CULTIVATING SUCCESS™

sustainable small farms education

Biochar: Properties and Potential as an Agricultural Amendment

Dan Strawn, University of Idaho Soil & Water Systems
and
Greg Moller, University of Idaho Food Science
February 16, 2021

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University of Idaho Extension

Rural roots
Healthy Food, Healthy Farms, Healthy Communities

Food Systems
Washington State University

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Today's Presenters

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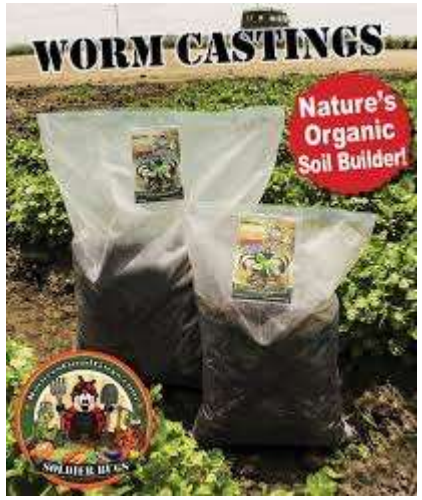
Colette DePhelps, moderator
Area Educator, Community Food Systems
University of Idaho Extension, Northern District

Amending soil to manage soil health, sustainability and productivity

Soil amendments: production gain vs cost



Background: Soil health and management

Three Concepts for managing soil health

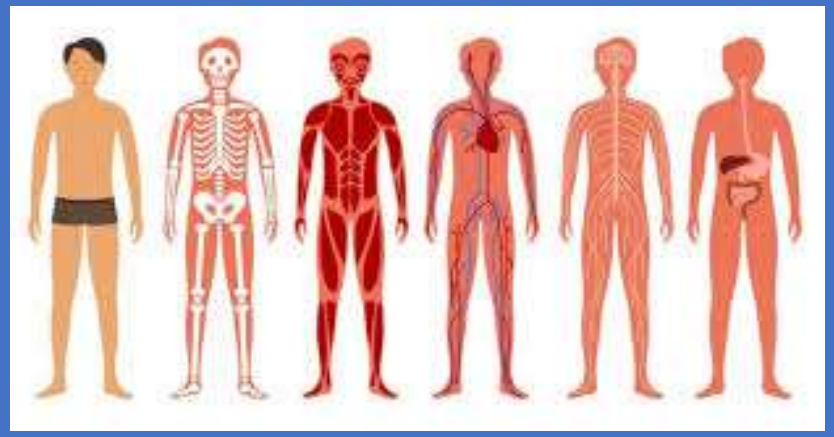
1. Soil is complex
2. Integrate better management
3. Adopt long-term goals for agriculture

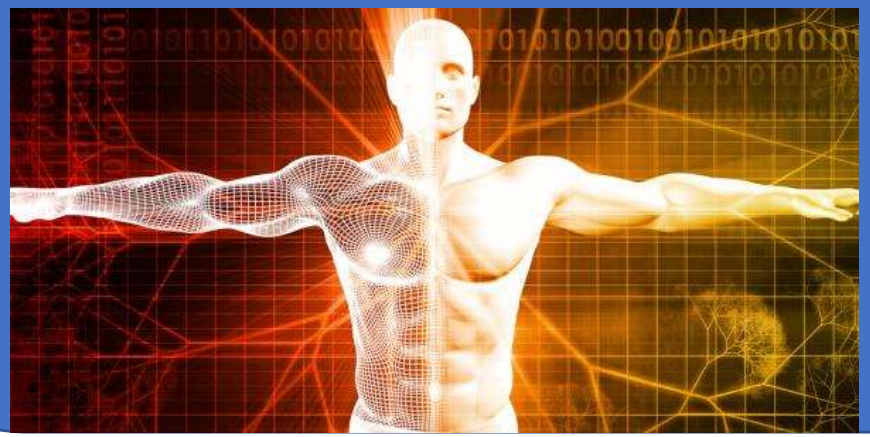
Photo Credit: Rich Sanders, USDA Natural Resources Conservation Service

Concept 1: When something is complex, caring for it is complex

Human systems:

Breakdown into parts

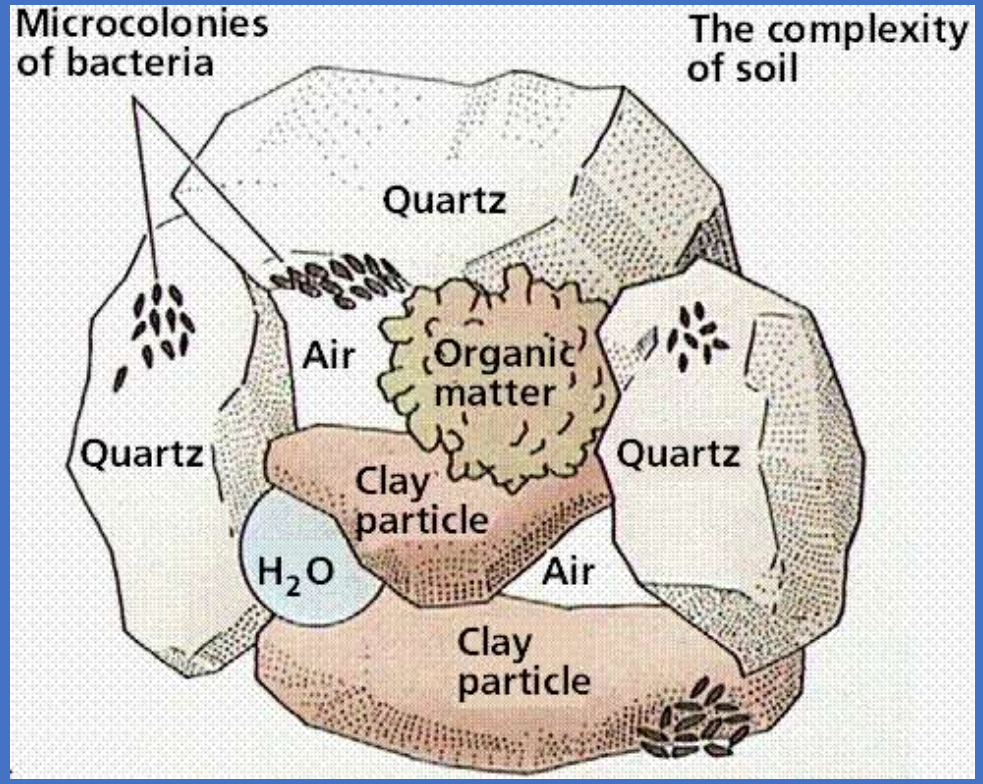




Care and treatment

Soil complexity

Soil can be broken down into parts



Soil is a very complex set of systems working together

Concept 2: We can manage agricultural and natural ecosystems to improve soil health

Traditional agriculture

- Manage soil for maximum productivity for the least cost
- What's good for crop production is good for soil
- Soil is resilient
- Problems in soil can be quickly fixed

Aspirational agriculture

- Manage soil and crop to produce profitable yield
  - … with an eye towards the long-term health of the soil and ecosystem
- Soil is worth investing in because it pays back dividends in terms of production and ecosystem services
- Healthy soil practices will create a more resilient soil
- Changes to the soil health should be a long-range plan

We are about 120 years into this experiment…

1200 BC

Ploughing with a yoke of horned cattle in Ancient Egypt. Painting from the burial chamber of Sennedjem, c. 1200 BC.

Early 20th-century image of a tractor ploughing an alfalfa field. Dan Albone constructed the first commercially successful gasoline-powered general-purpose tractor in 1901

Concept 3: The way forward-

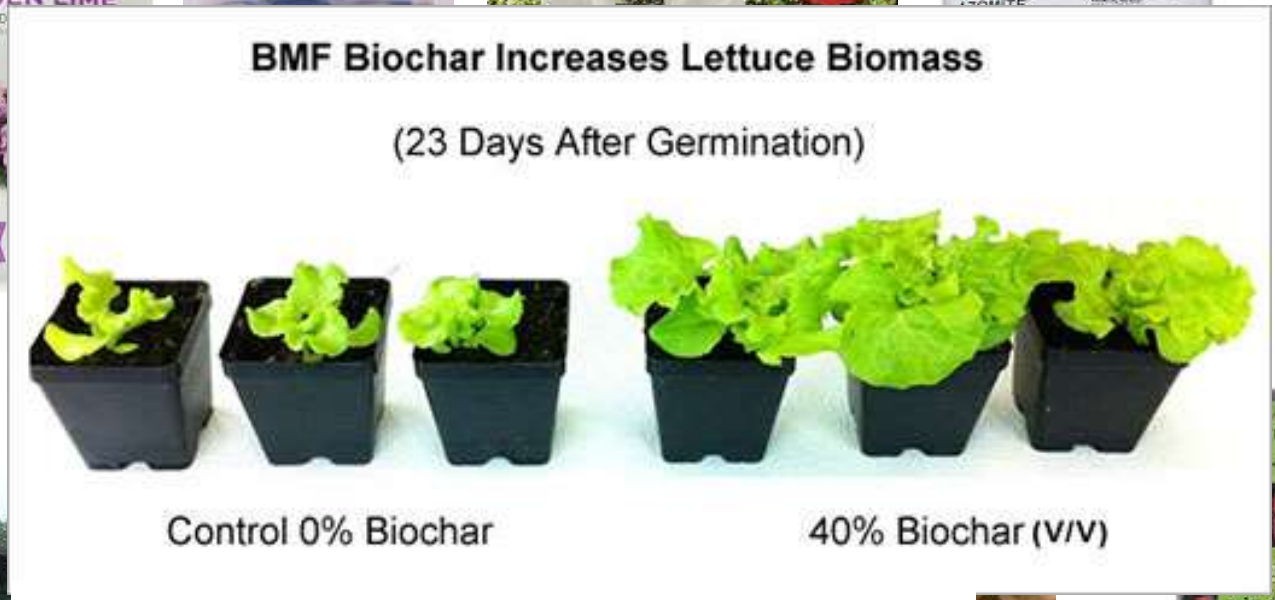
Increase understanding of soil processes

Apply technology for healthy soil management practices

- Improve soil properties
  - Aggregation
  - Water holding capacity
  - Nutrient availability
  - Soil carbon
  - Soil pH
  - Natural nutrient cycling
  - Microbes and invertebrates

- Results
  - Better water use efficiency
  - Lower fertilizer costs
  - More productivity
  - Decreased soil erosion
  - Carbon storage
  - Improved soil gas exchange
  - Less disease
  - Sustainable long-term profits
  - Healthy food production system

Soil amendments: Which one?



From: Biogrow Inc. Email: sales@biogrow.co.nz

Soil amendments: Biochar

Scientific papers on biochar in 2021 = 228

(over 8000 in the past 15 years)

What is Biochar? Pyrogenic carbon

- Similar, but different than charcoal
- Plant material heated in absence of oxygen
  - Produces biogas
  - Produces high carbon residual solid
- Biochar is manufactured with intent to add it to soils

Image from Colorado Biochar Resources

You can purchase biochar in large volumes

Rogue Valley Premium Biochar (4 Cu. Yds)

Potential benefits of biochar

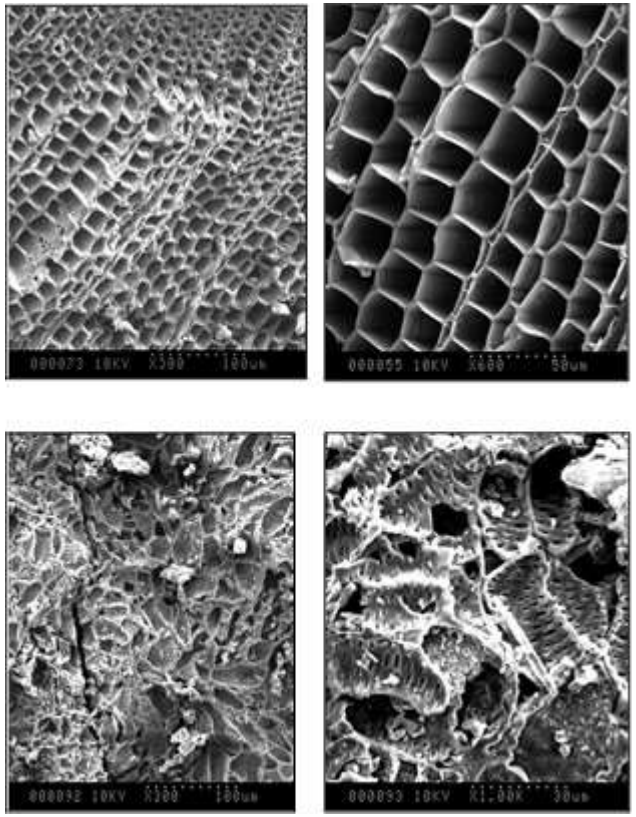
Biochar **may**:

- Increases water holding capacity
- Increase nutrient availability
- Improve soil aggregation
- Increase soil biota
- Retain nutrients from leaching
- Sequester and reduce greenhouse gas emission
- ….overall, increase soil health and plant productivity

- Biochar in soils is analogous to a reef

https://www.deep-roots-project.org/deep-roots-products/biochar

Biochar properties: depend on feedstock



Biochar physicochemical properties: pyrolysis temperature and feedstock kind effects

•Agnieszka Tomczyk,
•Zofia Sokołowska &
•Patrycja Boguta

Temp Yield Surf. Area Ash

Table 2 Biochar characteristic in different temperature from fruits and vegetables biomass

BF	PT (°C)	PY (%)	pH	SSA (m^2/g)	VM (%)	A (%)	CEC (cmol/kg)	C (%)	References
Peanut shell	300	36.9	7.8	3.1	60.5	1.2	–	68.3	Ahmad et al. (2012)
Peanut shell	700	21.9	10.6	448.2	32.7	8.9	–	83.8	
Peanut straw	700	–	11.2	–	–	38.5	254.0	–	
Dairy Manure	350	–	9.2	1.6	53.5	24.2	–	55.8	Cantrell et al. (2012)
Dairy Manure	700	–	9.9	186.5	27.7	39.5	–	56.7	
Feedlot manure	350	–	9.1	1.34	47.9	28.7	–	53.3	
Feedlot manure	700	–	10.3	145.2	19.8	44.0	–	52.4	
Poultry litter	350	–	8.7	3.9	42.3	30.7	–	51.2	
Poultry litter	700	–	10.3	50.9	18.3	46.2	–	45.9	
Separated swine solids	350	–	8.4	0.9	49.8	32.5	–	51.5	
Separated swine solids	700	–	9.5	4.1	13.4	52.9	–	44.0	
Turkey litter	350	–	8.0	2.6	42.1	34.8	–	49.3	
Turkey litter	700	–	9.9	66.7	20.8	49.9	–	44.8	
Dairy Manure	100	97.0	8.0	1.8	–	37.0	–	36.8	Cao et al. (2009)
Dairy Manure	200	58.0	6.8	2.7	–	44.0	–	31.1	
Dairy Manure	350	27.0	10.5	7.1	–	62.0	–	25.2	
Dairy Manure	500	25.0	10.5	13.0	–	95.0	–	1.7	
Prunings of fruit trees	500	–	10.8	–	58.8	4.7	–	–	Castellini et al. (2015)
Cattle manure	300	–	8.0	–	47.3	20.2	66.3	–	Cely et al. (2015)
Cattle manure	500	–	10.2	–	13.2	43.7	70.9	–	
Cattle–straw manure	300	–	10.1	–	24.9	38.3	65.5	–	

Physical Properties

Properties of biochar → Physical properties →

- Bulk density
- Particle density
- Particle size
- Macro and micro-porosity
- Surface area
- Hydrophobicity
- Water holding capacity
- Grindability

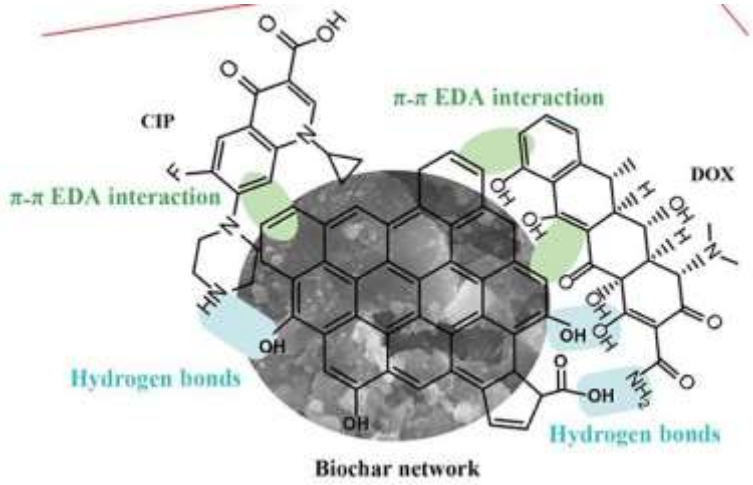
From Biochar for Sustainable Soils

Chemical Properties

Properties of biochar

Chemical properties

- Persistence: H/C ratio
- Soluble organic compounds
- Toxic compounds - PAHs
- Heavy metals
- Macro-nutrient content (N, P, K, S, Ca, Mg)
- Micro-nutrient content
- Fertiliser value: nutrient availability
- pH (proton activity) & liming value
- Electrical conductivity
- Cation exchange capacity (CEC)
- Anion exchange capacity (AEC)



From Biochar for Sustainable Soils

https://www.frontiersin.org/articles/10.3389/fchem.2018.00080/full

Is biochar good for soil and plants?

It depends…

- Soil properties
  - Acidic or alkaline soil
  - Soil mineralogy: clays, sand, iron oxides, calcite
  - Nutrient availability
  - Organic matter
  - Biological organisms (including plants)
- Climate
  - Wet-dry
  - Hot-cold

- Type of biochar
  - Feedstock
  - Pyrolysis
  - Aging
  - Post treatment
- Desired outcome
  - Crop productivity
  - Soil carbon storage
  - Short- or long-term benefit

https://knowledge.unccd.int/best-practice/biochar-application-soil-amendment

Effect of biochar on plant productivity
(1254 paired comparisons from 153 studies)

Science of the Total Environment 713 (2020) 136635

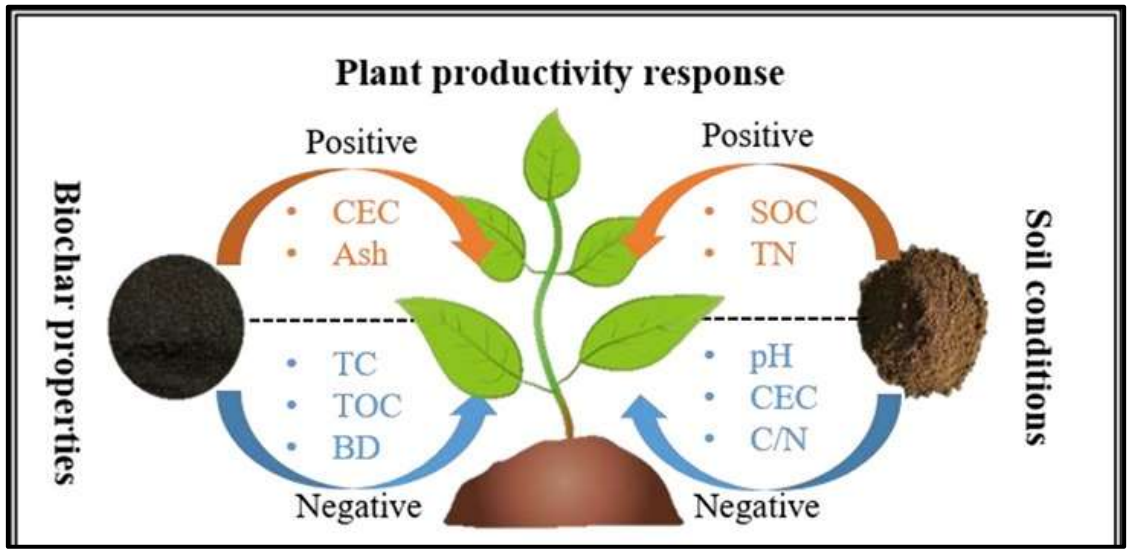
Contents lists available at ScienceDirect

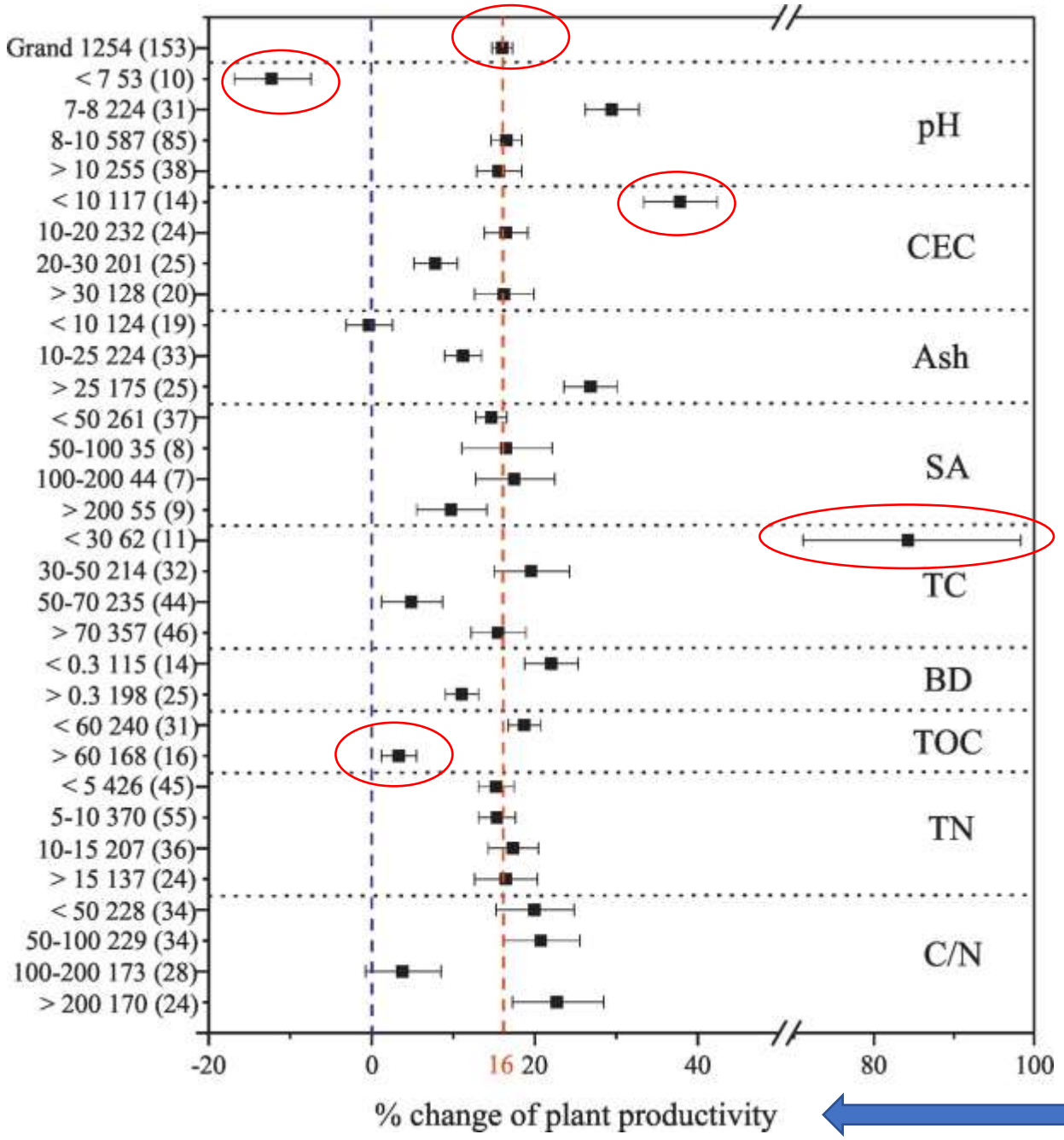
Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Combined effects of biochar properties and soil conditions on plant growth: A meta-analysis

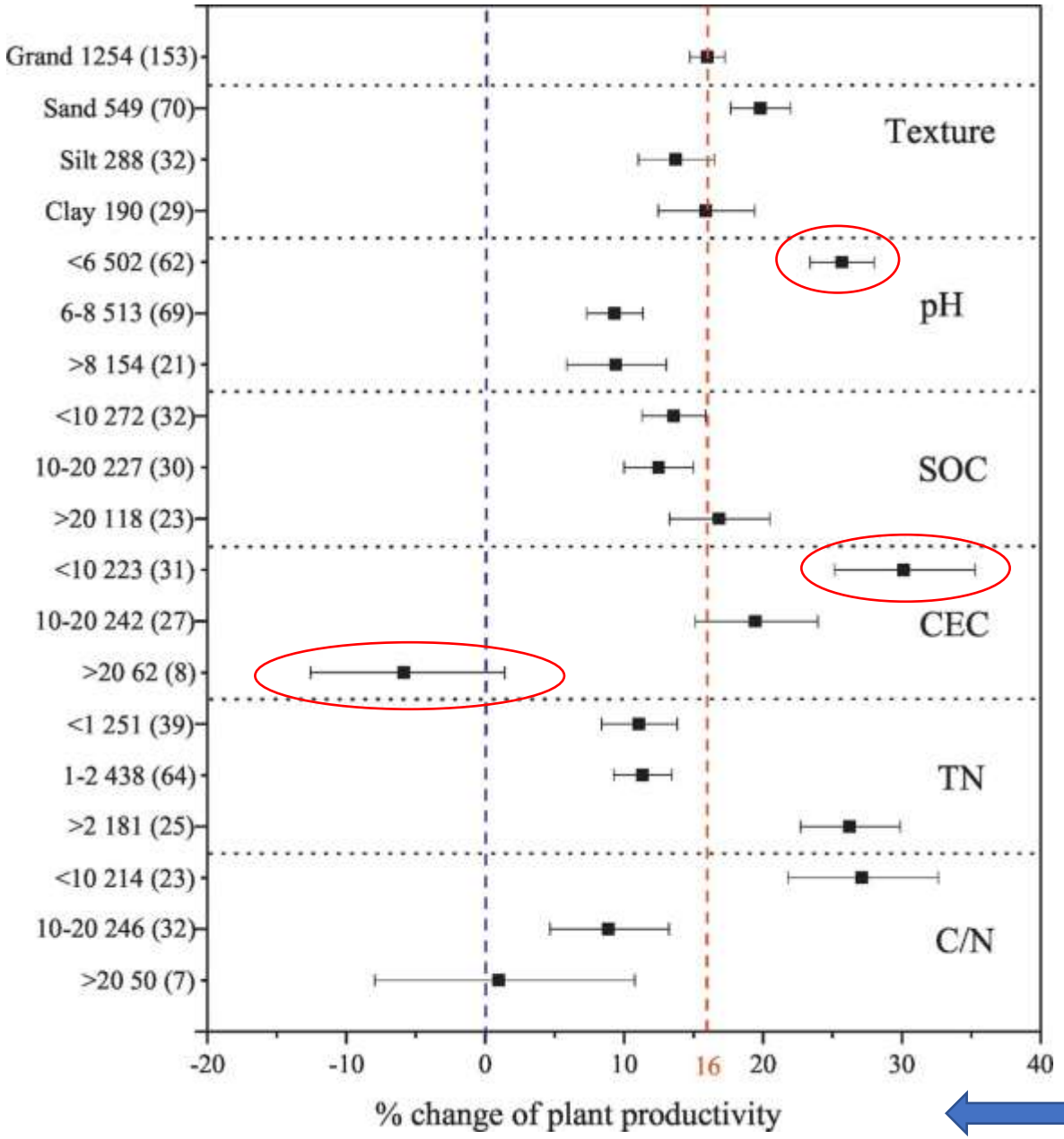
Yanhui Dai [a], Hao Zheng [b,c], Zhixiang Jiang [a,d,*], Baoshan Xing [a,**]





Biochar properties

Change compared to control



Soil properties

Change compared to control

Opportunities to sequester carbon

doi:10.2489/jswc.2021.1115A

VIEWPOINT

Integrated biochar research: A roadmap

James E. Amonette, Humberto Blanco-Canqui, Chuck Hassebrook, David A. Laird, Rattan Lal, Johannes Lehmann, and Deborah Page-Dumroese

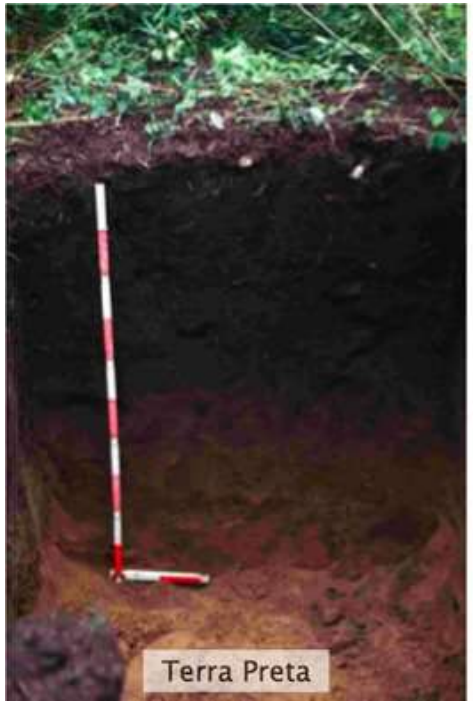
The maximum sustainable C-drawdown potential of biochar technology …over the course of a century, **could account for a third of the 1,000 Gt (1.1×10^{12} tn) CO_2 that needs to be removed from the atmosphere**.

Feb 15, 2021 report

[The First Farmer in the US to Sequester Carbon for Cash Earns $115,000 For His New Planting Strategies]

https://www.goodnewsnetwork.org/us-policy-to-feature-carbon-credits-from-regenerative-farming-practices/

Terra Preta: 6000 to 18,000 km^2 of the wooded Amazonian lowlands

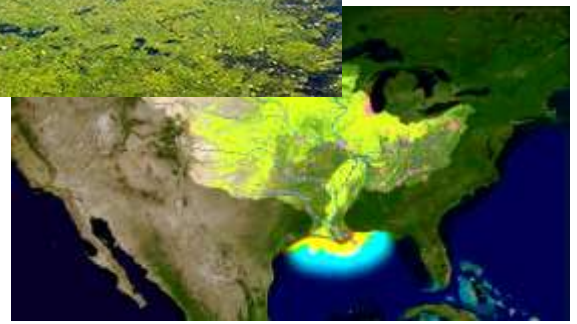


N-E-W Terra Plant Growth Trials

Nutrient recovery on biochar from wastewater

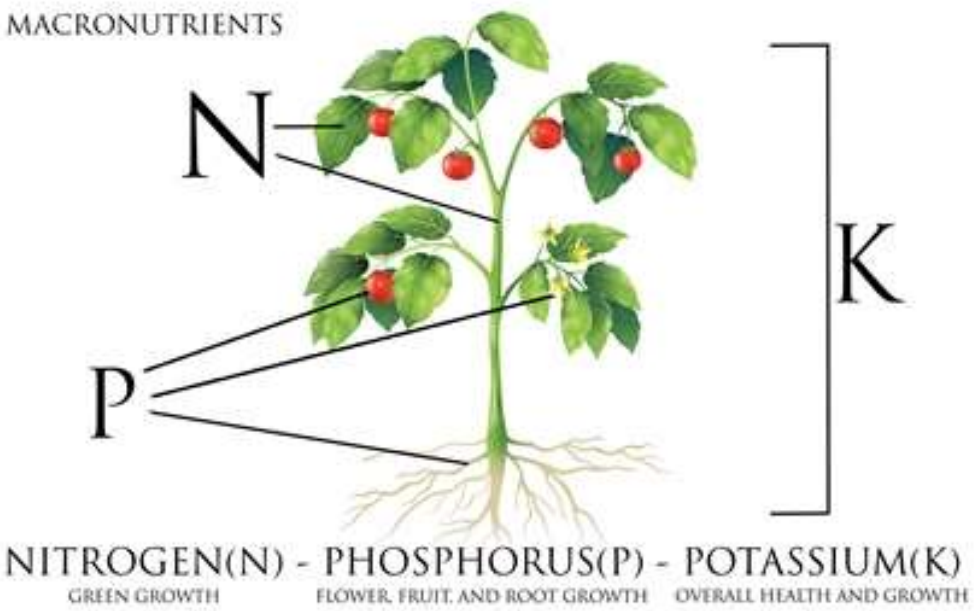
Water treatment using iron-modified biochar

- Mimics processes in nature to remove phosphorus and nitrogen from water
  - Wastewater treatment technology
  - Potential use to treat natural waters
- A recycling technology for nutrients
  - P is a limited resource that is mined a few places in the world
  - N is fixed from the atmosphere
- Current end-of-life for P and N is natural waters
  - Nutrient-enriched water promote algae growth
  - Decreases water quality



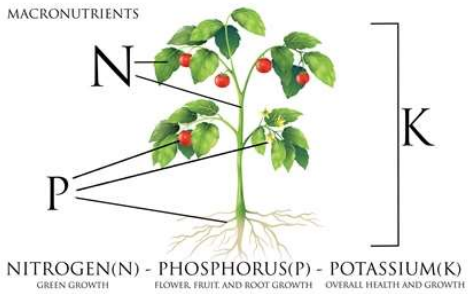
Biochar recovery

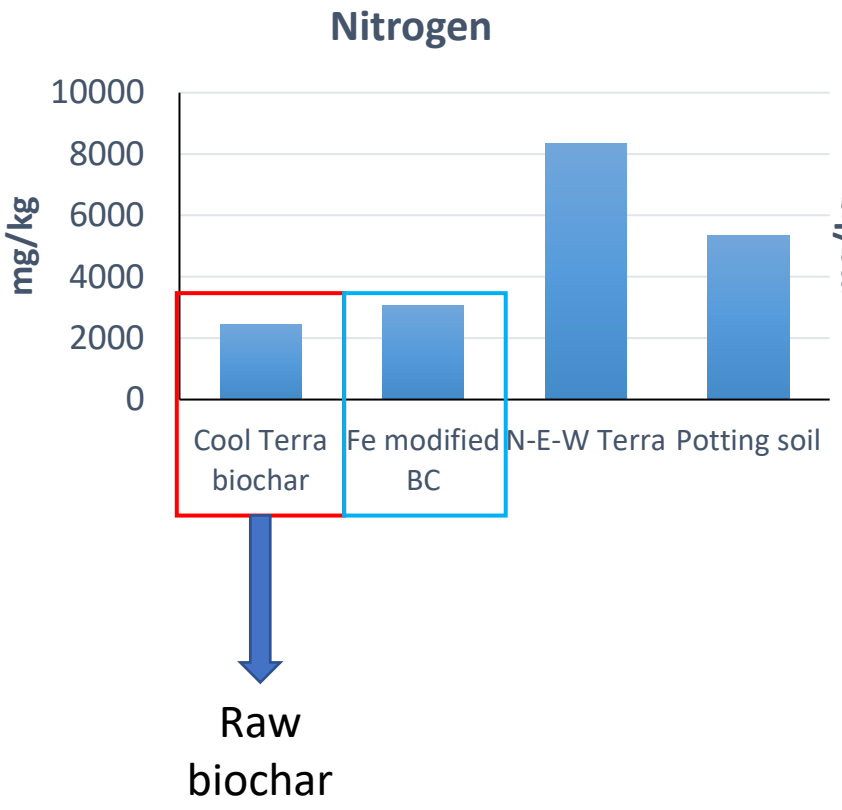
Total N, P, K in recovered biochar (N-E-W Terra)

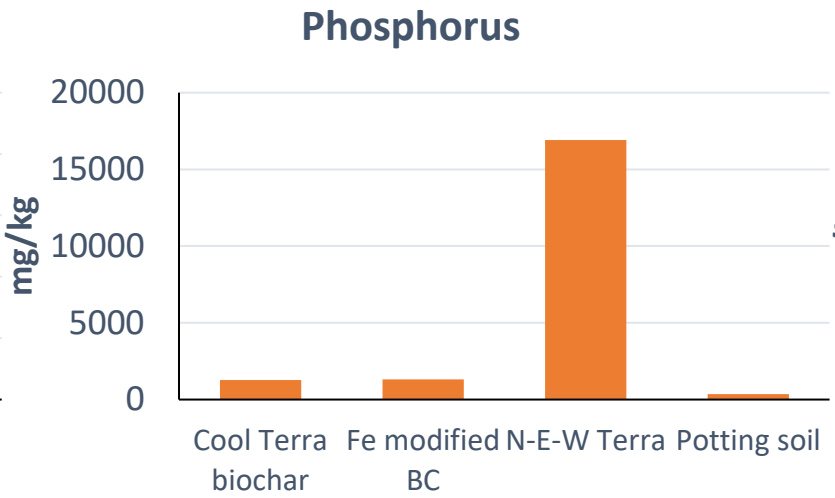


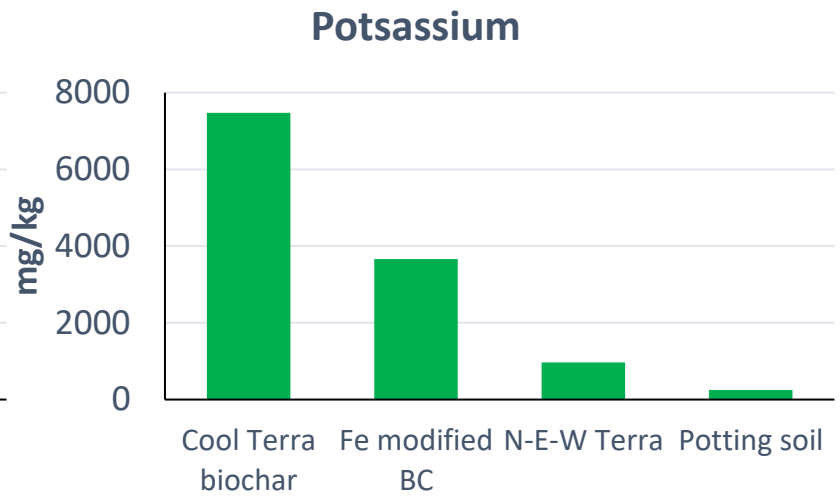
https://www.botanicalinterests.com/product/How-do-I-Know-Which-Fertilizer-to-Use

Total N, P, K









https://www.botanicalinterests.com/product/How-do-I-Know-Which-Fertilizer-to-Use

Greenhouse trial

Treatments	Description
Potting soil	Sunshine mix #2 (no nutrients added)
Cool Terra biochar	Micronized biochar
Fe modified BC	Treated with ferric salts to form HFO coatings
N-E-W Terra	Injected into wastewater treatment process

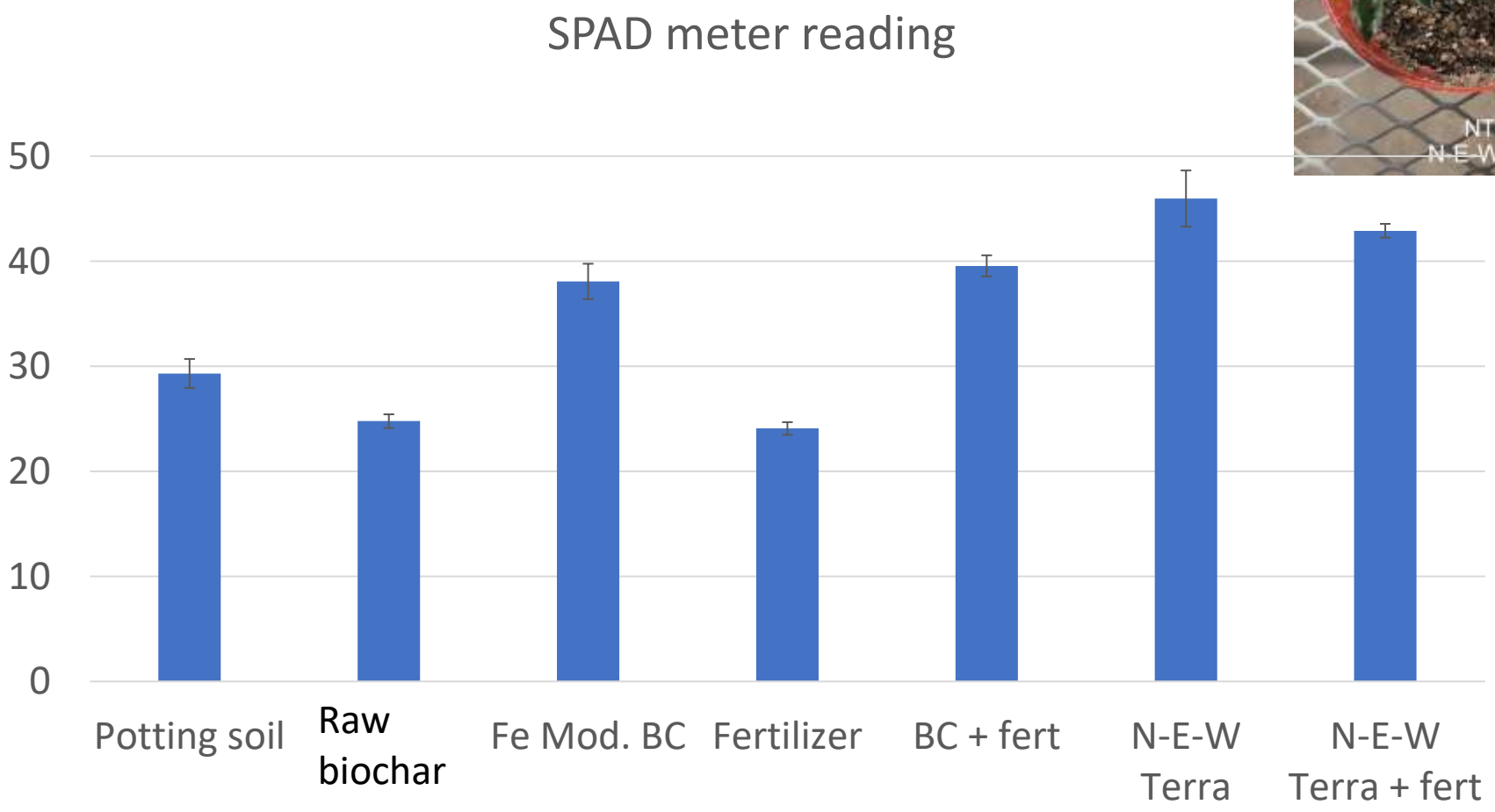
- All amendments added at 10% mass ratio
- Fertilizer amendment is MG slow-release flower formulation (N:P matches N-E-W Terra)
- Tomato plants planted after 2 weeks of germination (Early Girl variety)
- Experiment set up as a 3 x 3 randomized block design (three replicates in each block, three blocks)
- Plants grown for 35 days
- Watered as needed, with leaching minimized

Plant quality measures

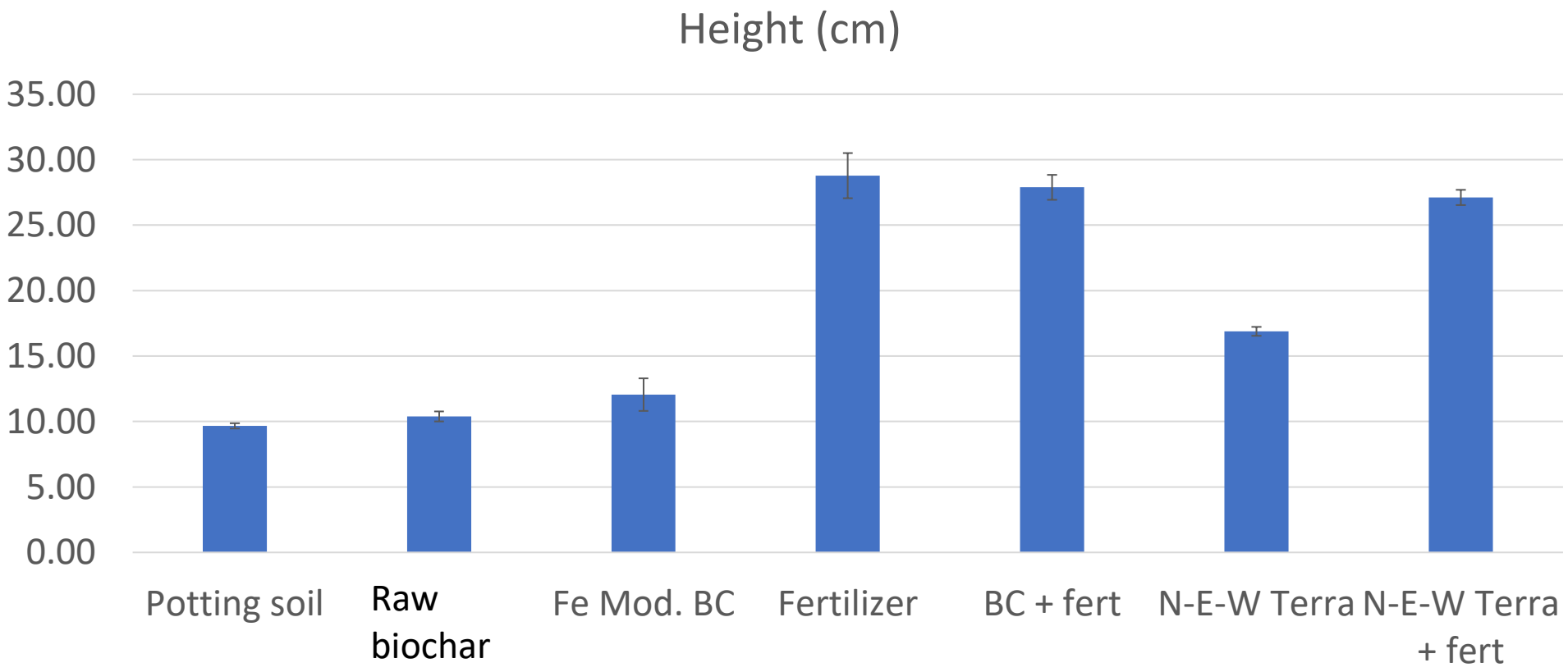
- Color (SPAD meter)
  - Indicates of nitrogen status
- Height
  - Indicates vigor of growth
- Budding
  - Potential fruit production
- Biomass
  - Total growth
- Overall plant quality
  - Rated 1-5

Plant color

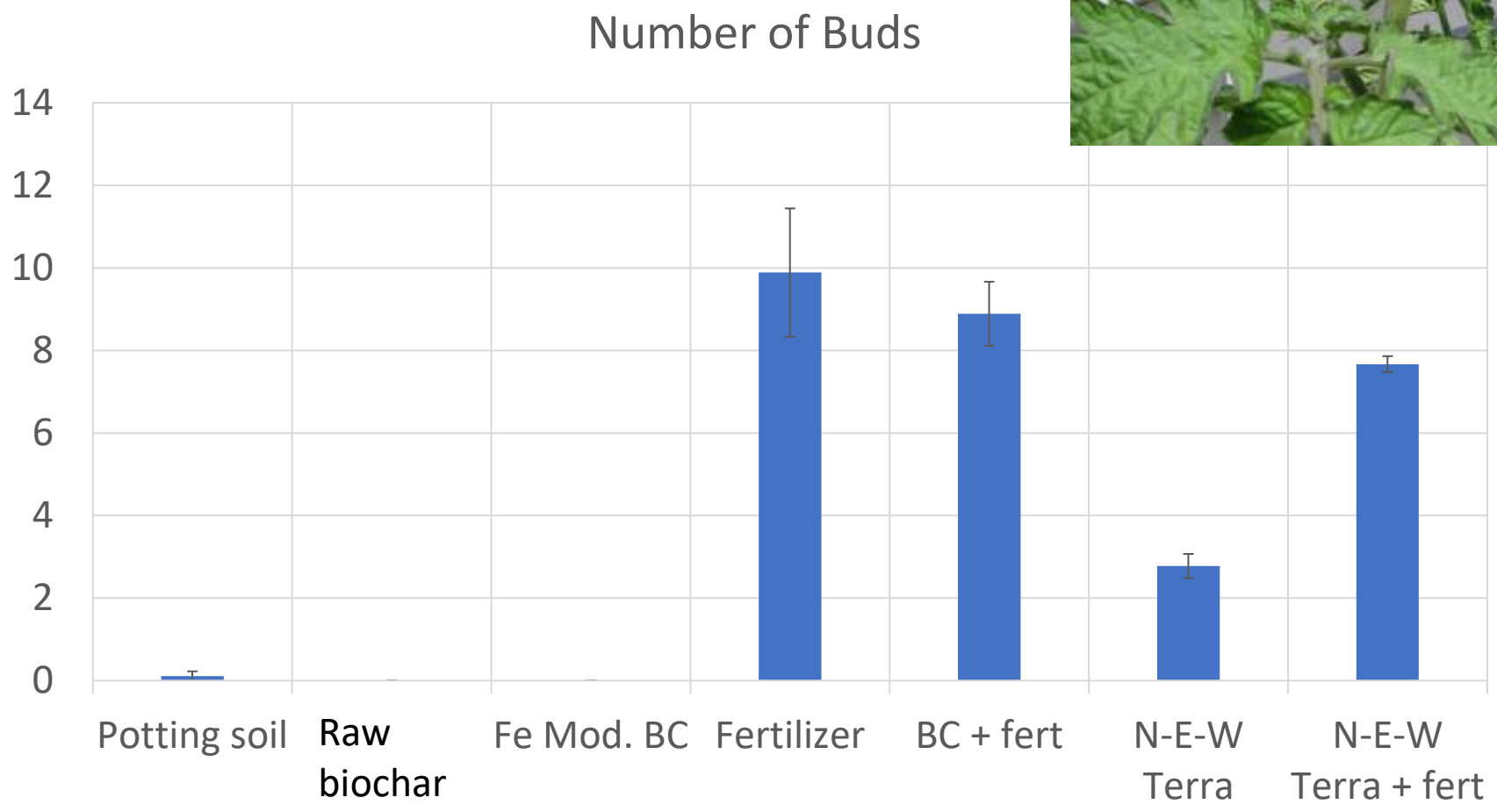

NT1
N-E-W Terra
Fe-BC no fertilizer


SPAD meter reading
50
40
30
20
10
0
Potting soil
Raw biochar
Fe Mod. BC
Fertilizer
BC + fert
N-E-W Terra
N-E-W Terra + fert

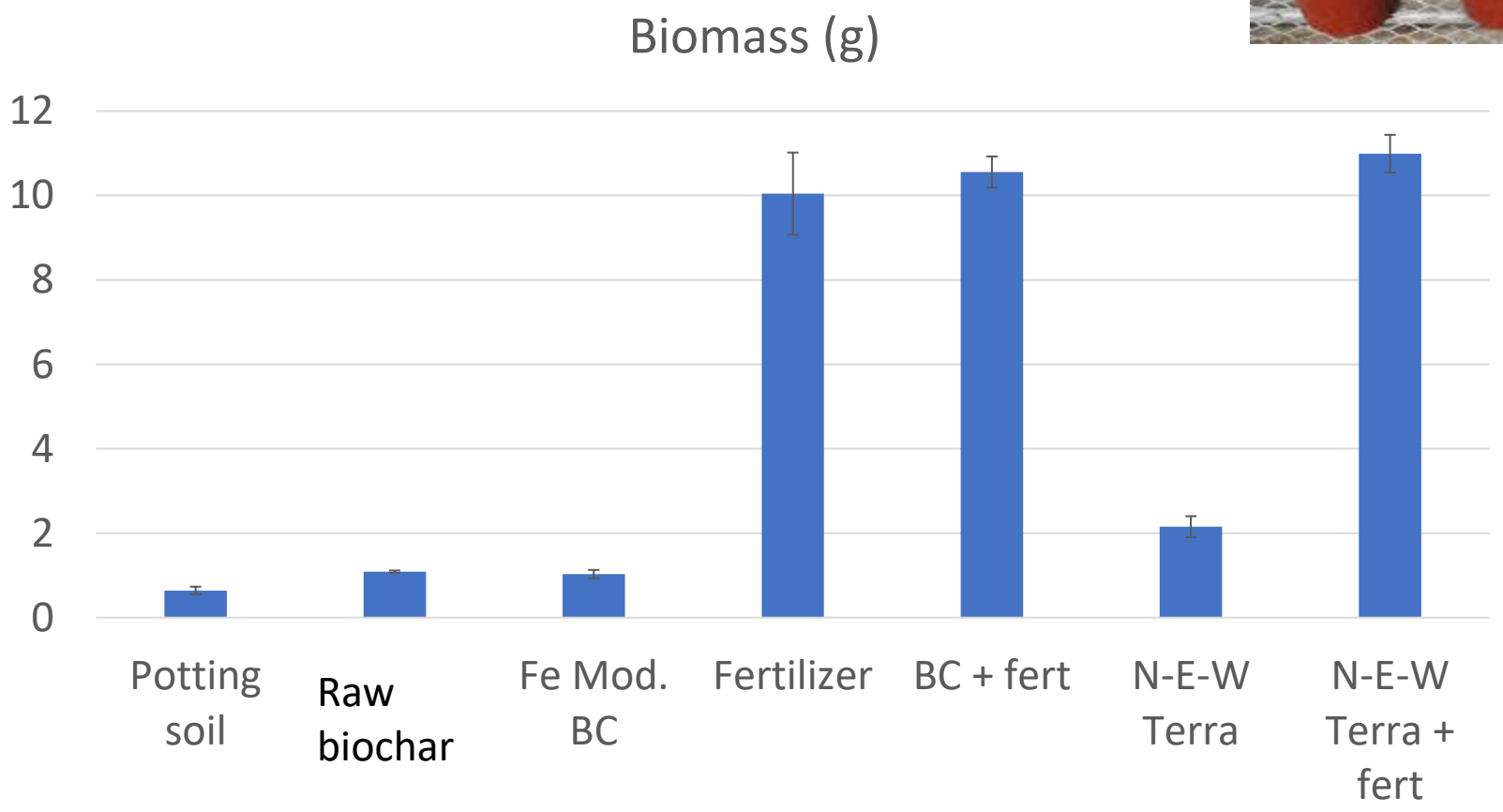
Plant height



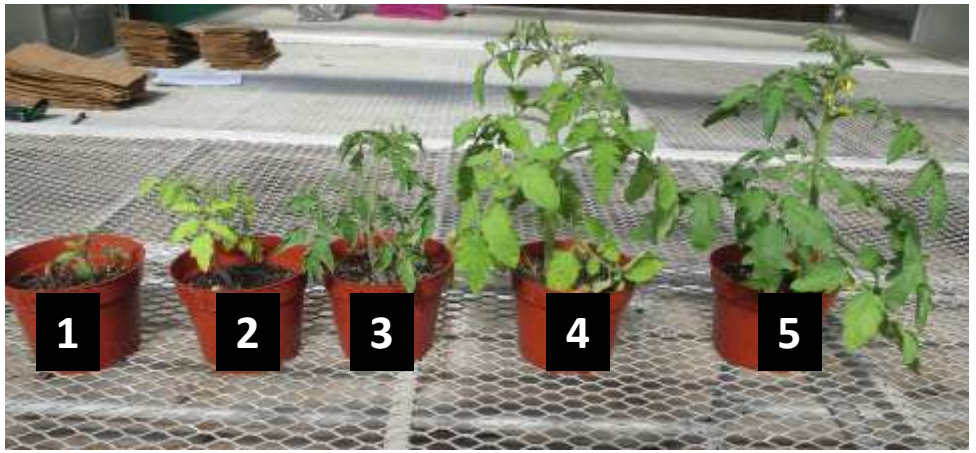
Number of buds

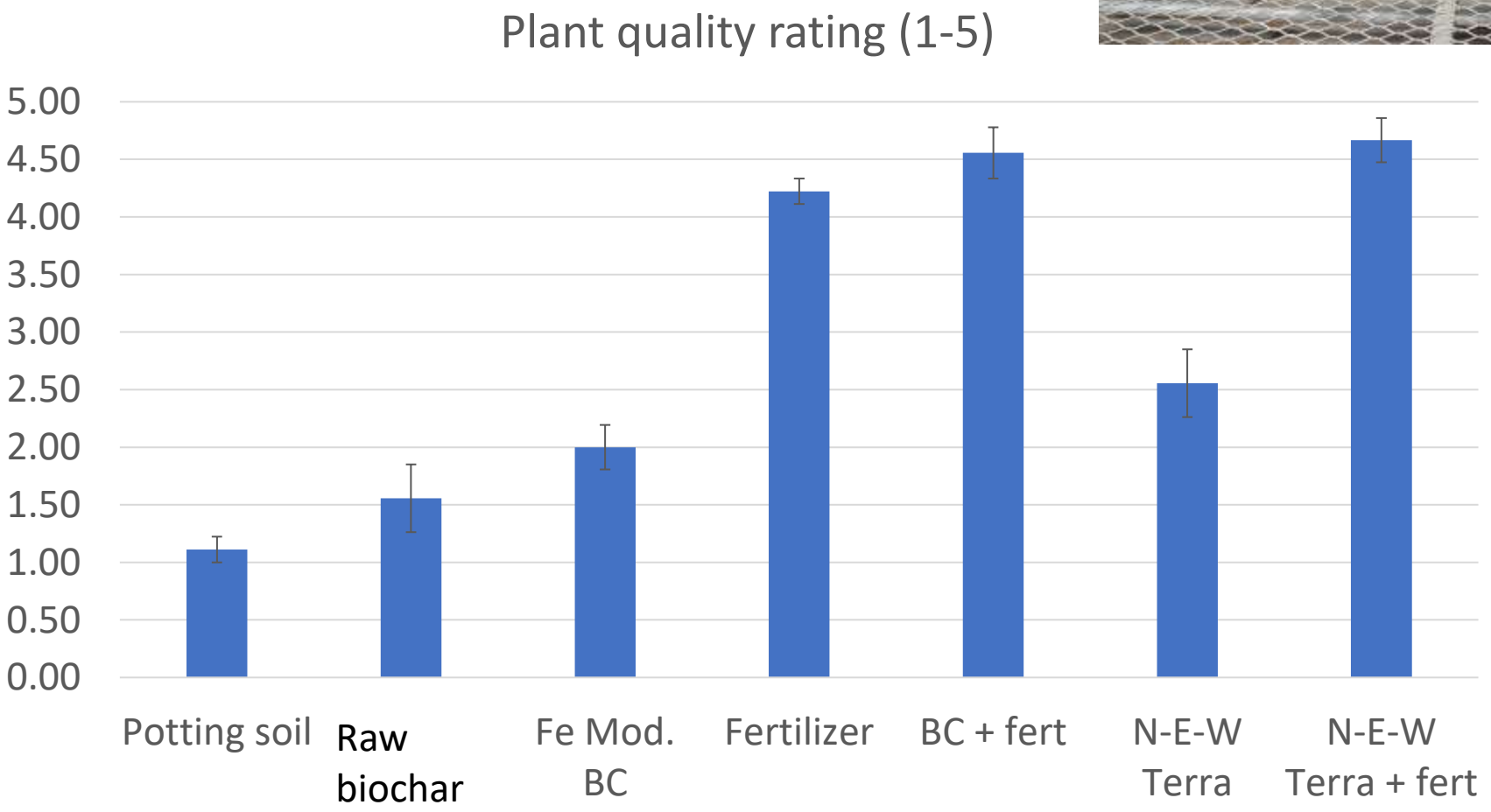


Biomass

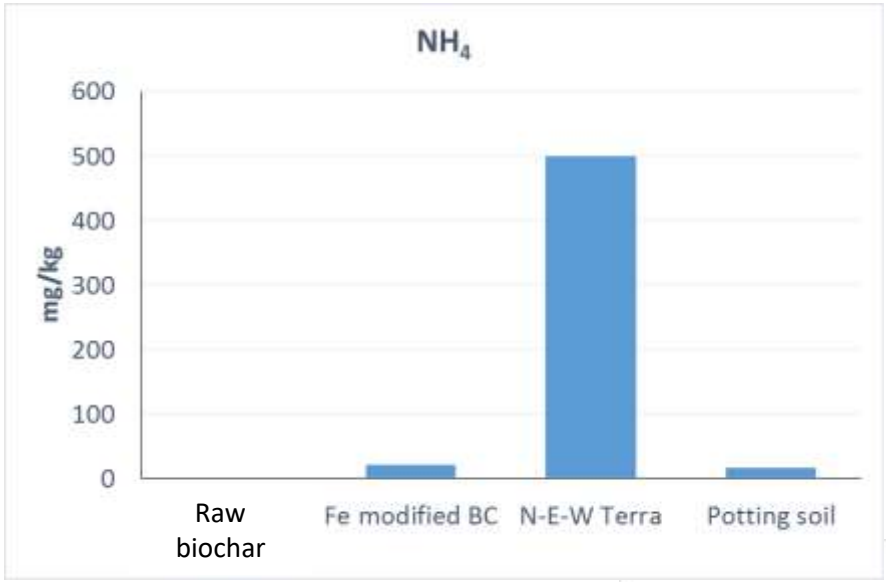

Biomass (g)
12
10
8
6
4
2
0
Potting soil
Raw biochar
Fe Mod. BC
Fertilizer
BC + fert
N-E-W Terra
N-E-W Terra + fert

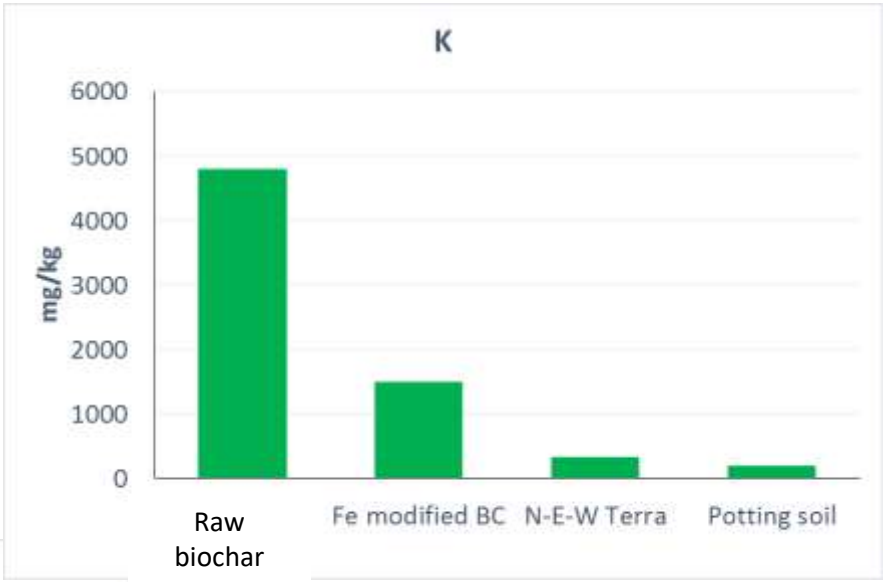
Overall plant quality

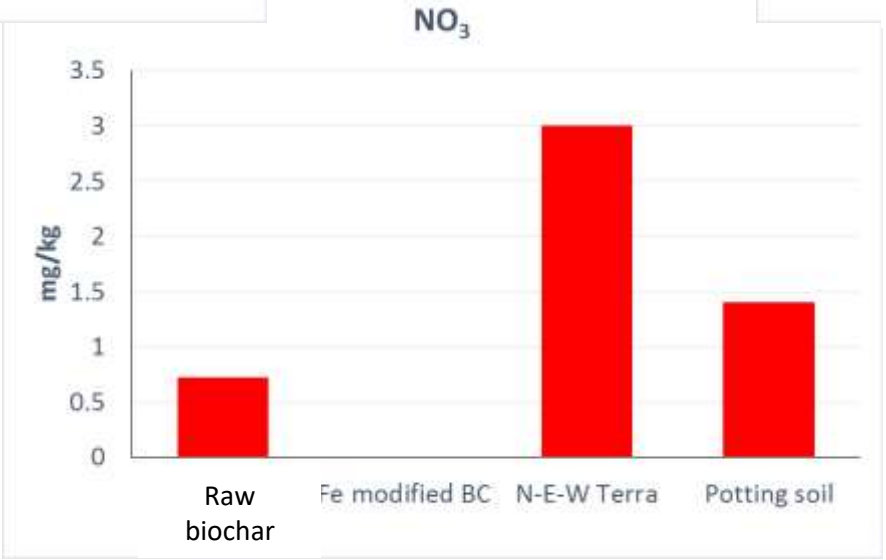




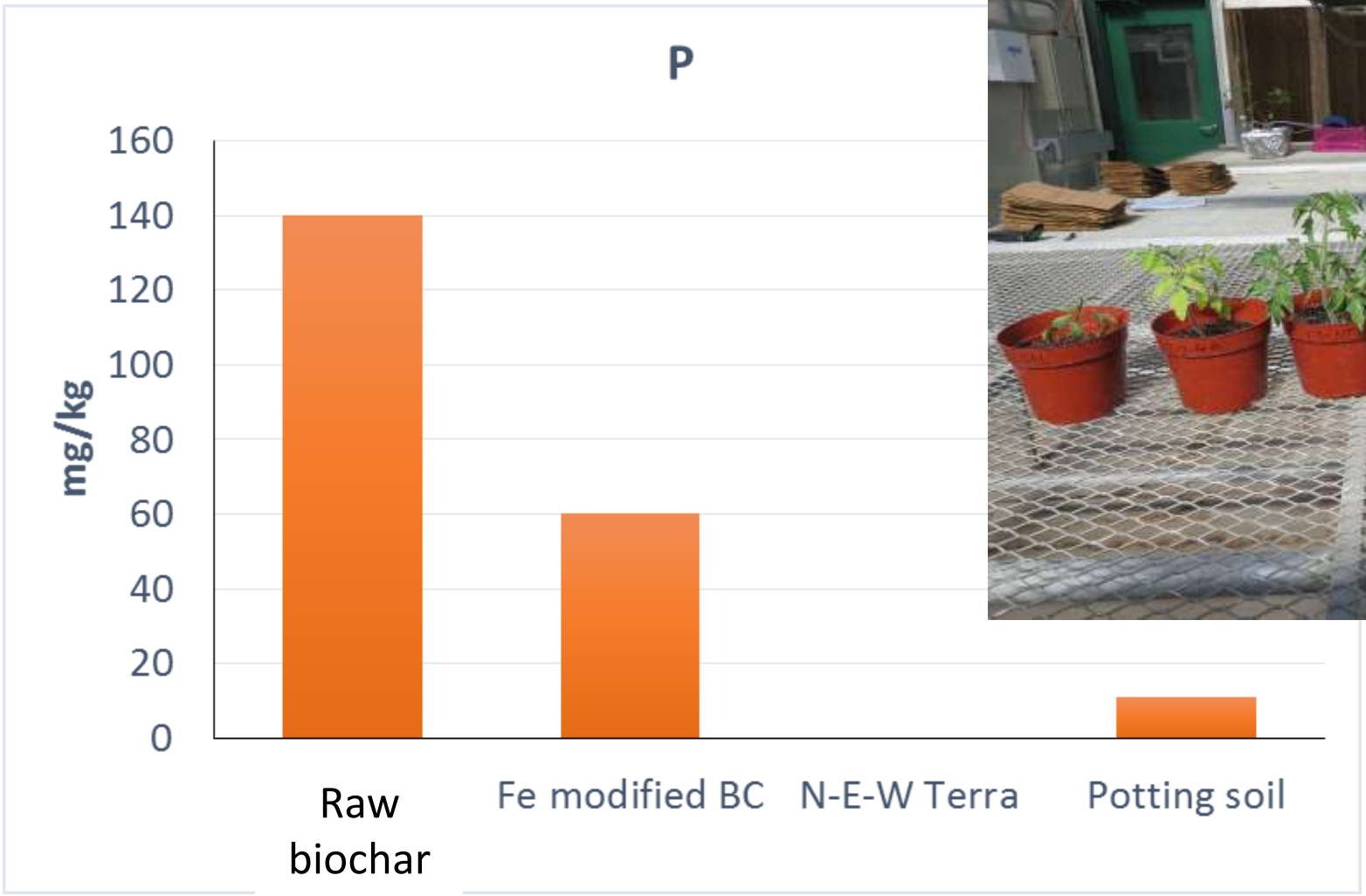
Extractactable nutrients (plant available)







Bray extractable P (estimate of plant available)



Effects of biochar on lettuce growth

Data analysis is in progress

Future research objectives

- Develop slow-release fertilizer test
- Conduct trials at different N-E-W Terra amendment rates
- Measure effects of different biochar on soil water holding capacity
- Optimize N-E-W Terra for slow P release
- Recover nutrients on biochar from a dairy operation
- Use microbe-altered N-E-W Terra to enhance P release
- Study N release and mineralization
- Test pelletization and delivery processes

N-E-W Tech™

University of Idaho

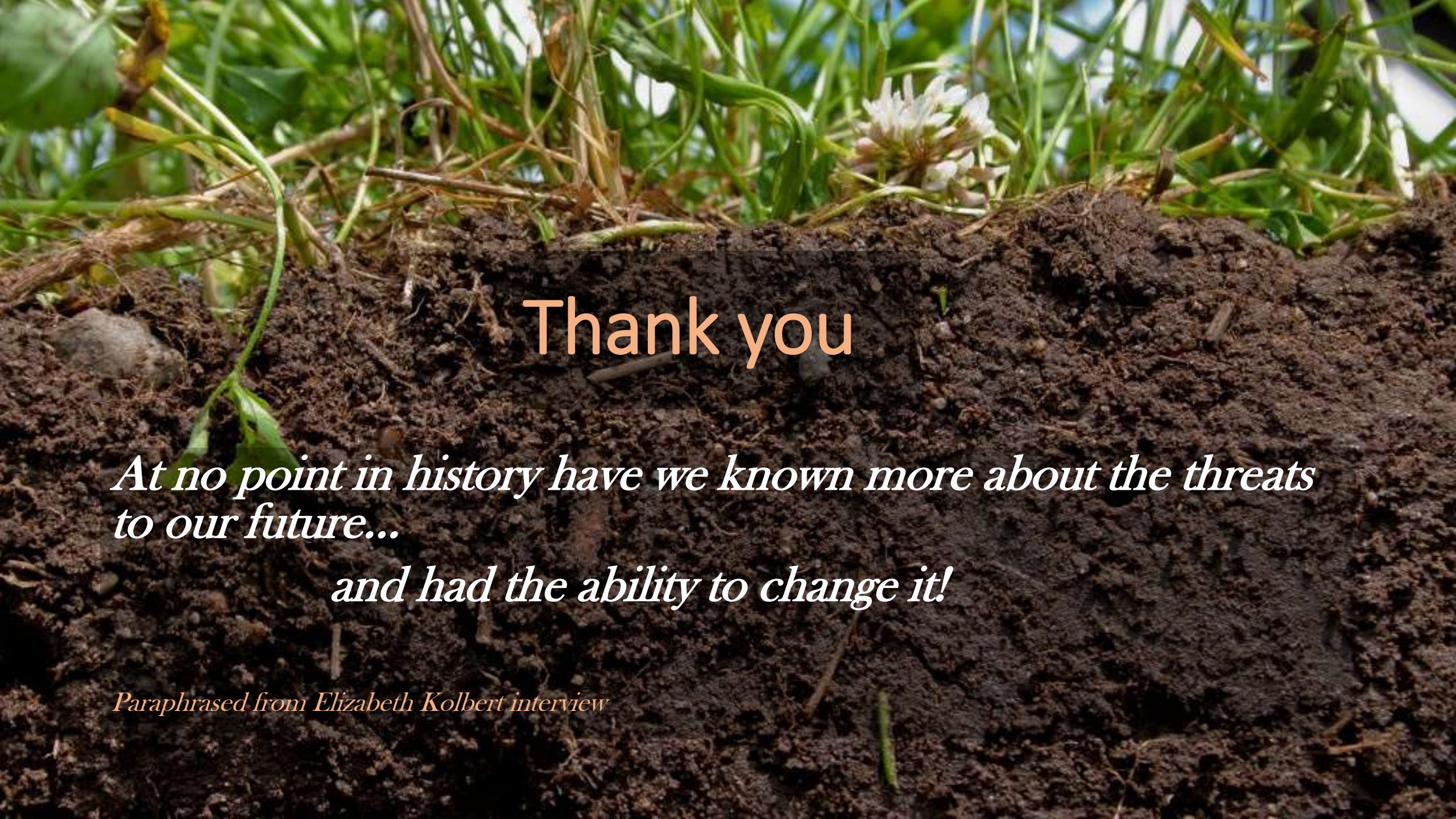
Recommendation

- Do the cost analysis
- Look for long-term benefits
- Start small
- Look for ways to increase cost efficiency
- Biochar is a co-amendment

- Stay tuned for value added biochar ….

We are in a revolution…lots of unknowns

- Science and industry will drive new knowledge and create improved manufacturing and targeted application
- Biochar does have a future in small and large agricultural applications
- Biochar will be part of the solution to feeding our world and increasing sustainable living for a positive future



Thank you

At no point in history have we known more about the threats to our future...

and had the ability to change it!

Paraphrased from Elizabeth Kolbert interview

Questions?

Please take our post-webinar evaluation!

Evaluation Link
https://uidaho.co1.qualtrics.com/jfe/form/SV_enXPaYGdz52kXB4

Tomorrow, you will receive by email

- Link to the post-webinar survey
- Link to webinar recording & slide handout

https://www.cultivatingsuccess.org/recordedwebinars

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www.cultivatingsuccess.org

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February Theme: Digging Into Soils and Compost

February 23 Vermicomposting: Vegetable Kitchen Scraps to Usable Compost

March 1-5 Soil & Water Week

March 2 Choosing the Best Irrigation System for You

March Theme: All Things Insects- Pest Management and Pollinators

March 9 Encouraging Native Pollinators with Plant Diversity

March 16 Wireworm Online Field Day

March 23 Organic Orchard Pest Management

March 30 White Rot in Garlic

https://www.cultivatingsuccess.org/webinar-series