Biochar: Its role in organic vegetable production

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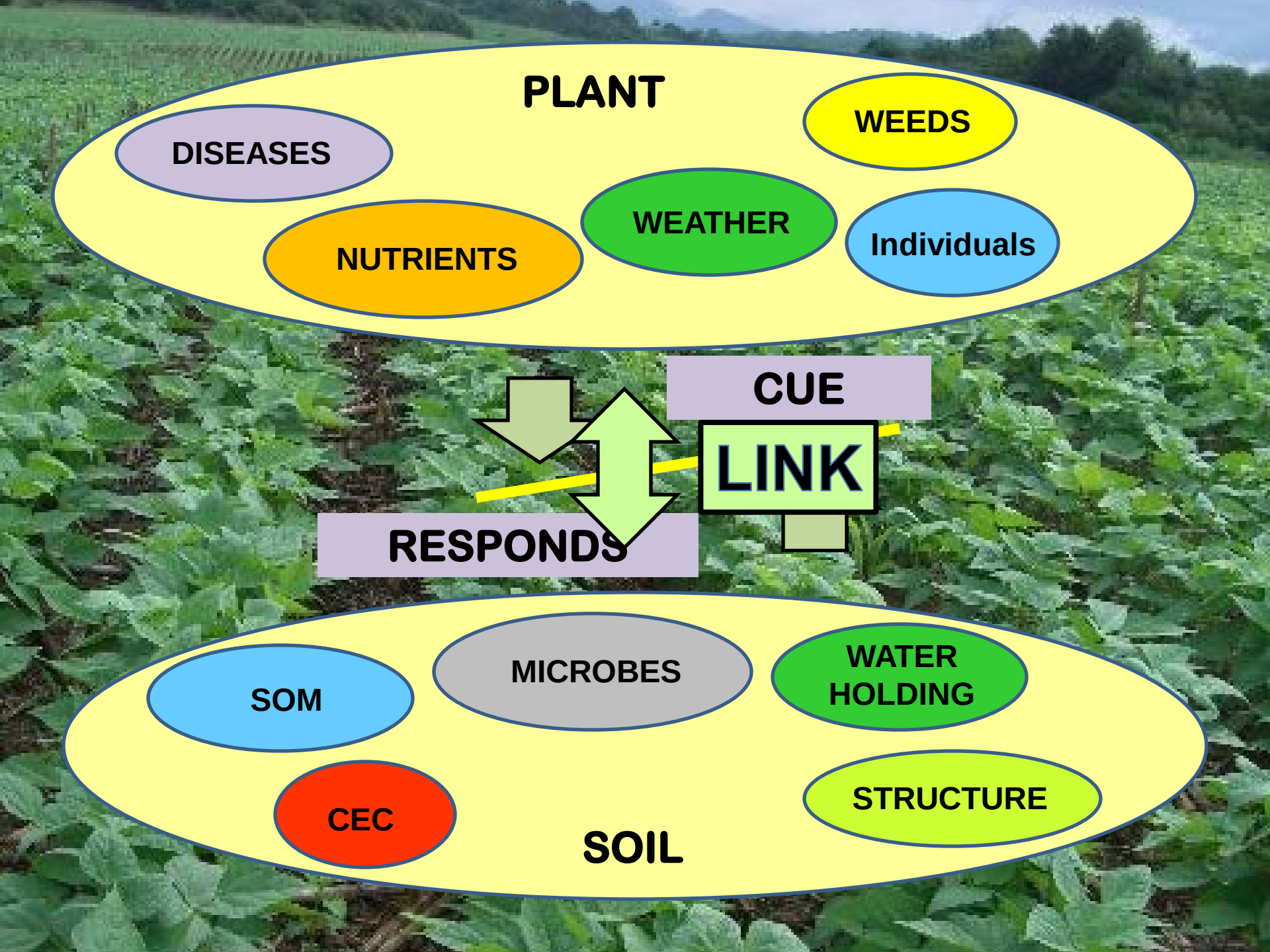
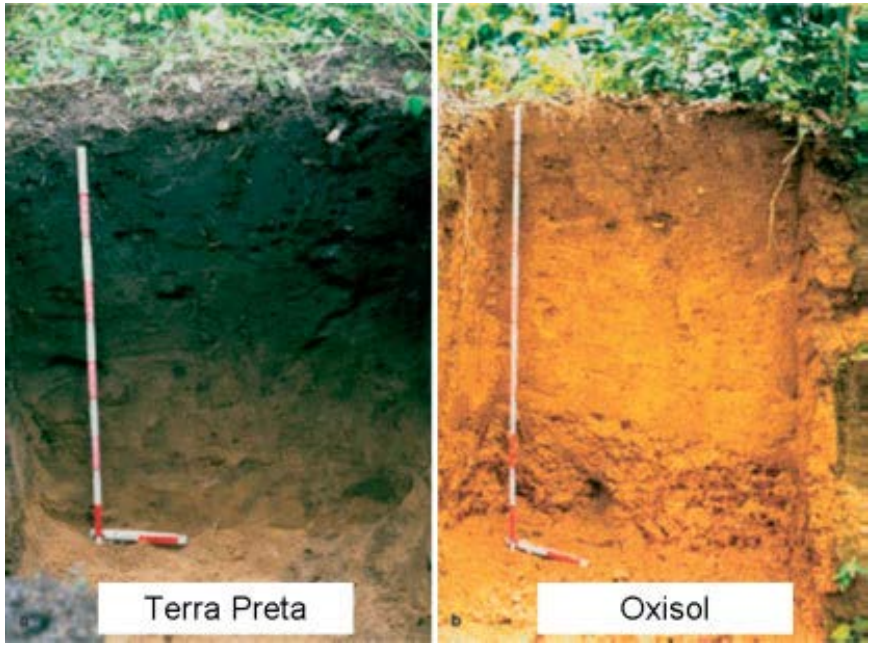
Outline

- What is biochar
- How it is made and its properties
- Research projects on pepper, sweet corn, and potato production


PLANT
DISEASES
WEEDS
WEATHER
NUTRIENTS
Individuals
CUE
LINK
RESPONDS
SOM
MICROBES
WATER HOLDING
CEC
STRUCTURE
SOIL

Biochar origin

- Ancient practice in the tropics
  - Terra Preta soils of the Amazon
- Plant material burned in pits
- Enhanced soil productivity




I think I got it right
Is it O or A horizon?
Is it time for lunch?

Biochar

- Biochar is a form of carbon, which can be made by heating wood with limited oxygen (pyrolysis)
- Can be made from different sources
- Promotes carbon sequestration

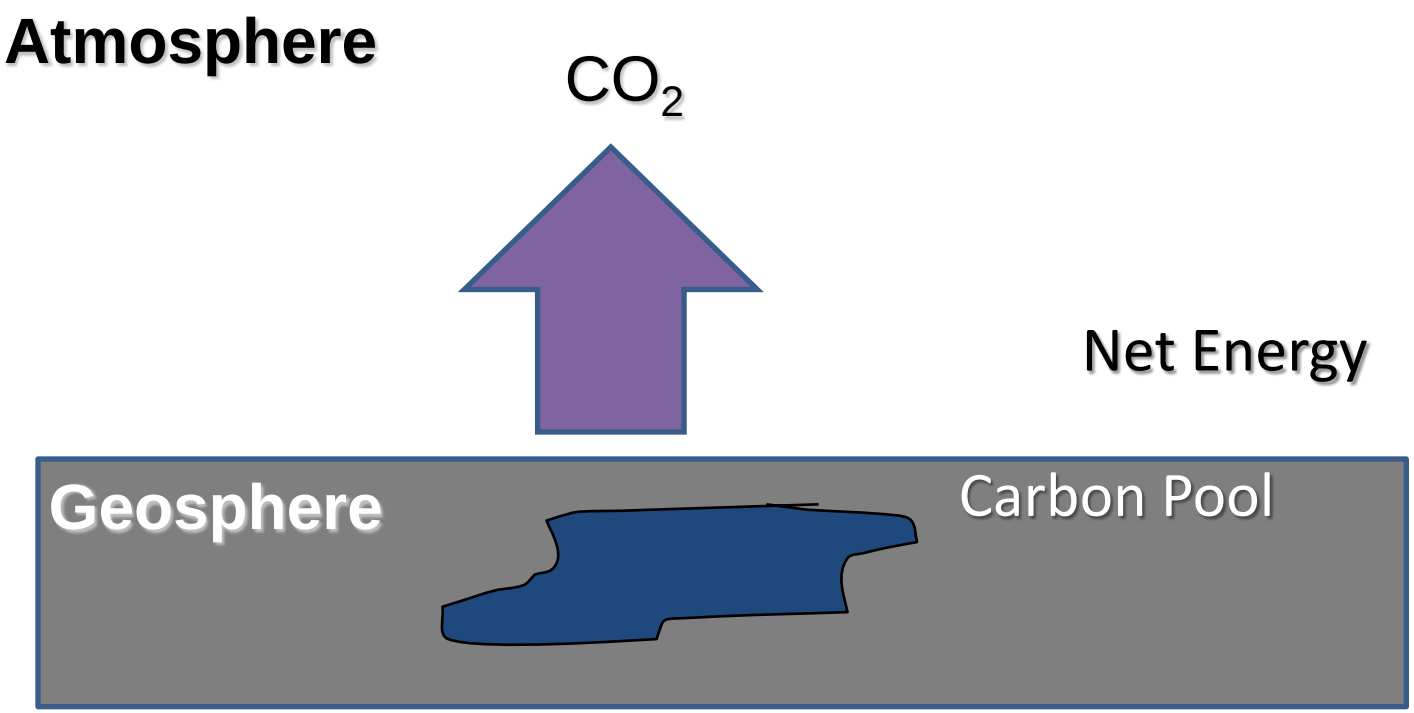
Pyrolysis

Definition – thermal decomposition of organic compounds in the absence of oxygen

Temperatures in the range of 350-600 ^{o}C

We Live in a Petroleum Economy

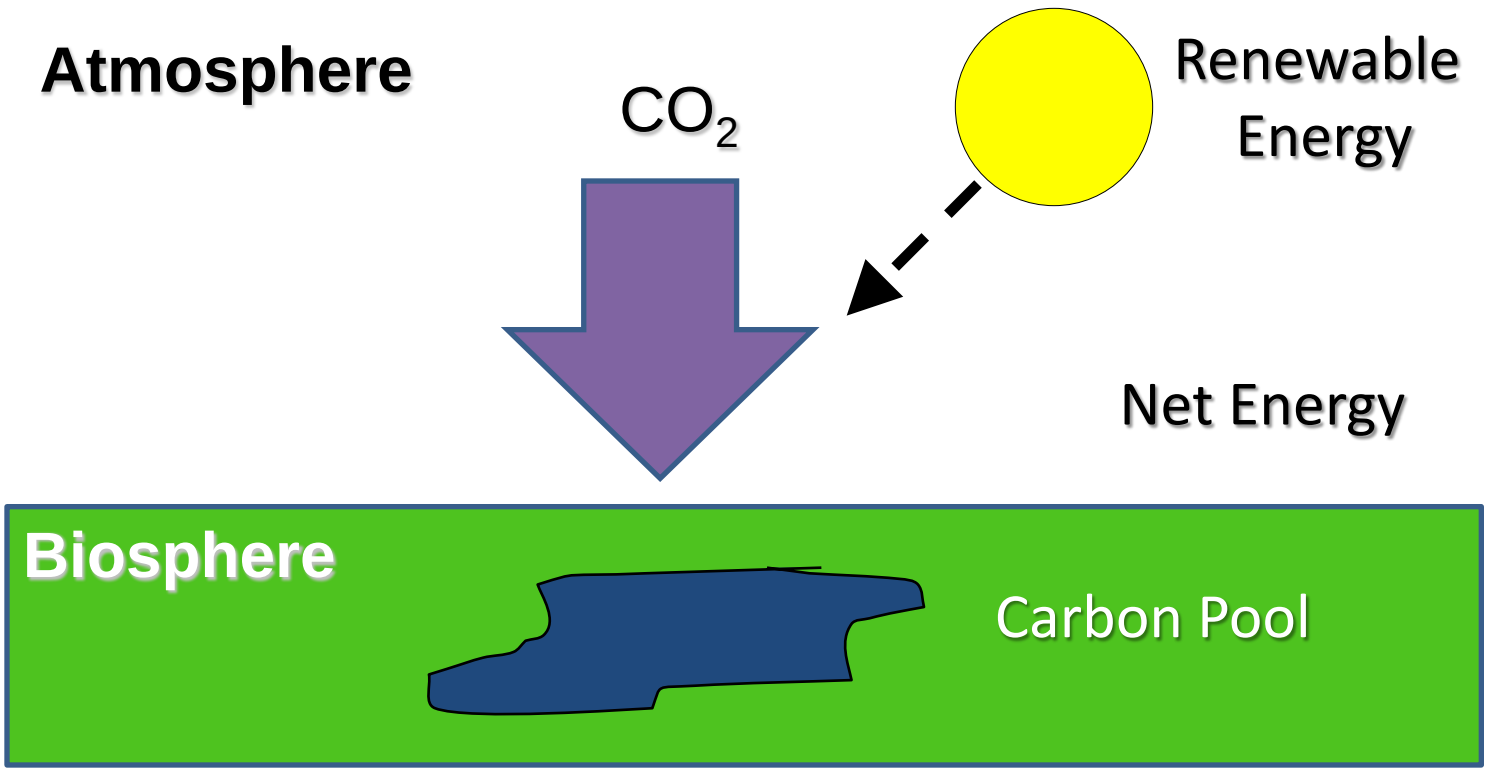
Petroleum Economy



Slide, courtesy Dr. Robert Brown, Biocentury Farm, ISU

Reversing the Paradigm

Carbon Negative Economy



Slide, courtesy Dr. Robert Brown, Biocentury Farm, ISU

Carbon negative approach

- Carbon dioxide, CO_2, is removed from the atmosphere by photosynthesis during the growth of the wood or other biomaterials used to make the biochar.
- The carbon remains in the buried biochar when it is added to the soil.
- Hence, CO_2 from the atmosphere is converted to an inert solid which remains in the ground. **This is CARBON NEGATIVE**.

Isn't charcoal the same....

- Char – any carbonaceous residue from pyrolysis including natural fires.
- Charcoal - char produced from pyrolysis of animal or vegetable matter in kilns for use in cooking or heating.
- **Biochar – char produced specifically for application to soil for agronomic or environmental management.**

Slide; courtesy Dr. Robert Brown, Biocentury Farm, ISU

It is trivia time !

What is the percentage carbon in wood-based biochar

✓ 1. 70%
2. 90%
3. 60%
4. 50%

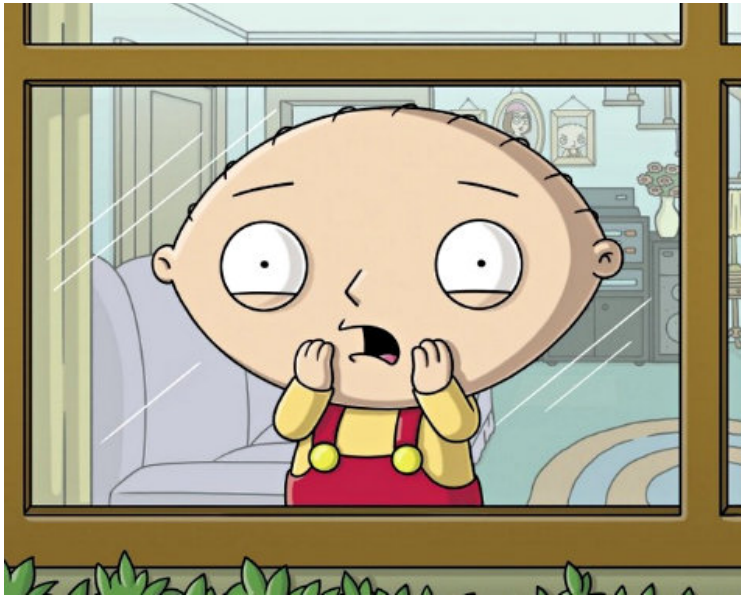
How is biochar made

- Major Techniques:
  - Slow Pyrolysis
    - traditional (dirty, low char yields)
  - Flash Pyrolysis
    - modern, high pressure, higher char yields
  - Fast Pyrolysis
    - modern, maximizes bio-oil production, low char yields

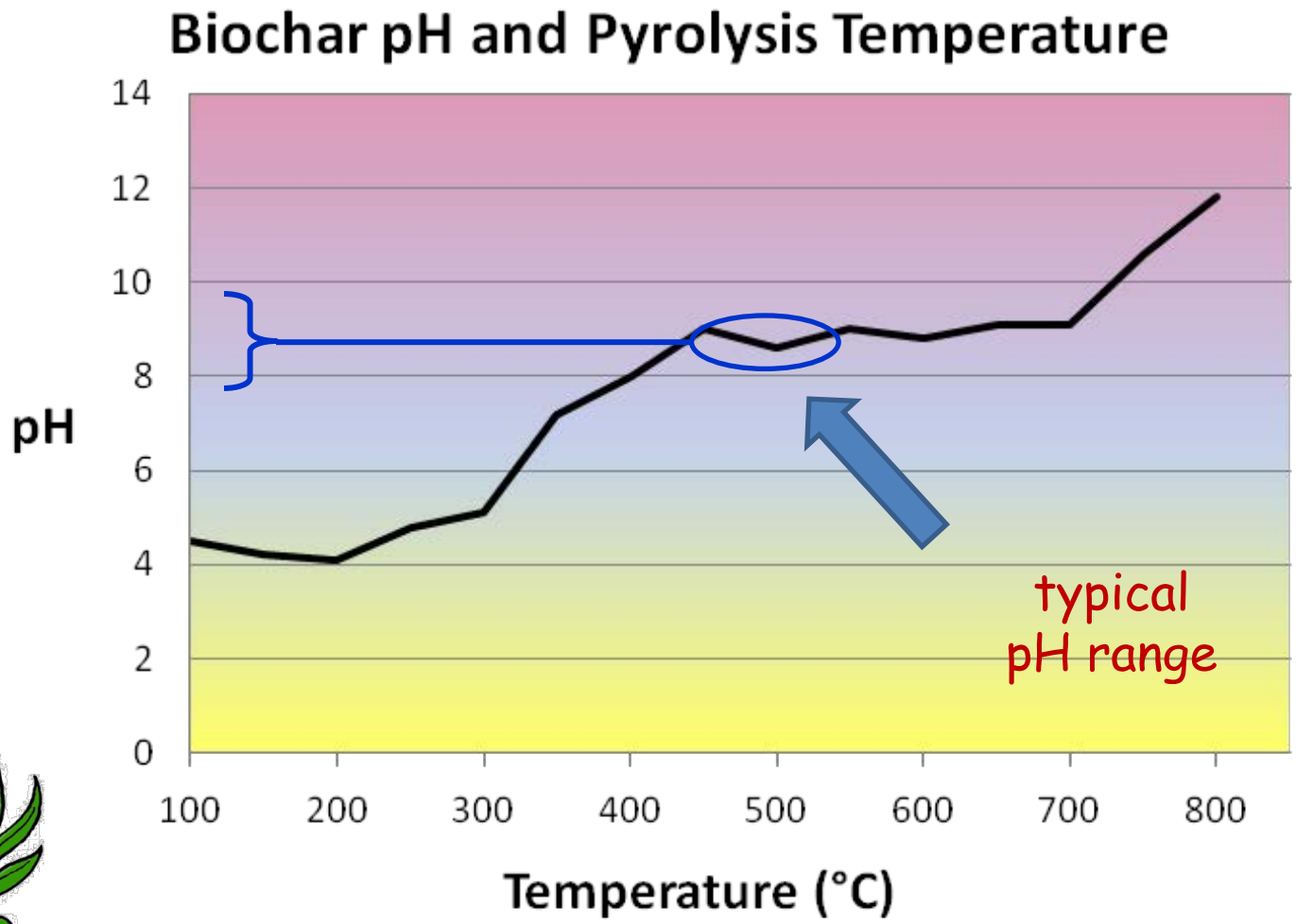
Interest is growing, but…

- **Knowing how to apply, how much to apply, and under what circumstances to apply……not widely known or clearly understood.**

- **Just like NPK fertilizers or liming agents, Biochar too can have negative impacts on your crop when incorrectly applied.**



- Biochar is usually alkaline
- Biochar pH depends on the pyrolysis temperature



Planning to use biochar to change soil pH?

Pay attention to the process !

- **Slow Pyrolysis chars produced in presence of steam tend to be acidic (carboxylic acid groups activated)**
- **Fast Pyrolysis chars produced in absence of steam tend to be very basic and make good liming agents**

What does biochar look like

Different sizes

Size #2

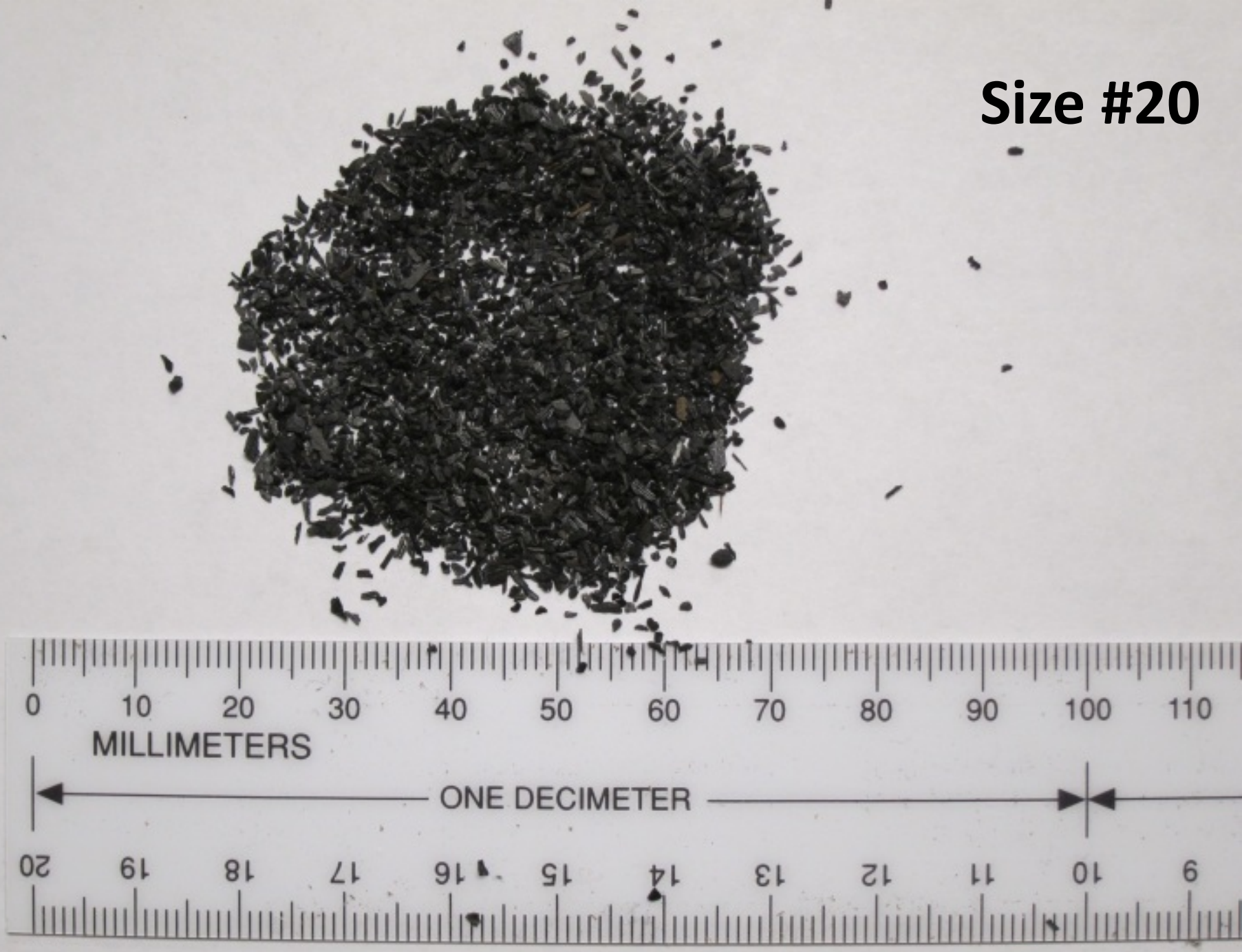

Size #3
0 10 20 30 40 50 60 70 80 90 100 110 120
MILLIMETERS
ONE DECIMETER
20 19 18 17 16 15 14 13 12 11 10 9 8

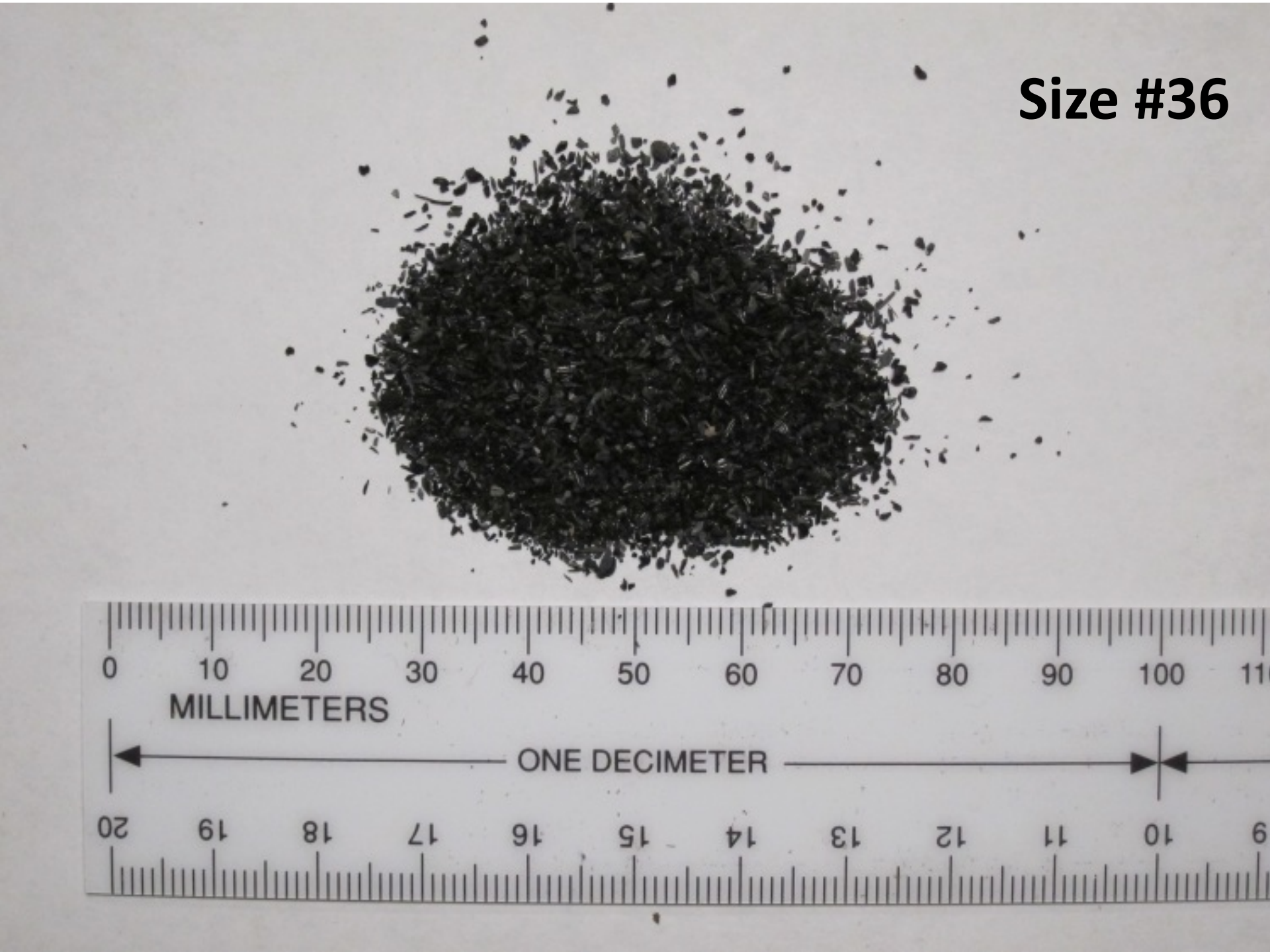

Size #4
10 20 30 40 50 60 70 80 90 100 110 120
MILLIMETERS
ONE DECIMETER

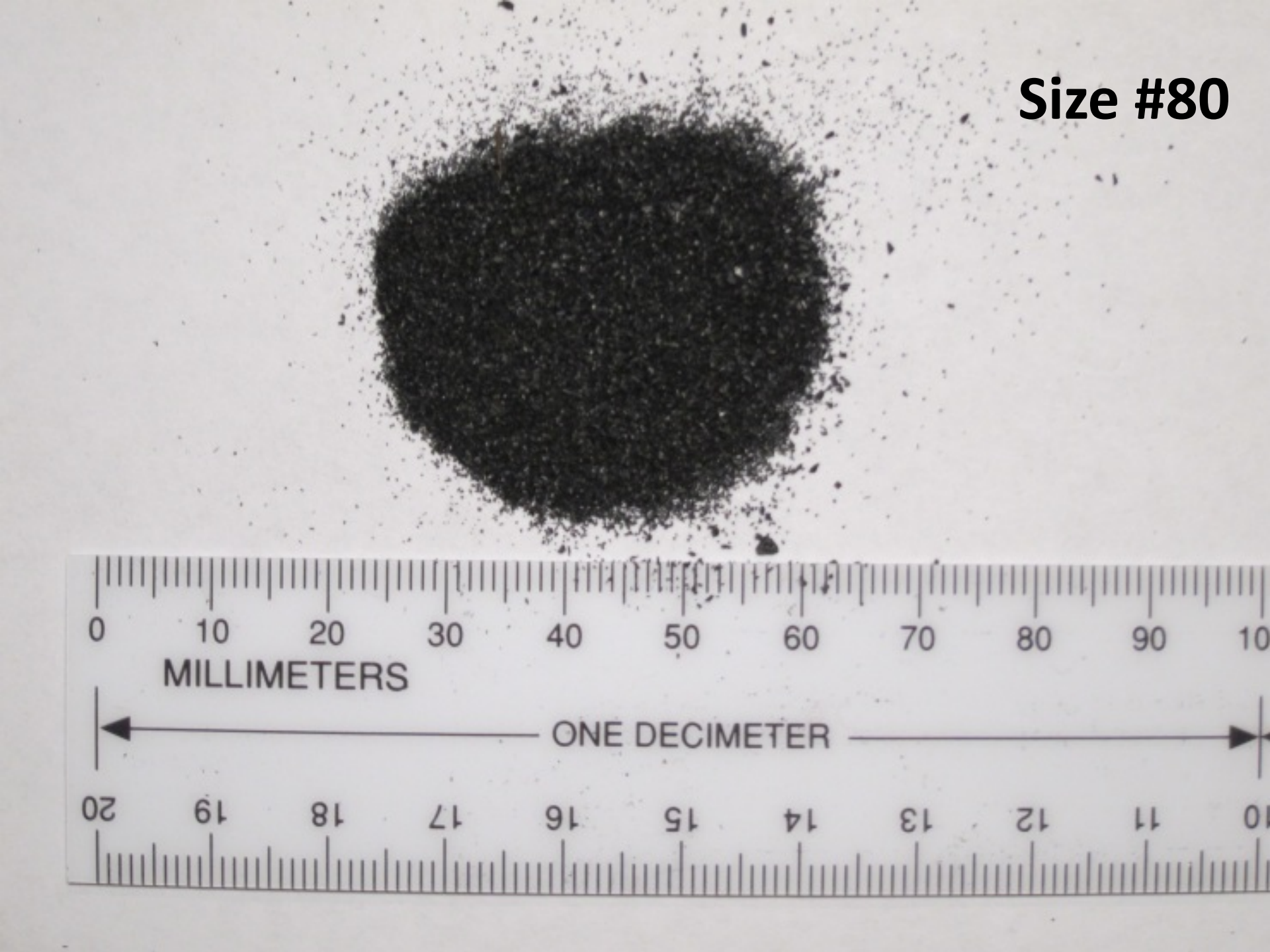

Size #6
0 10 20 30 40 50 60 70 80 90 100 110 120
MILLIMETERS
ONE DECIMETER

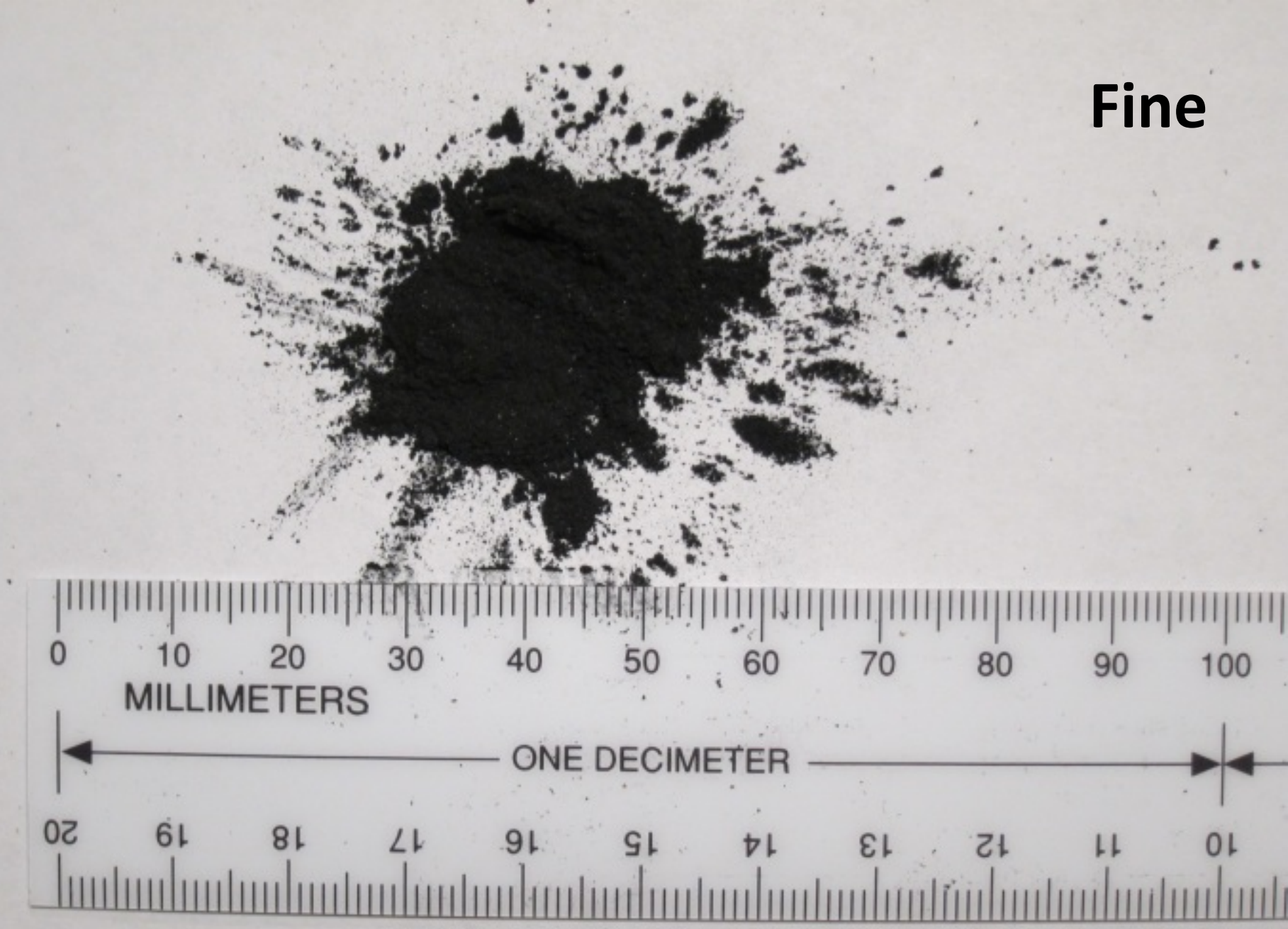
Size #10


0 10 20 30 40 50 60 70 80 90 100 110 120
MILLIMETERS
ONE DECIMETER
20 19 18 17 16 15 14 13 12 11 10 9 8


Size #20
0 10 20 30 40 50 60 70 80 90 100 110
MILLIMETERS
ONE DECIMETER
20 19 18 17 16 15 14 13 12 11 10 9


Size #36
0
10
20
30
40
50
60
70
80
90
100
MILLIMETERS
ONE DECIMETER
20
19
18
17
16
15
14
13
12
11
10


Size #80
0 10 20 30 40 50 60 70 80 90 10
MILLIMETERS
ONE DECIMETER
20 19 18 17 16 15 14 13 12 11 10

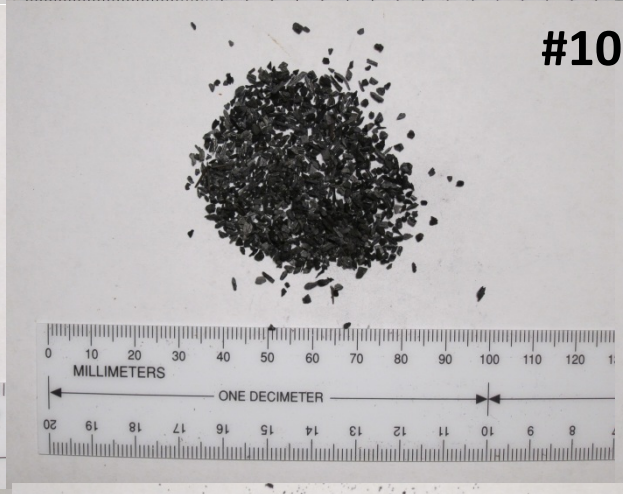

Fine
0 10 20 30 40 50 60 70 80 90 100
MILLIMETERS
ONE DECIMETER
20 19 18 17 16 15 14 13 12 11 10

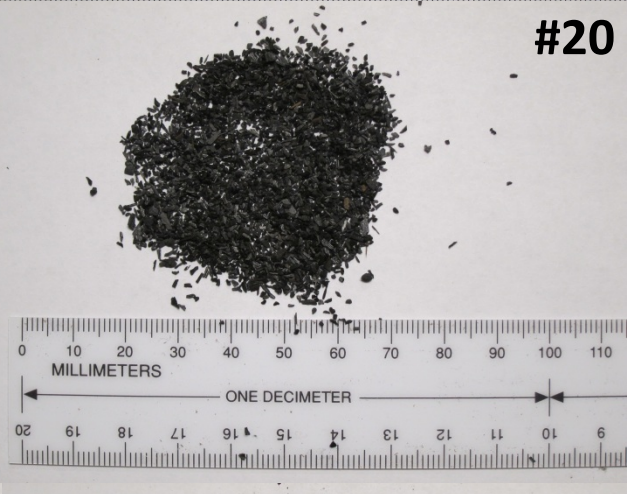

#2
MILLIMETERS
ONE DECIMETER


#3
MILLIMETERS
ONE DECIMETER

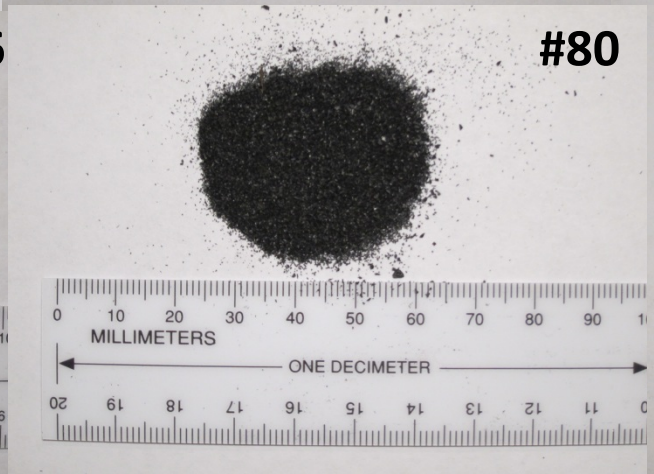

#4
MILLIMETERS
ONE DECIMETER

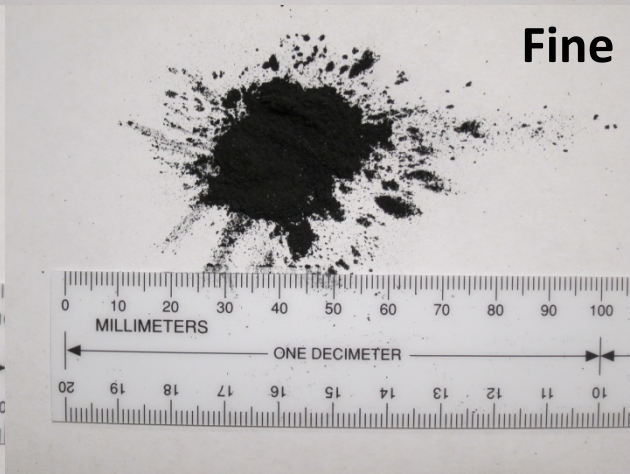

#6
MILLIMETERS
ONE DECIMETER


#10
MILLIMETERS
ONE DECIMETER

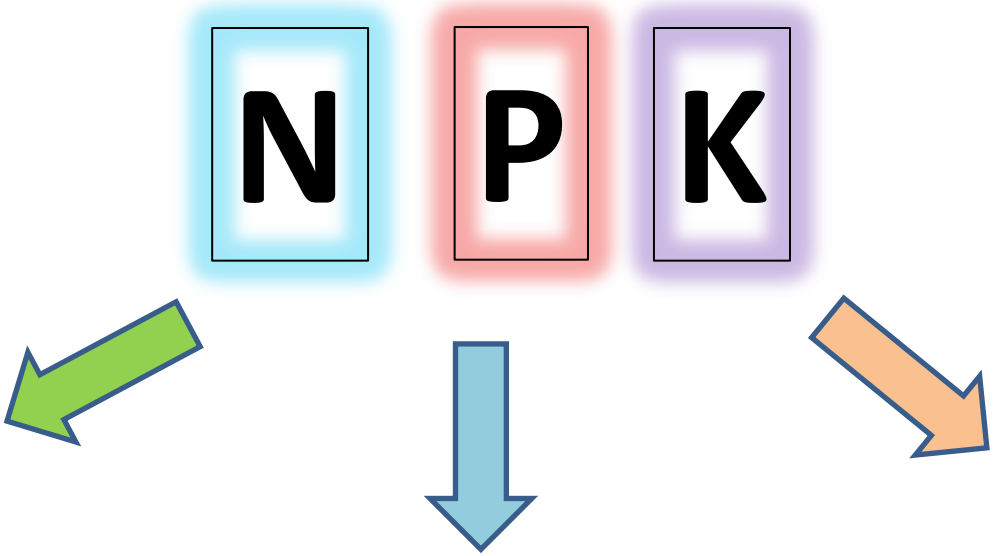

#20
MILLIMETERS
ONE DECIMETER


#36
MILLIMETERS
ONE DECIMETER


#80
MILLIMETERS
ONE DECIMETER


Fine
MILLIMETERS
ONE DECIMETER

Nutrient properties of biochar



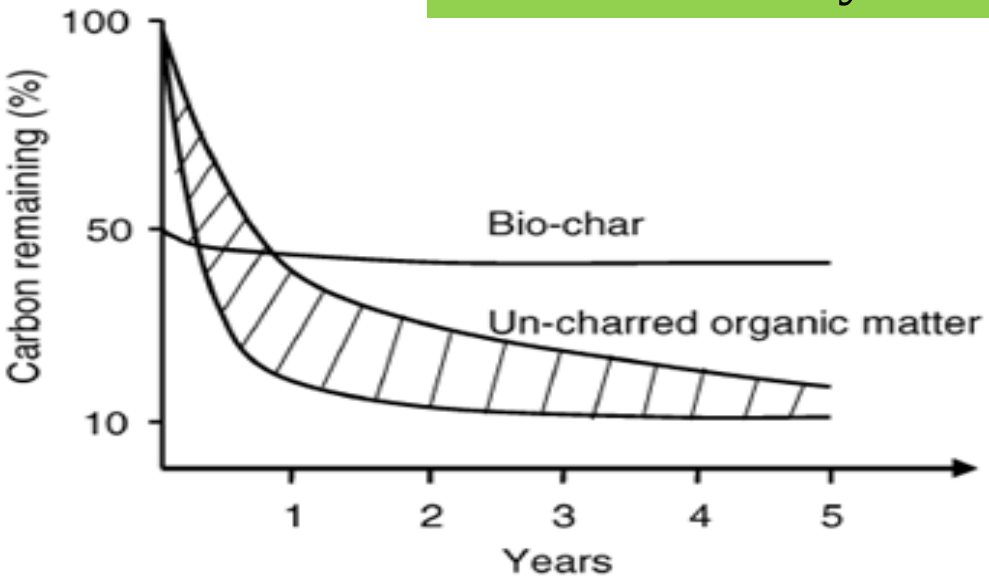
N	P	K
0.1 % (green waste)	0.02 %(green waste)	0.1 % (green waste)
1.0 % (wood)	0.7 %(wood)	0.1 % (wood)
2% (poultry litter)	2.5 % (poultry litter)	2.2 % (poultry litter)

What is the half life of the carbon in biochar

1. 200 years
2. 500 years
3. 1,000 years
4. ✓ 1,400 years

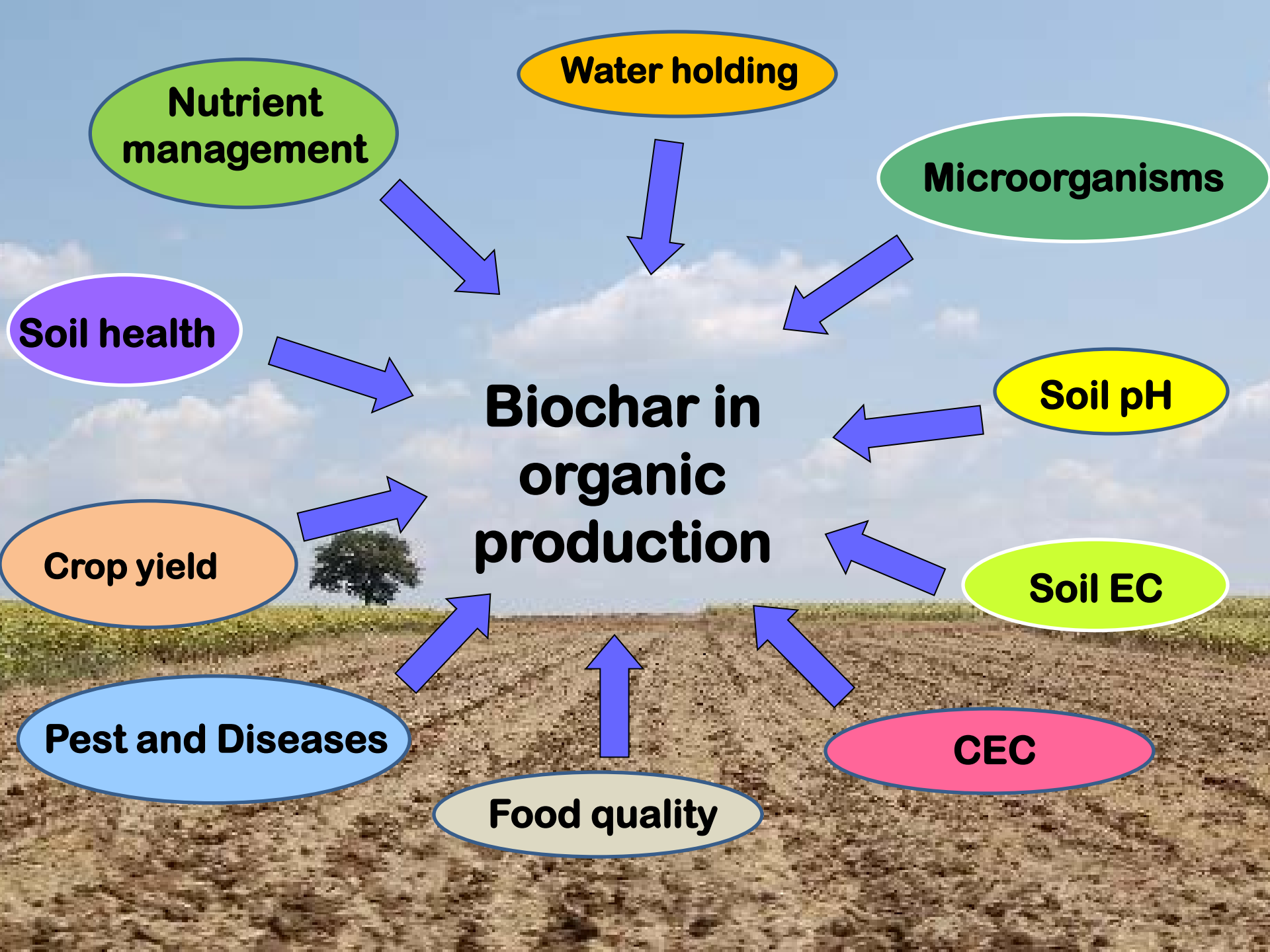
Longevity of Biochar in soil

Half-life of biochar is close to ~1400 years.



AVAILABILITY and COST

- Hard to find it in larger quantities
- Consistency in product
- Prices have not yet stabilized to an actual market value
- $18-20/50 lb bag
- Shipping is expensive


Water holding
Nutrient management
Microorganisms
Soil health
Soil pH
Biochar in organic production
Crop yield
Soil EC
Pest and Diseases
CEC
Food quality

Biochar in carrot and pepper production

Yes! We hired astronauts from NASA

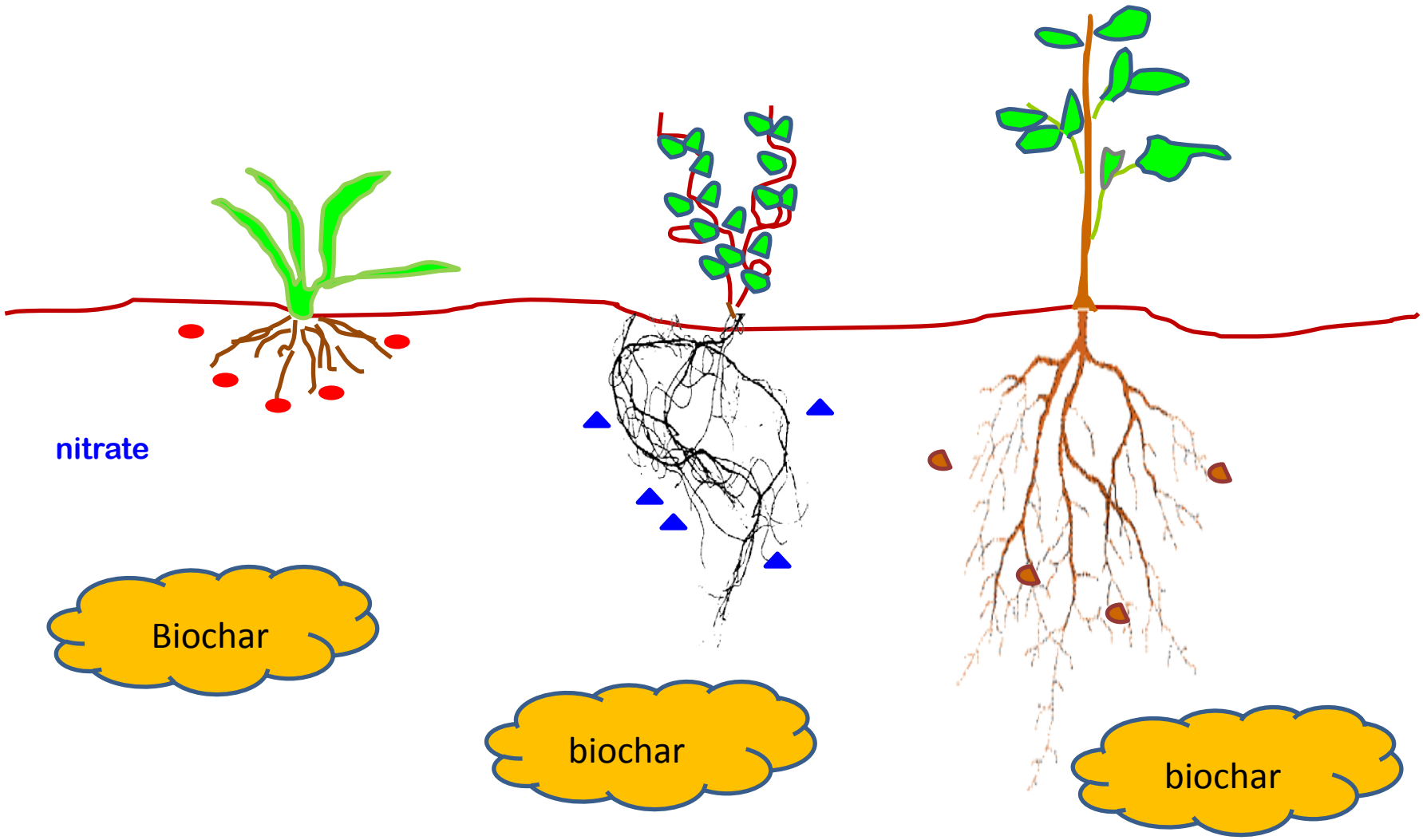

0 T/A
5 T/A
Treatments
10 T/A
20 T/A
Biochar tilled in to the soil.
8-10 inch deep

Biochar in carrot and pepper production

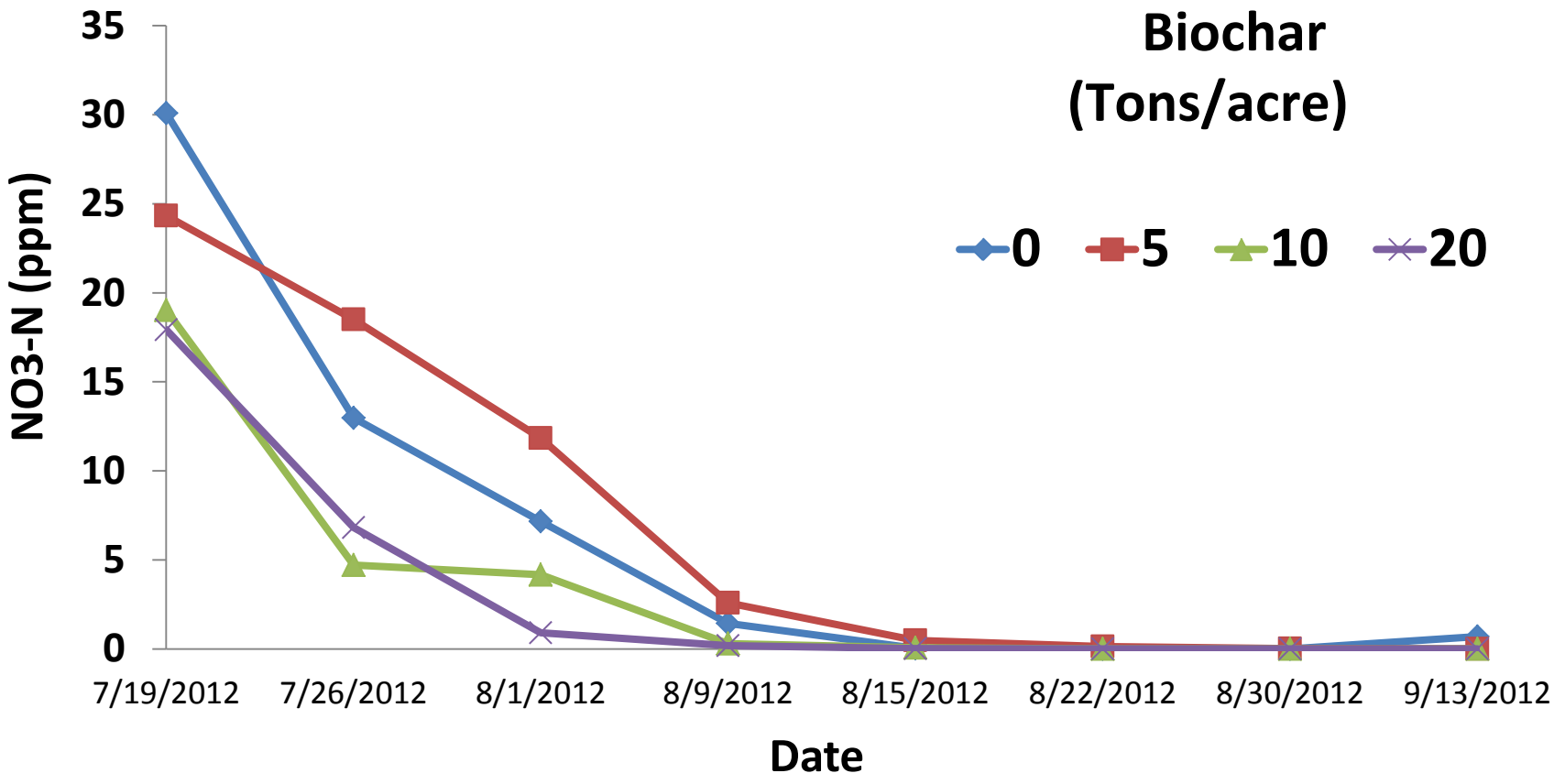
Pepper yield

Plastic treatment	Biochar (tons/ acre)	Fruit Yield per plot (kg)		Fruit Number per plot	
		Marketable[y]	Nonmarketable[ns]	Marketable[ns]	Nonmarketable[ns]
Black plastic	0	22.2abc	9.4	176	123
	5	20.1abc	8.1	166	101
	10	19.8bc	8.0	155	96
	20	18.9c	9.0	151	110
No plastic	0	27.0a	9.3	192	103
	5	24.6abc	8.9	178	106
	10	25.1abc	10.0	187	114
	20	25.5ab	7.4	192	87

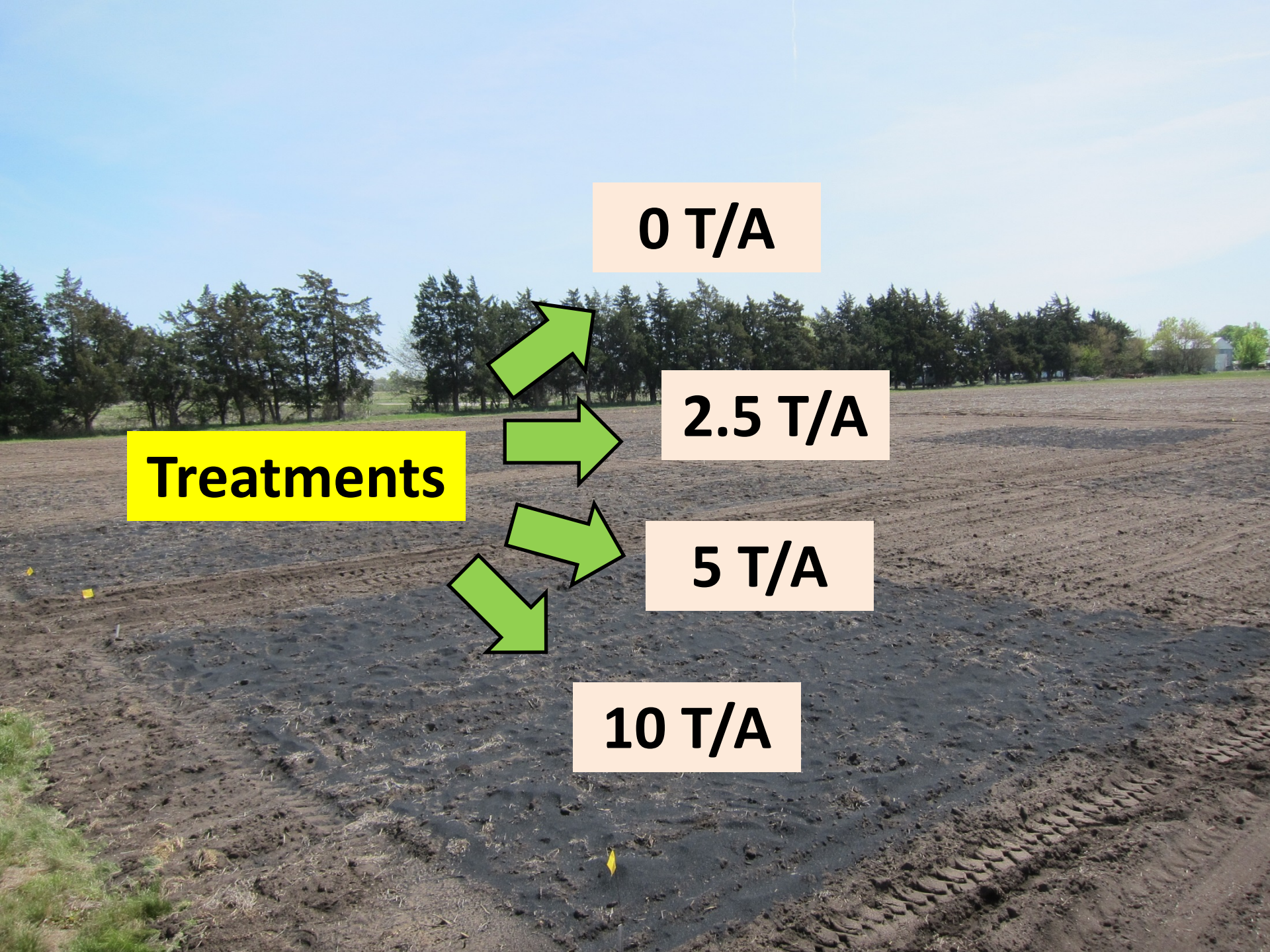
Reduced nitrate leaching



Nitrate leaching



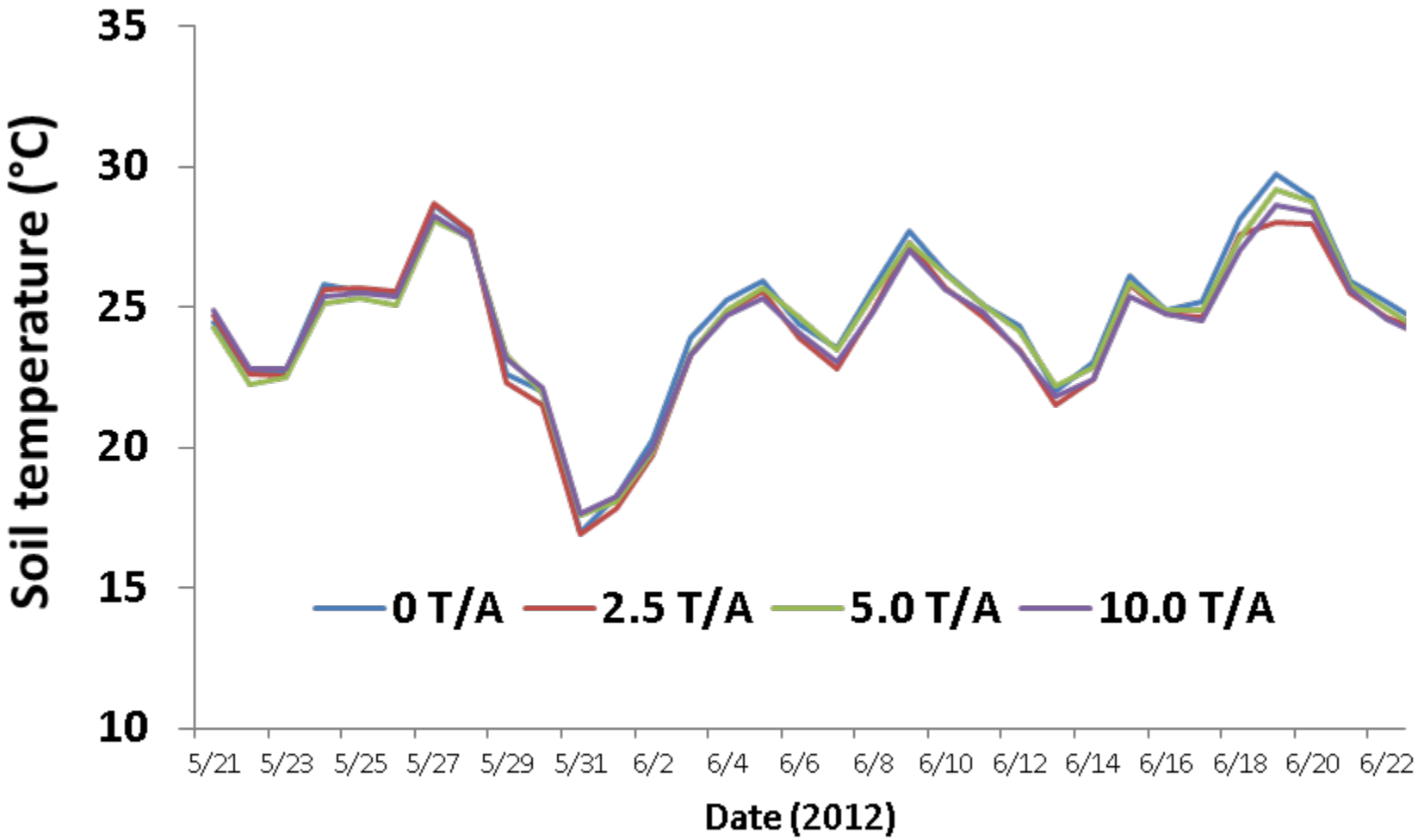

Biochar in sweet corn production
Muscatine Island Research Station, Iowa


Treatments
0 T/A
2.5 T/A
5 T/A
10 T/A

Biochar disked in


Mid May

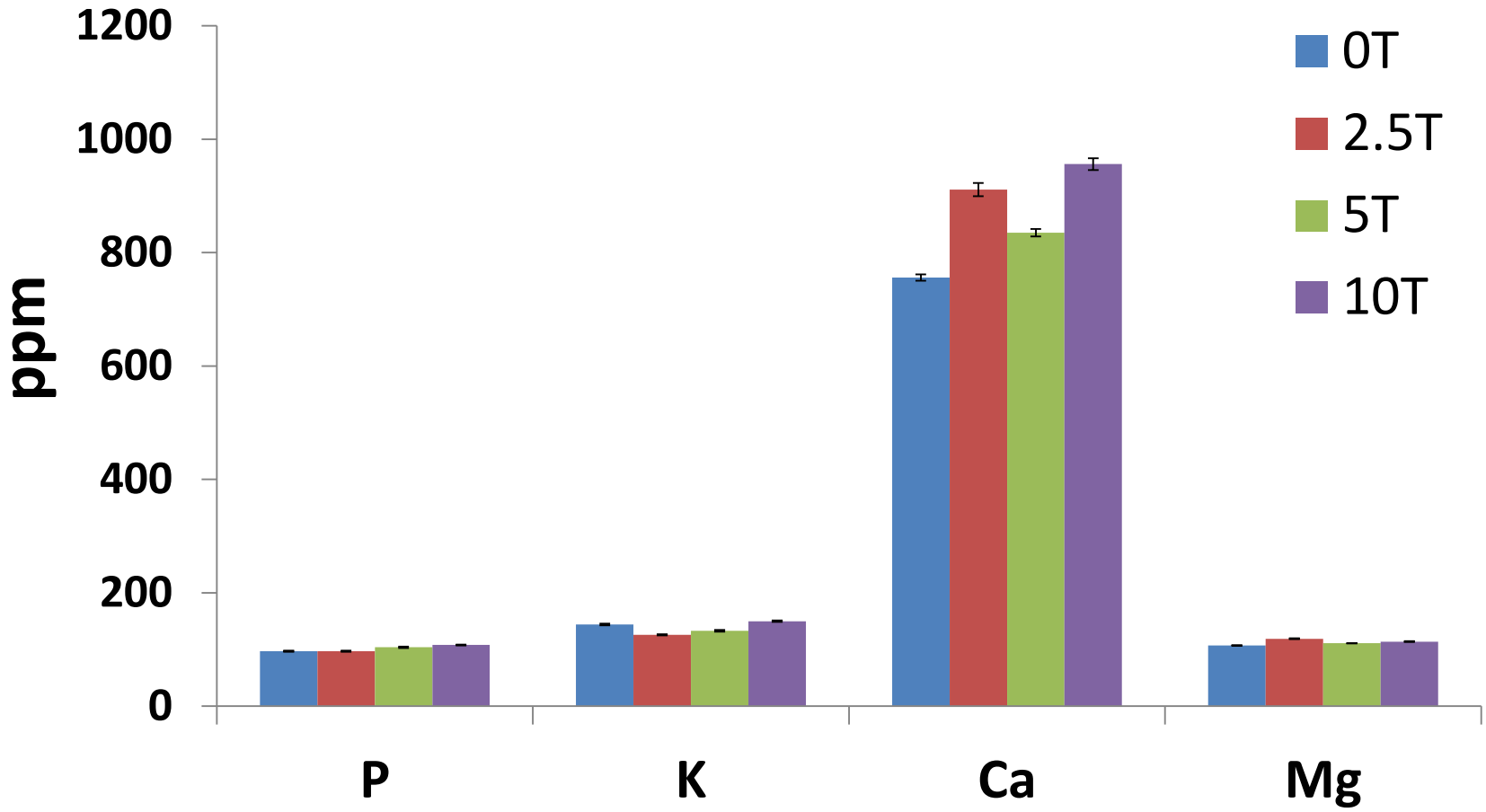
Soil temperature at 6” depth



Effect of biochar on soil pH and electrolytic conductivity at the time of sweet corn harvest

Treatment (T/A)	Soil pH[NS]	Electrolytic conductivity[NS]
Control (0)	6.2	0.37
2.5	6.1	0.31
5.0	6.3	0.23
10.0	6.4	0.36

Effect of biochar on soil nutrients



Temptation (SE; bicolor)

Sweet corn yield

Treatment	Marketable		Non-marketable[NS]	
	Number[†]	Weight (kg)	Number	Weight (kg)
Control	56 a	16.8 ab	3	0.8
2.5 t/A	57 a	17.1 a	2	0.6
5.0 t/A	51 b	15.3 bc	6	1.4
10.0 t/A	52 b	15.6 c	4	0.9

[NS] Non-significant

[†] Mean separation within columns; means followed by same letter(s) are not significantly different ($P \leq 0.05$)

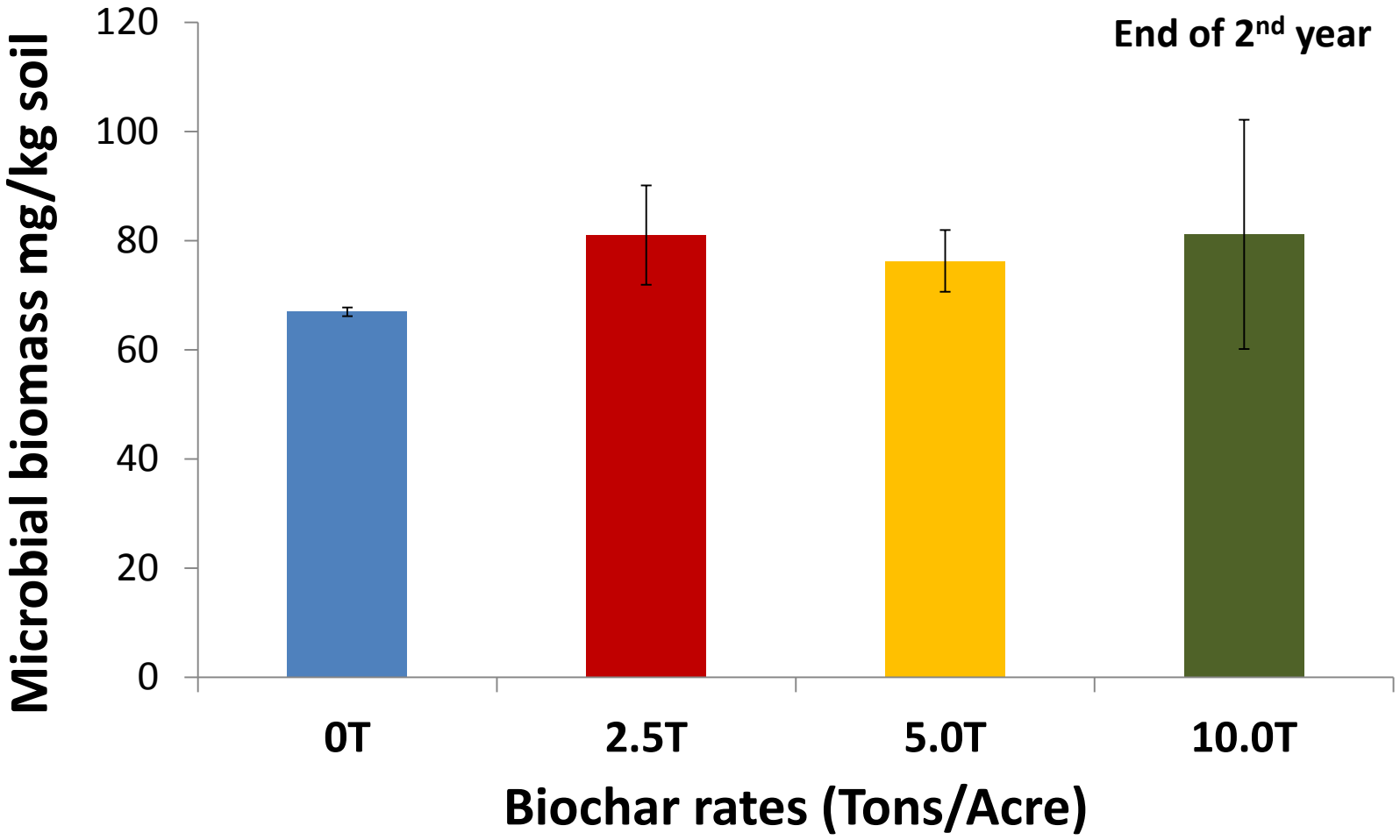
Sweet corn growth and quality

Treatment	Plant height (cm) †	Husked weight (kg)NS	Ear length (cm) NS	Ear width (cm) NS	BrixNS
Control	56 a	0.23	18.1	4.8	24.6
2.5 t/A	57 a	0.23	18.3	4.8	25.4
5.0 t/A	51 b	0.24	18.4	4.8	25.3
10.0 t/A	52 b	0.23	18.6	4.8	24.5

NS Non-significant

† Mean separation within columns; means followed by same letter(s) are not significantly different ($P \leq 0.05$). Plant height taken at 8-leaf stage

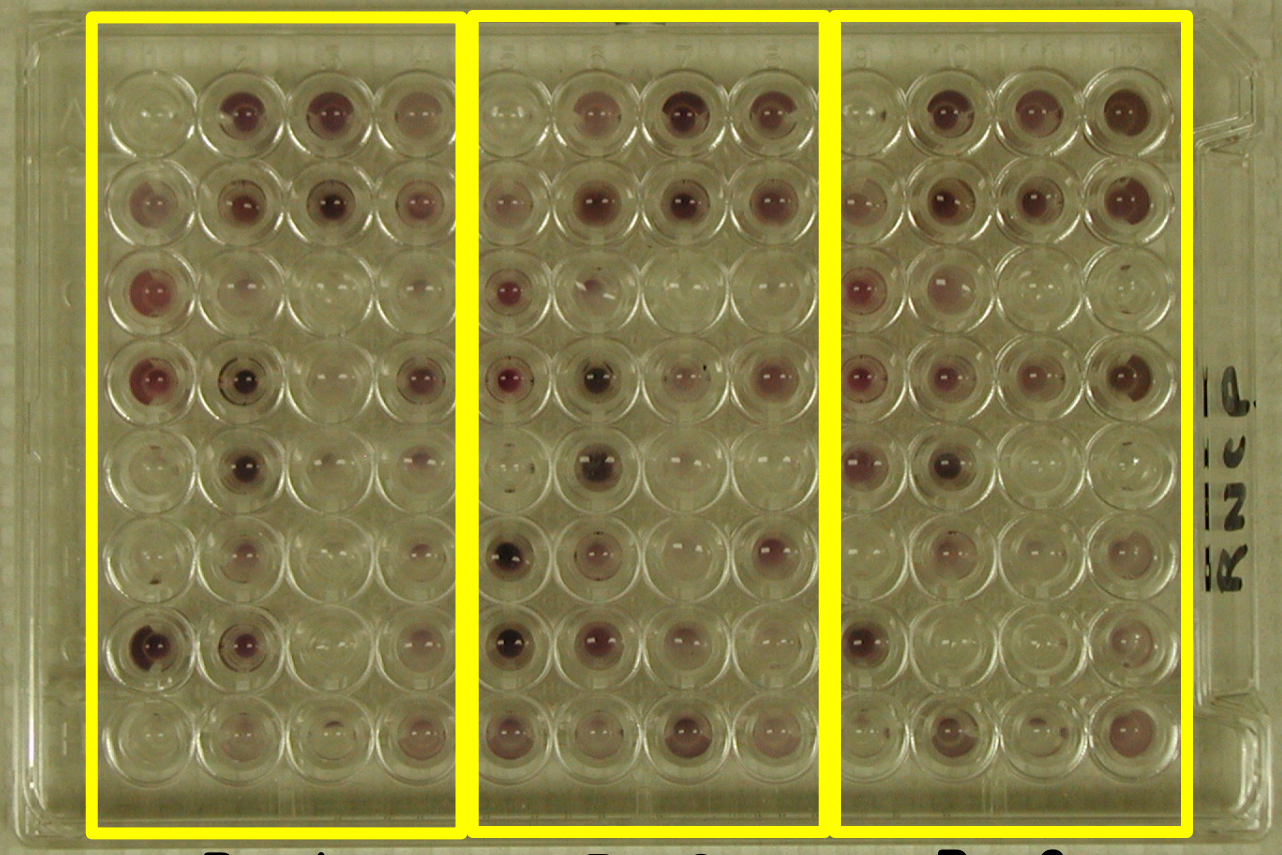
Microbial Biomass Carbon



Community level physiological profile

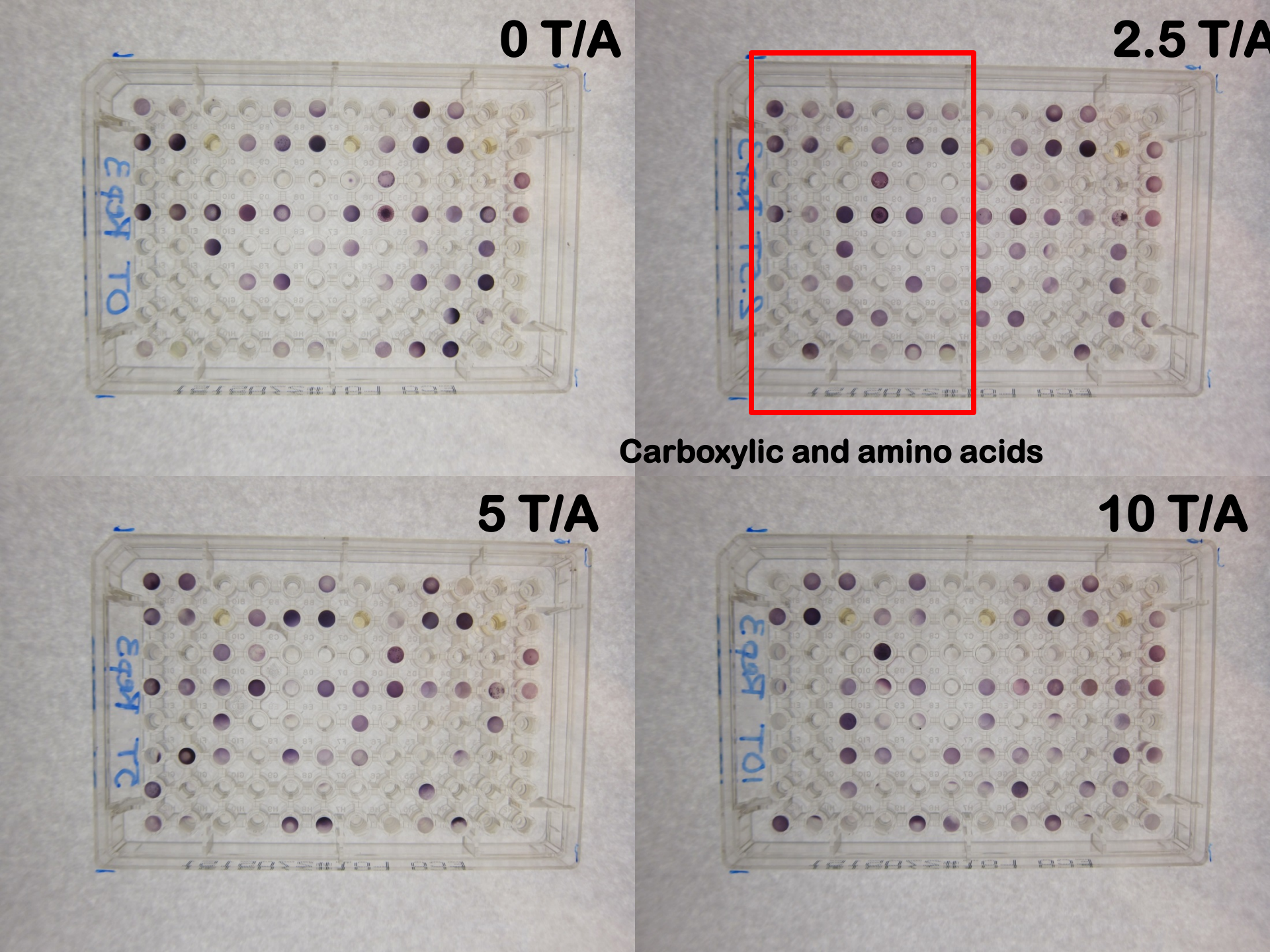
CLPP is a rapid means of detecting relative change in microbial communities

Patterns of potential C source utilization

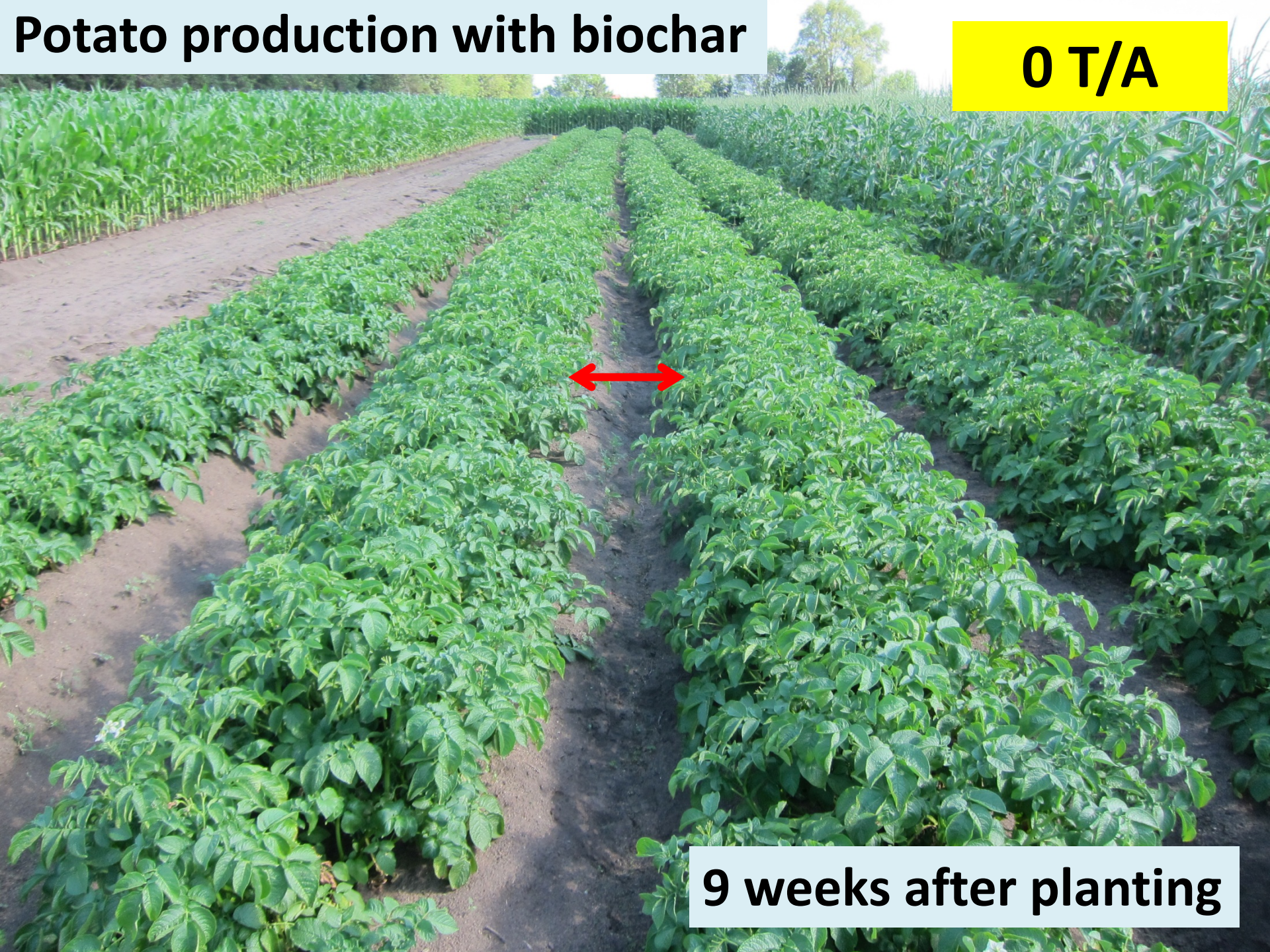


Rep 1 **Rep 2** **Rep 3**

- **Biolog® Ecoplates**
- **31 carbon different carbon substrates**


0 T/A
2.5 T/A
Carboxylic and amino acids
5 T/A
10 T/A

Potato production with biochar

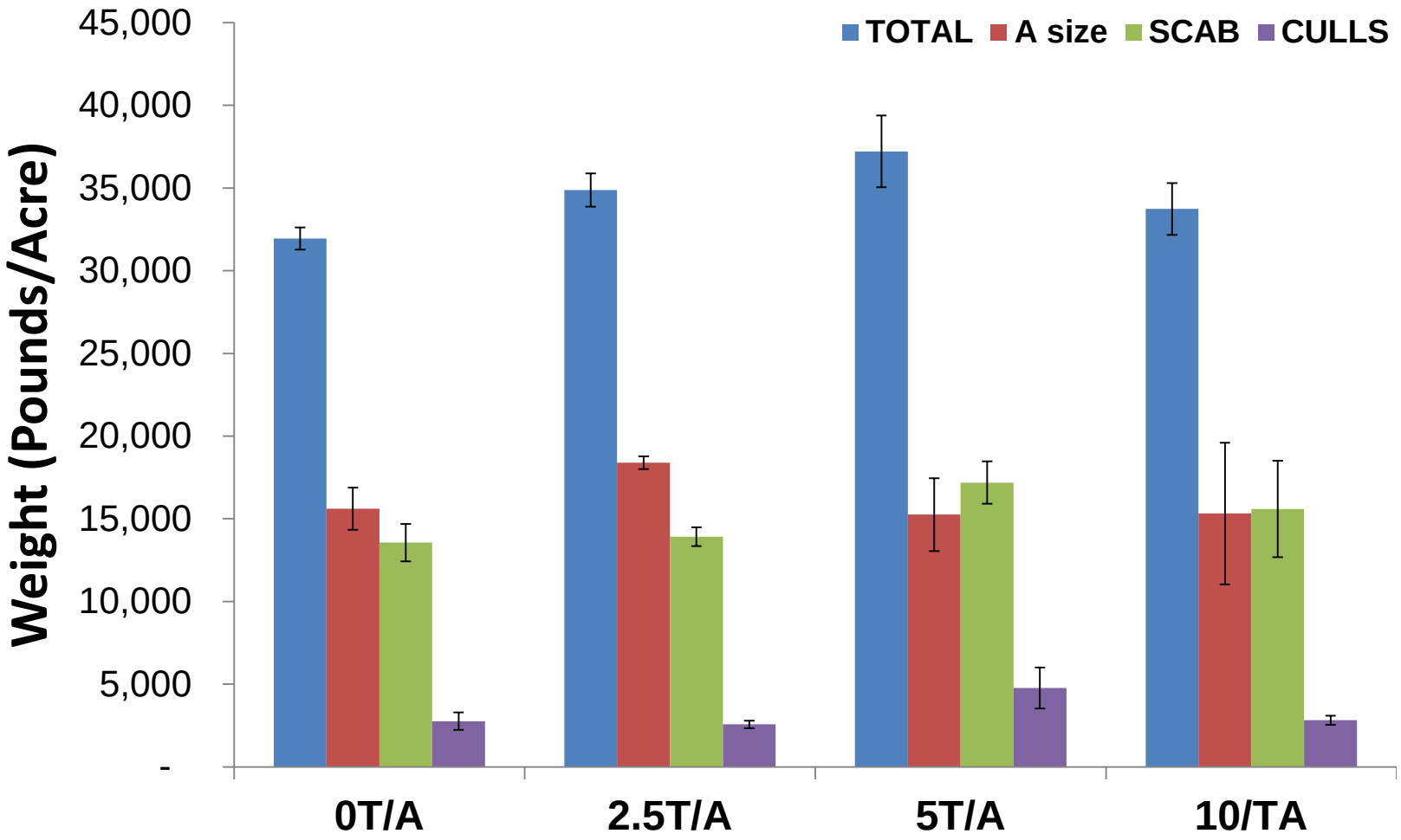



2.5 T/A


5 T/A


10 T/A

Potato yield



Summary

- First year results show promising trends of reduced nitrate leaching from biochar plots
- Pepper yield slightly affected by biochar application
- Yield reduction observed in sweet corn plots as well.
- No significant effect on sweet corn quality
- Microbial biomass positively affected

Soil Building Processes

Cover Crops

Compost

Why biologically active ?

Crop rotation

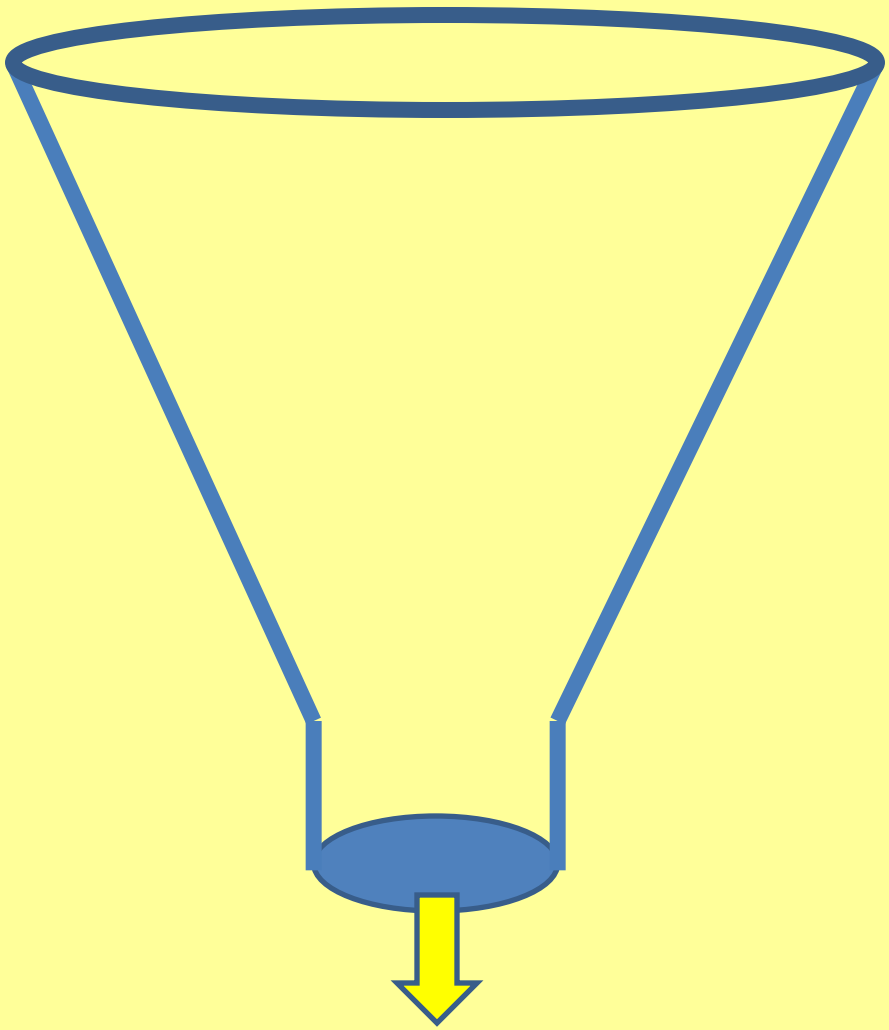
No-Till

Irrigation

Nutrient Management

Strip Till

- *Initiate decomposition reactions*
- *Release of nutrients for plant uptake*
- *Development of humus and other growth promoting substances*
- *Improvement in soil structure and physical propeties*
- *Suppress soil-borne pathogens by occupying the niche*
- *Drive nature's C and N cycles*



Biologically Active Soil

Many Thanks

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Iowa Fruit & Vegetable Growers Assn.

Practical Farmers of Iowa

LEOPOLD CENTER
FOR SUSTAINABLE AGRICULTURE

IOWA DEPARTMENT OF AGRICULTURE AND LAND STEWARDSHIP

NORTH CENTRAL SARE
Sustainable Agriculture Research & Education

Thank you !

This happens in Iowa

Questions ?

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