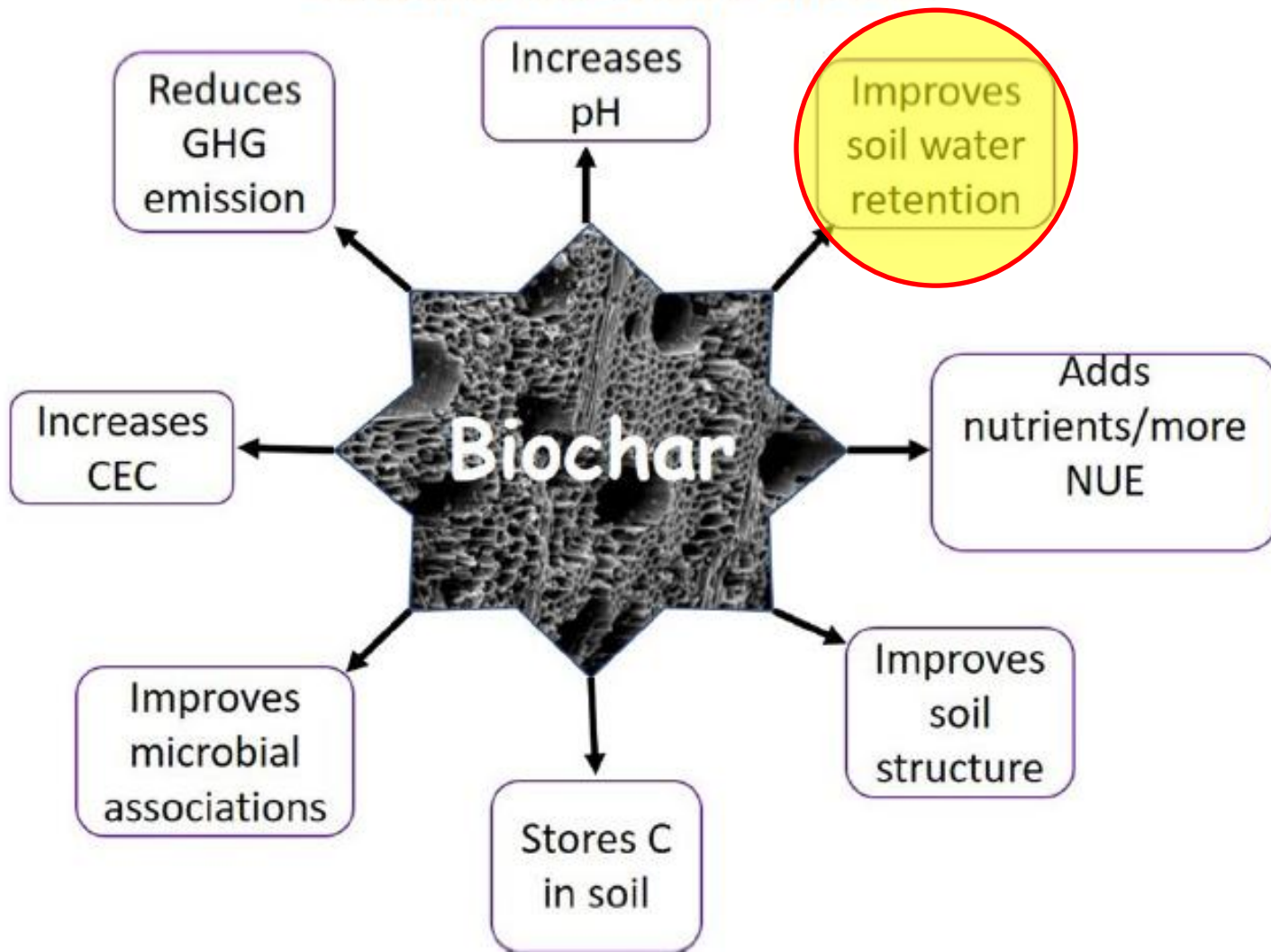




HOBOnet T12
Soil moisture
/temp/EC



Influence of Biochar on Soil



Soil Moisture Limitation Within Ecoregion:

- Infiltration Rate
- Hydraulic Conductivity (percolation)
- Soil Water Storage Capacity
- Evapotranspiration
- Drainage
- Salinity
- Water retention

Water Use Efficiency

Values of WUE (g dry matter/kg water) of energy crops and of some common forest trees and agricultural crops.

Transpiration only, aboveground biomass

Beets (<i>Beta</i>)	6.1 g/kg
Beech (<i>Fagus</i>)	5.9 g/kg
<i>Pseudotsuga</i>	5.8 g/kg
Willow (<i>Salix</i>)	4.1-5.5 g/kg
<i>Salix + Alnus + Betula</i>	4.8 g/kg
Barley (<i>Hordeum</i>)	4.2-4.8 g/kg
Spruce (<i>Picea</i>)	4.3 g/kg
Peas (<i>Pisum</i>)	3-4.3 g/kg
<i>Miscanthus</i>	2.2-4.1
Larch (<i>Larix</i>)	4.0 g/kg
Peas (<i>Pisum</i>)	3.4 g/kg
14 C ₄ plants	3.1 +/- 0.3 g/kg
Pine (<i>Pinus</i>)	3.3 g/kg
Birch (<i>Betula</i>)	3.1 g/kg
Oak (<i>Quercus</i>)	2.9 g/kg
Oats (<i>Avena</i>)	2.6 g/kg
51 C ₃ plants	1.6 +/- 0.4 g/kg

Water Use Efficiency

Evapotranspiration, above-ground biomass

<i>Miscanthus</i>	7.8-9.5 g/kg
<i>Spartina</i>	5.1-8.2 g/kg
<i>Cynara</i>	3.1-5.5 g/kg
<i>Miscanthus</i>	3.4-4.1 g/kg
<i>Willow (Salix)</i>	3.0-3.7 g/kg
Maize (<i>Zea</i>)	3.0 g/kg
Willow (<i>Salix</i>) stems only	2.2-2.9 g/kg
Willow (<i>Salix</i>) stems only	1.7-1.9 g/kg

Willow (short rotation):

10 – 12 Mg ha⁻¹ yr⁻¹

WUE ~ 4 g kg⁻¹

1 kg biomass → 250 L

1 Mg biomass → 250 m³

10 Mg biomass → 2,500 m³



~ 650,000 gal

~ 10 inch



Nutrient Use Efficiency

Table 2. Nutrient use efficiencies (g dry matter/ g nutrient) of some energy crops, forest trees, and of conventional agricultural crops. Calculated for the aboveground material at harvest. Values are shown for the 3 macro-nutrients N, P and K.

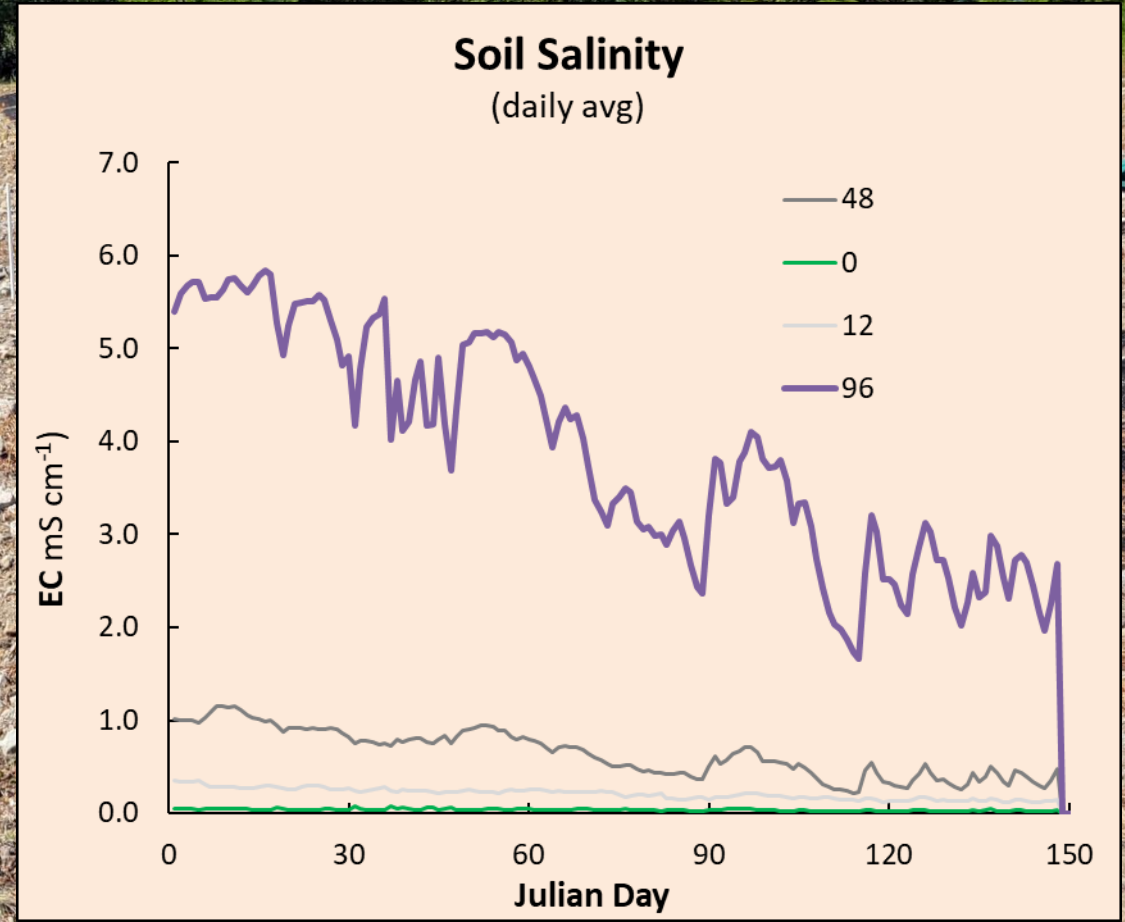
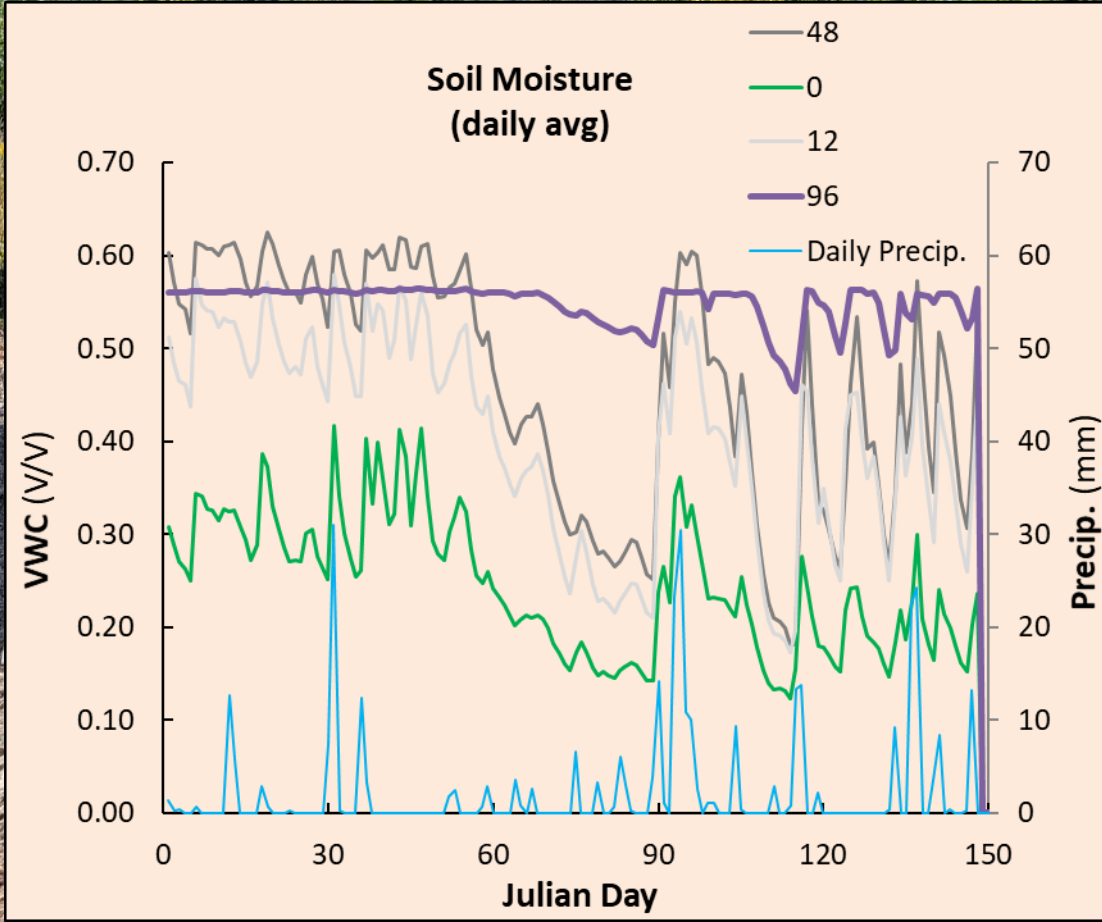
	N	P	K	
Forest wood chips	143-1000	5000	250-2000	(Sander, 1997)
<i>Miscanthus</i>	135-704	526-5000	78-556	(Lewandowski et al., 2001)
Poplar (<i>Populus</i>)	145-370	1000-2000	256-370	(Jug et al., 1999)
Cereal straw	67-333	500-3333	53-500	(Sander, 1997)
<i>Spartina</i>	310	2530	670	(Beale & Long, 1997)
Willow & poplar	104-269	831-2201	197-706	(Adegbidi et al., 2001)
Willow (<i>Salix</i>)	152-244	909-1429	323-500	(Jug et al., 1999)
Eucalypt 8y	219	3477	427	(Lodhiyal & Lodhiyal, 1997)
<i>Miscanthus</i>	200	1580	80	(Beale & Long, 1997)
<i>Miscanthus</i>	145-182	-	97-385	(Jørgensen, 1997)
Hemp (<i>Cannabis sativa</i>)	169-179	909-1111	91	(Flengmark, 2000)
Poplar (<i>Populus</i>)4y	174	1566	318	(Lodhiyal & Lodhiyal, 1997)
Poplar (<i>Populus</i>)9y	169	1496	318	(Lodhiyal & Lodhiyal, 1997)
Pine (<i>Pinus</i>)100y	129	1130	219	(Lodhiyal & Lodhiyal, 1997)
Maize (<i>Zea</i>)	66-111	333-556	86-161	(Beale & Long, 1997)
Rye (<i>Secale</i>) whole crop	107-109	-	97-105	(Jørgensen, 2000)
Reed Canary grass (<i>Phalaris</i>)	101	-	909	(Mortensen & Jørgensen, 2000)
Wheat (<i>Triticum</i>) whole crop	83-87	-	117-133	(Jørgensen, 2000)
Reed Canary grass (<i>Phalaris</i>)	43-78	278-385	40-76	(Geber, 2000)
Potatoes (<i>Solanum</i>)	73	358	53	(Beale & Long, 1997)
Ryegrass (<i>Lolium</i>)	63	333	56	(Beale & Long, 1997)

1 Kg of Willow biomass require:

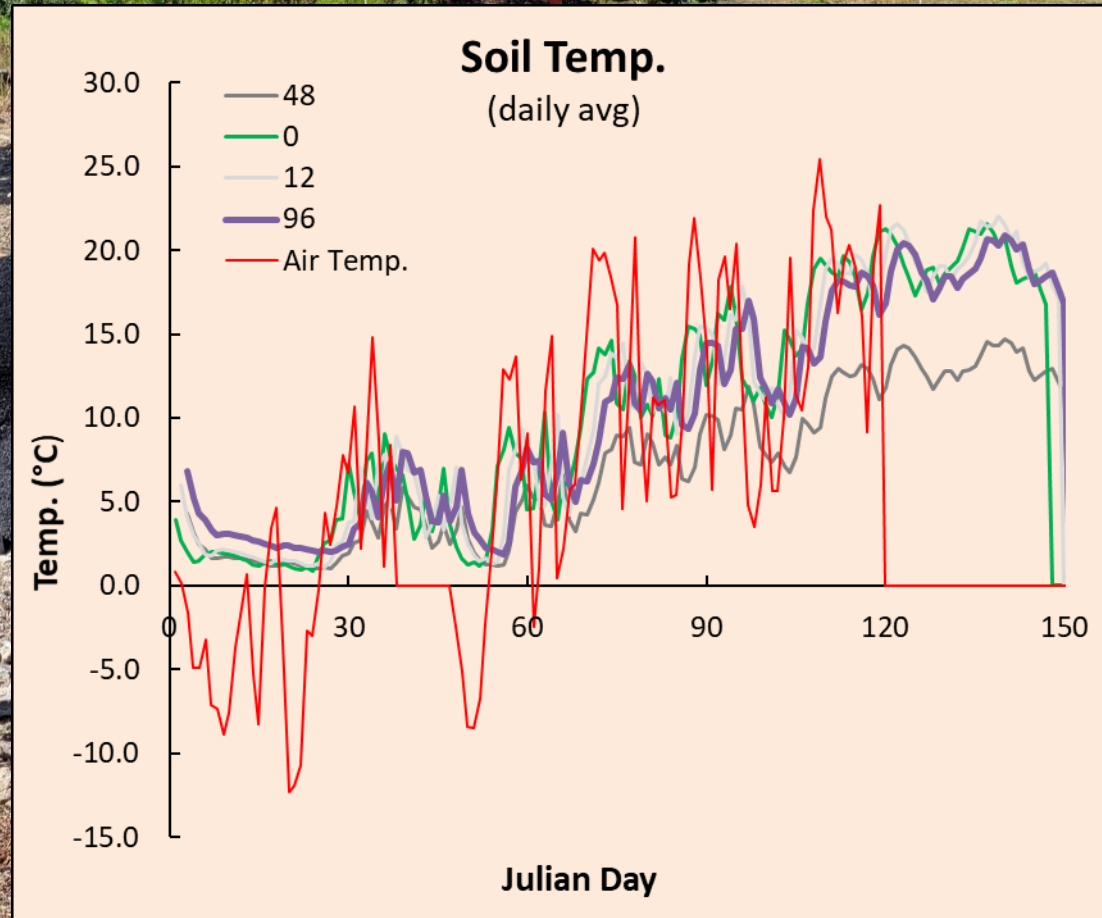
4.0g N	0.7g P	0.5g K
↓	↓	↓
40kg N	7kg P	5kg K



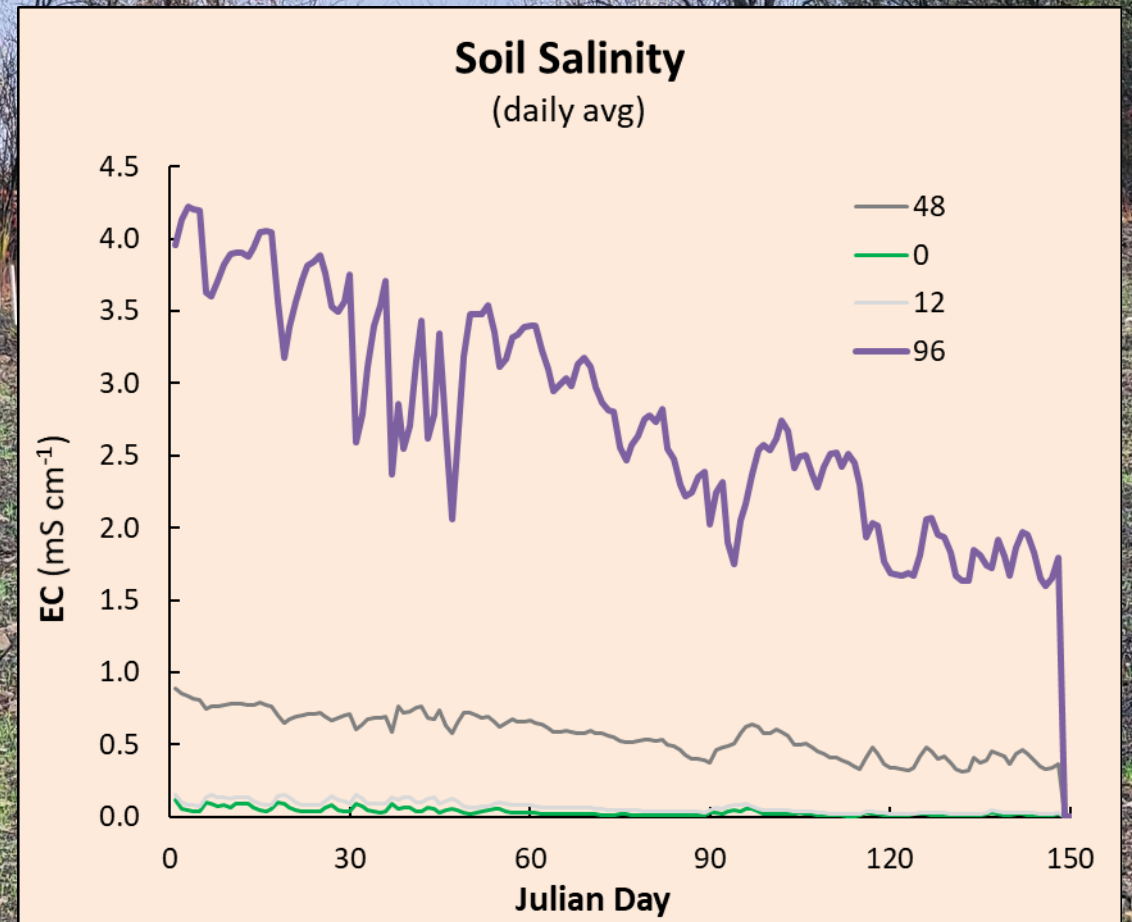
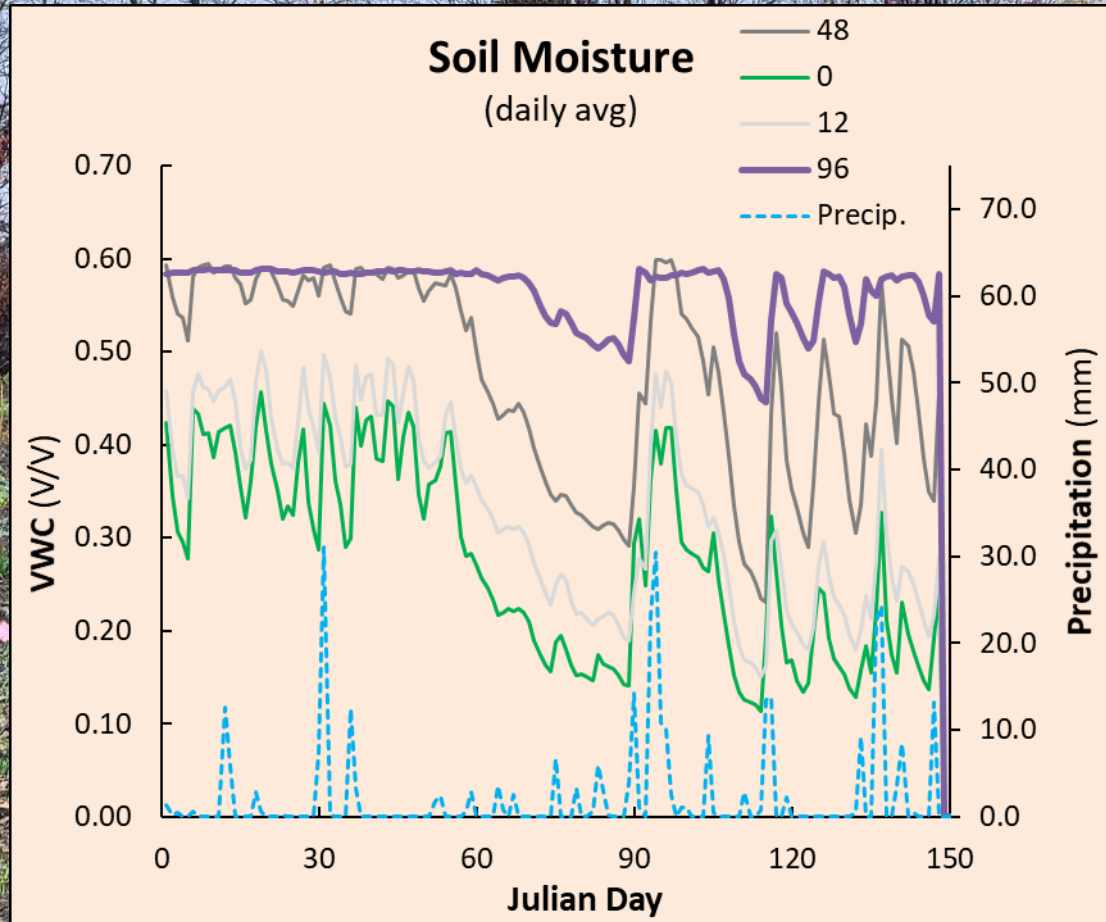
BIO 1



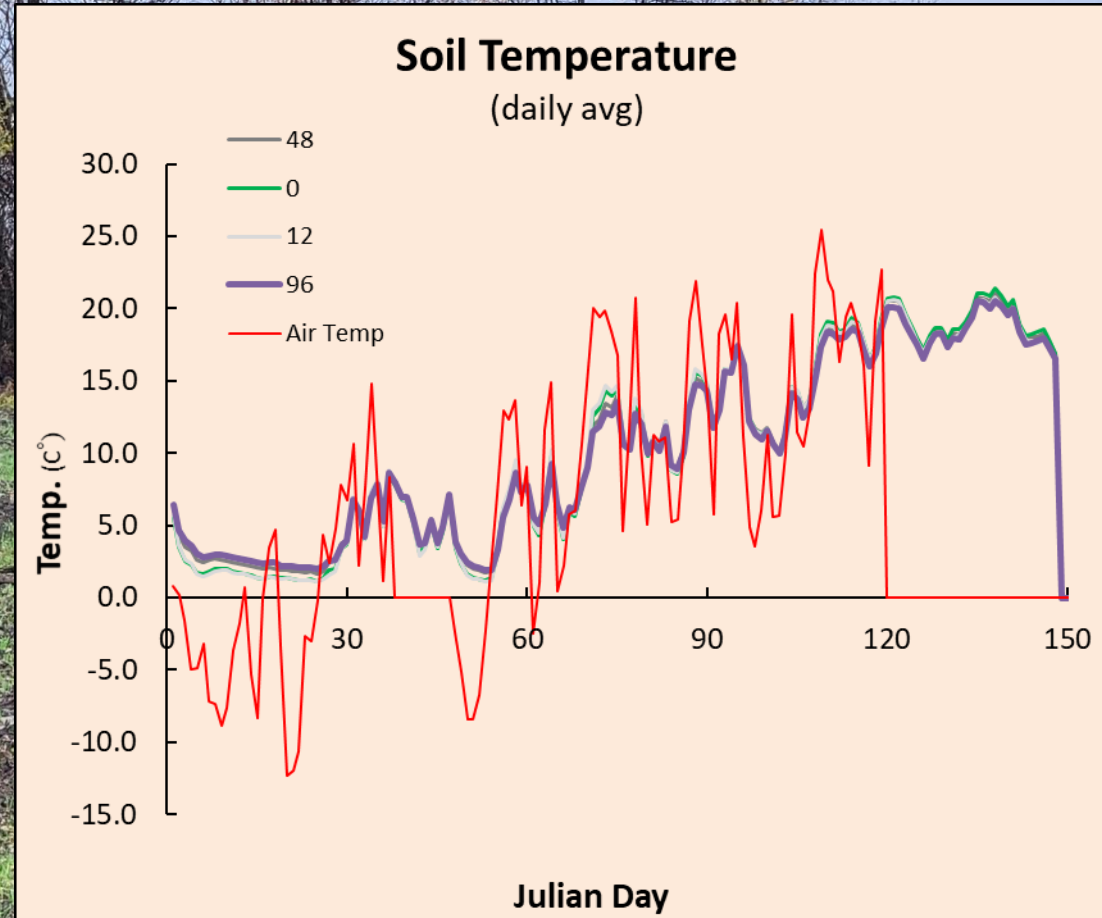
BIO 1



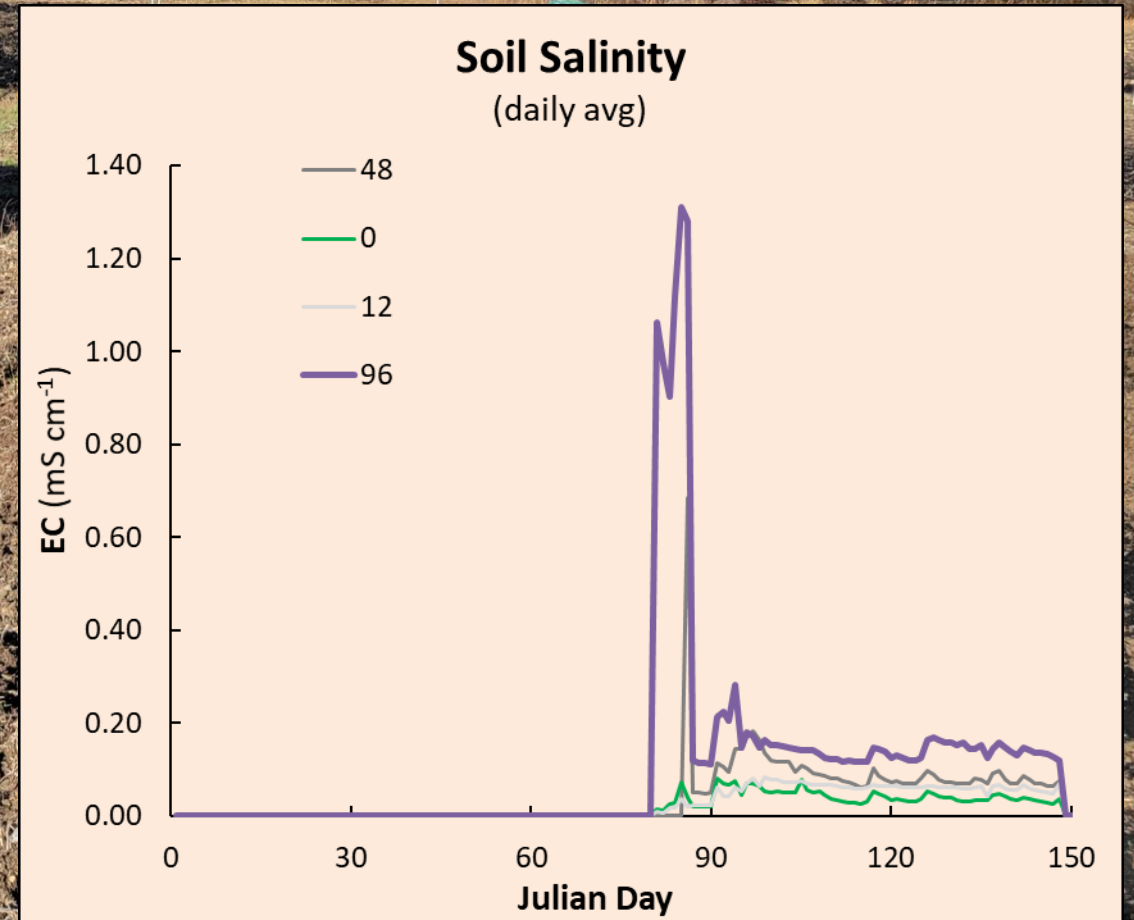
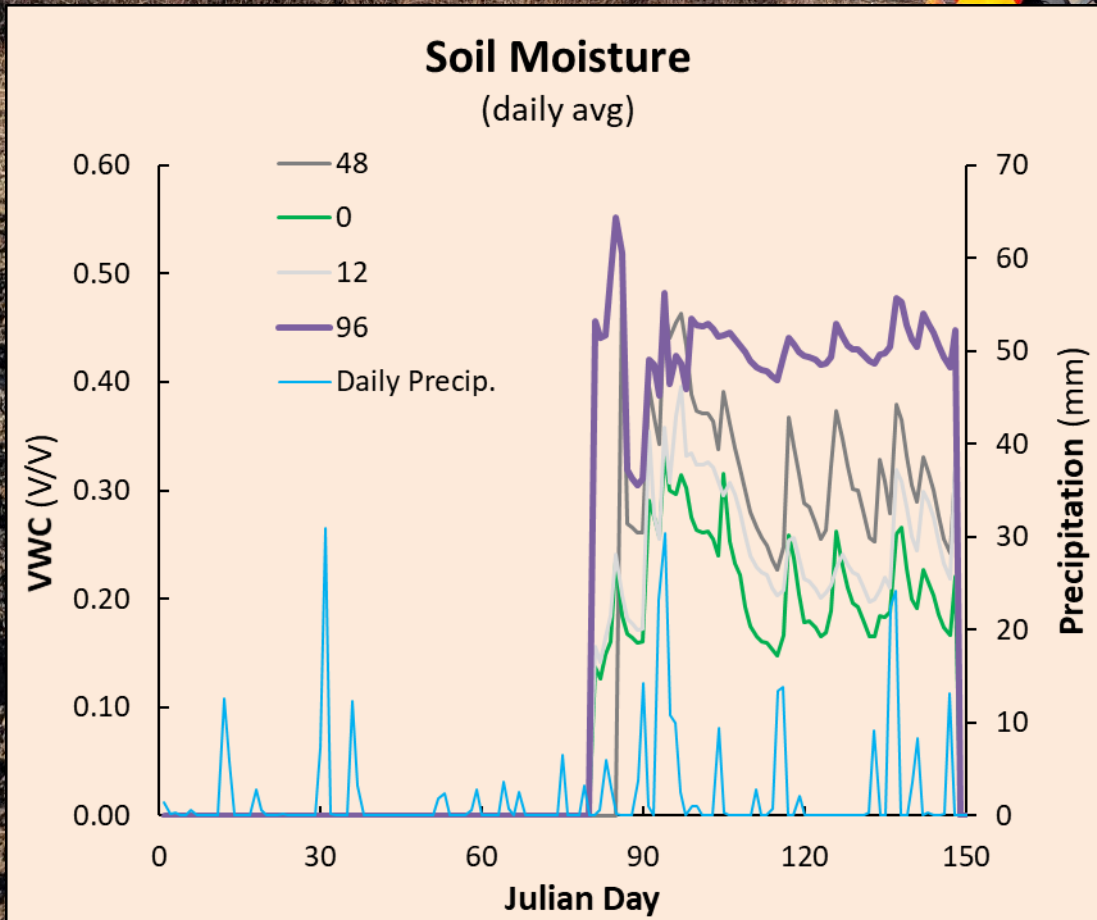
BIO 2



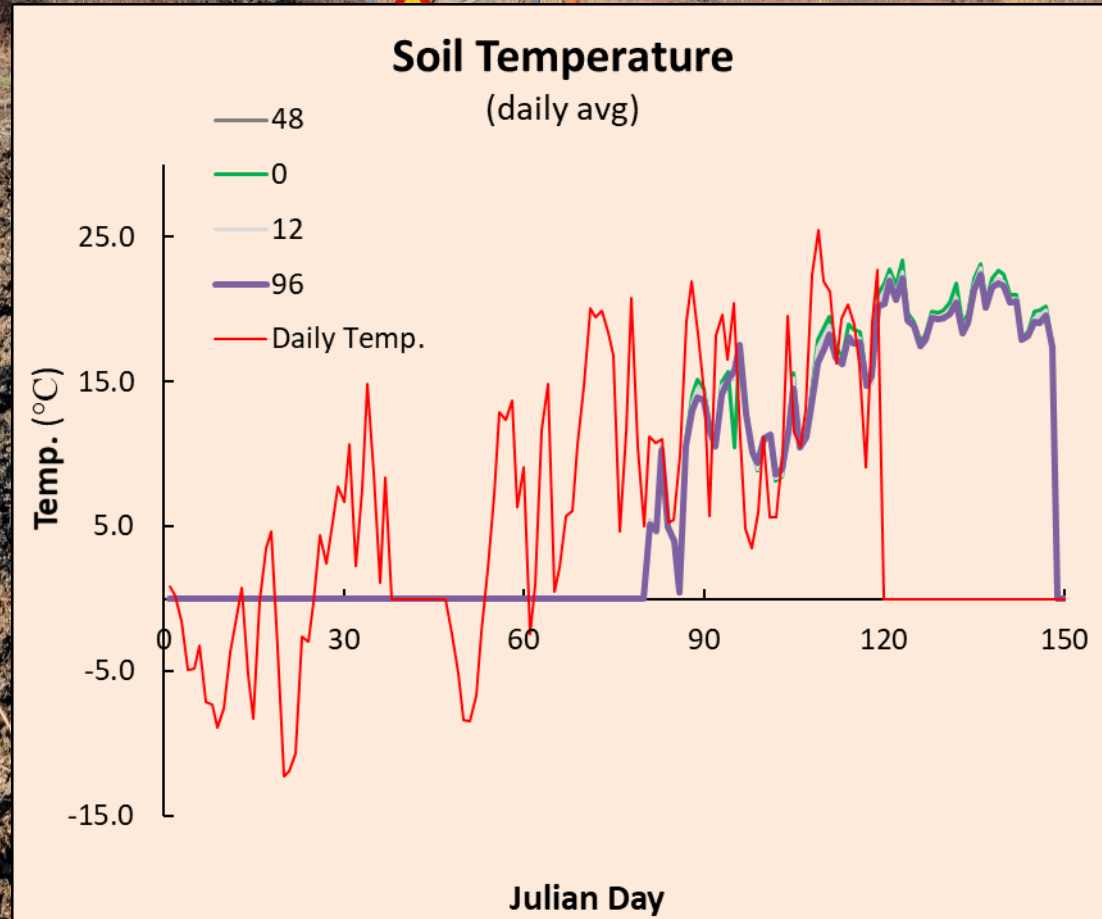
BIO 2



BIO 3

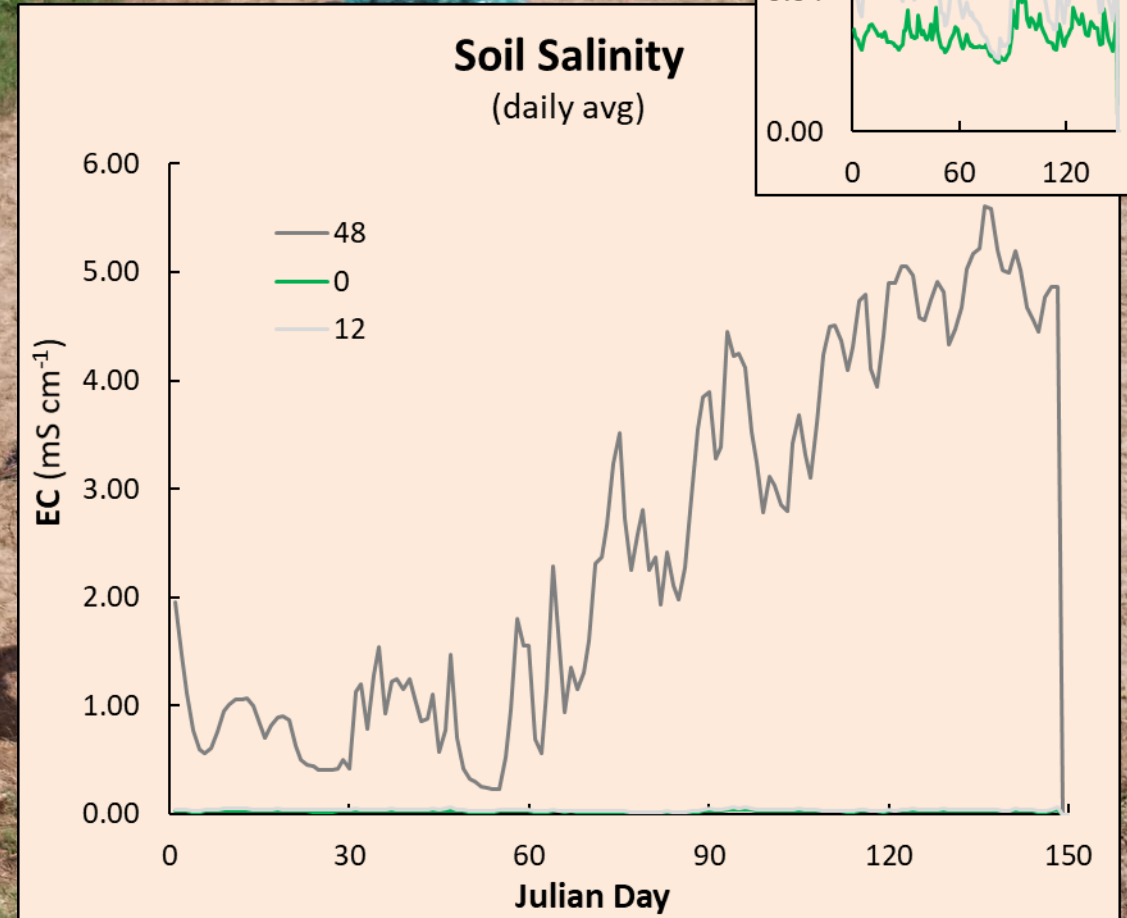
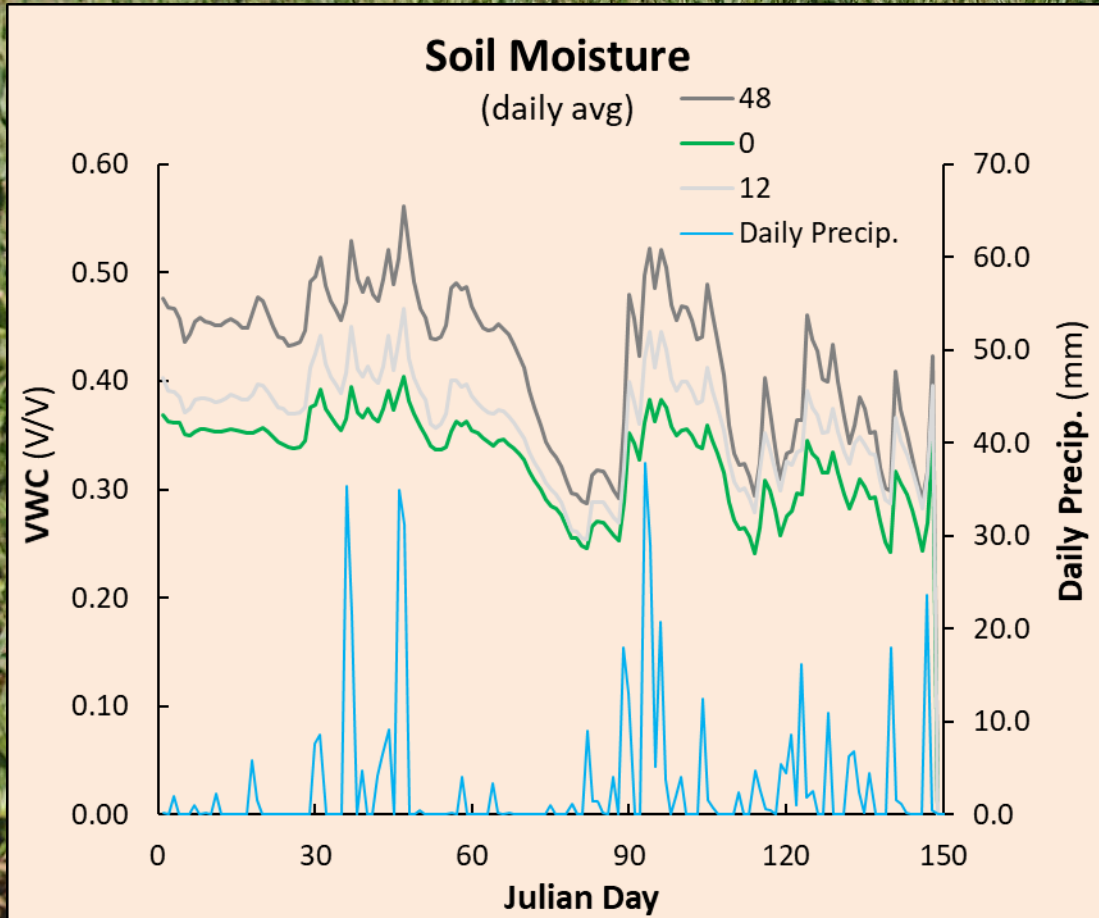


BIO 3



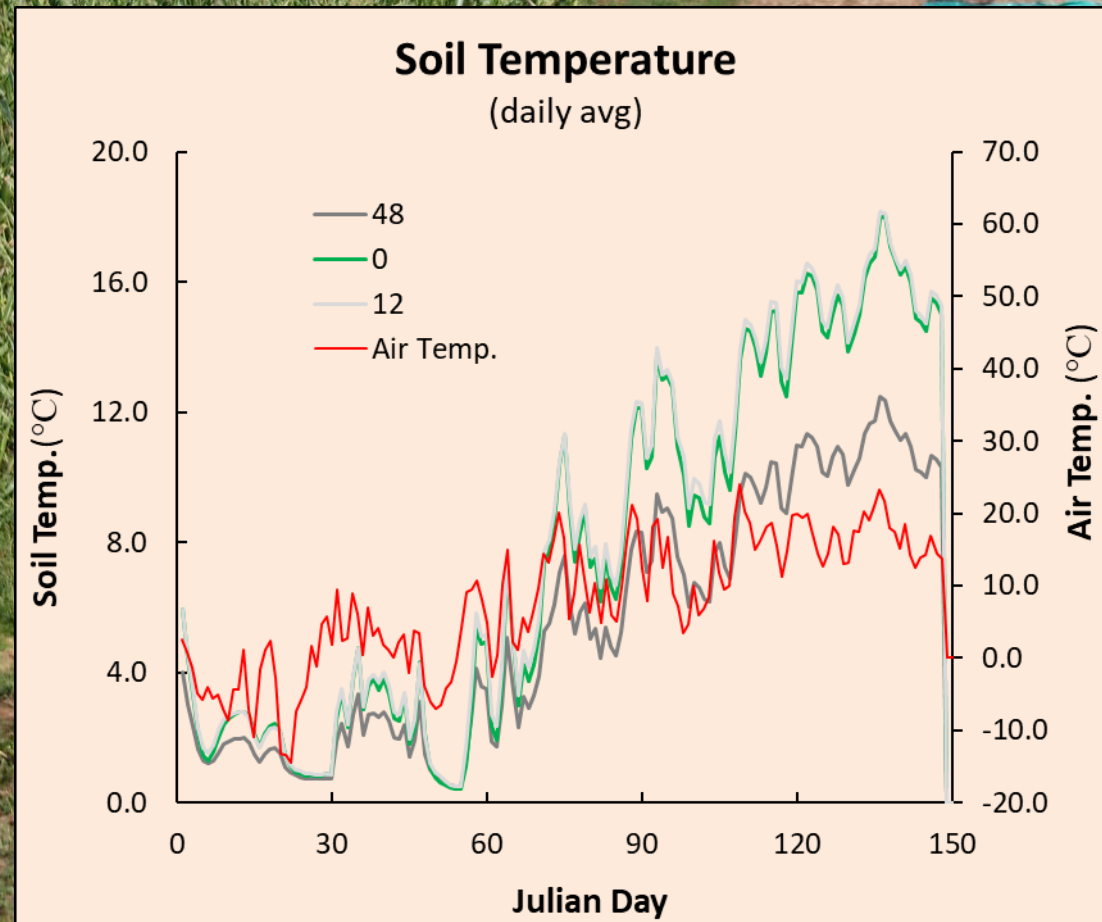
BIO 4

(Farm Land (acid, sandy, Lakin Soil Series))



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(Farm Land (acid, sandy, Lakin Soil Series))



Summary

- Biochar positively affected soil moisture content
- The effect on soil moisture increased with increase in application rate across sites
- Biochar application did not led to increase in soil temperature
- Biochar effect on soil salinity was additive and site/soil specific
- High application rate (96 Mg ha^{-1}) led to elevated levels of EC ($> 4 \text{ mS cm}^{-1}$), that decrease over time in the mine sites.



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Integrated Project on Ecosystem Resiliency**

Canyon Creek Charcoal Kilns

23 brick-domes charcoal kilns were built and operated from 1884-1900, turning local lodgepole pines into charcoal to the smelter in Glendale, some six miles downhill which extract silver and lead from ore mind in Helca, MT.

Silver Bow Club in Divide

- 1 acre of lodgepole pine forest produce 14 cords of wood.
- 1 cord of wood produces 45 bushels of charcoal
- 25 – 35 bushels of charcoal required to smelt 1 ton of ore

