

Using Biochars to Improve Soil C Sequestration and Fertility Characteristics


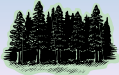

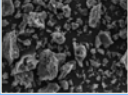
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Biochar presentation:

- Biochar terminology
- Pyrolytic production
- Characterization
- South Carolina soil morphology
- Use as a soil amendment
- Biochar incubation studies
 - * Norfolk (SC)
 - * Margate (FL)
- Conclusions






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Biochar terminology:

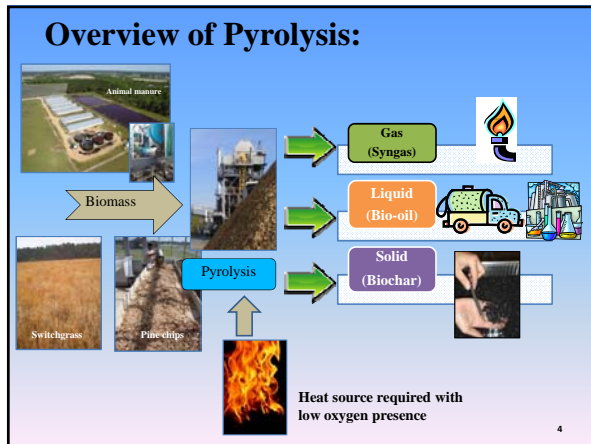


- Biochar is used to describe charred organic matter applied to soil with the intent to improve soil properties (Lehmann and Joseph, 2009).
- Popular terms to describe alternate C-enriched residues:
 - Charcoal, black carbon, char, activated carbon



Charcoal bricks Char Activated C

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Biochar characterization (pH):

Feedstock	Pyrolysis (°C)	Mean pH (H ₂ O)	Source
Wood	400	6.9	Singh et al. (2010)
	500	8.8	
Cow manure	400	9.0	Jones et al. (2012)
	450	8.8	
Pecan shell	350	5.9	Novak et al. (2009a)
	700	7.2	
Poultry litter	350	8.7	Novak et al. (2009b)
	700	10.3	
Pine chips	465	6.1	Novak and Busscher (2012)
	Corn stover	500	

As pyrolysis temperature increases, biochar pH can increase

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Biochar characterization (nutrient):

Feedstock	Pyrolysis (°C)	Fertilizer equivalent ratio (kg/t biochar)			source
		N	P	K	
Swine manure	350	37	39	18	Cantrell & Martin, 2011
	700	26	59	26	
Cow manure	400	14	4	26	Singh et al. 2010
	550	11	5	23	
Poultry litter	350	50	30	60	Novak et al. 2009b
	700	30	40	90	
Pine chips	350	5	0.2	2	Novak et al. 2012
	500	4	0.3	3	
Switchgrass	250	4	1	5	Novak et al. 2012
	500	11	2	12	

Biochars made from manures have higher fertilizer equivalent N P K ratios, and as pyrolysis temperature increases (> 500°C) N declines, P & K increase.

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❖ **Examples of biochars used for soil fertility improvement.**

- Norfolk loamy sand (Ultisol in SC)
- Margate sand (Entisol in FL)



Norfolk loamy sand has low SOC content, and a poor nutrient and water retention capacity.



Margate sand has an alkaline soil pH that limits micronutrient availability.

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Norfolk loamy sand (Ultisol) fertility characteristics (Novak et al. 2009)¹

Treatment (°C)	pH (H ₂ O)	SOC (%)	Mehlich-1 extractable (lbs/ac)	
			P	K
Control	5.6	0.31	63	44
Pecan shell (500)	6.3	1.55	55	139
Poultry litter (700)	8.4	1.16	1647	638
Switch grass (500)	7	1.96	75	197
Hardwoods (500)	6.6	1.72	51	144
Peanut hull (500)	7.8	1.95	64	401

¹biochars added at 40 mt/ha (9 g/450g soil); incubated for 120 d

- Not all biochars were effective at improving soil fertility.
- Manure biochars contain excessive P and K and can have an environmental impact.
- For Norfolk soils, a soil test recommendation for 100 bu/ac corn crop is:
 - soil pH 5.8 to 6.4
 - Mehlich 1 extractable nutrient sufficiency levels are for P -- 31 to 80 and
 - for K are 71 to 182 lbs/ac, respectively (Clemson Extension Service).

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Margate sand (Entisol) fertility characteristics (Novak et al. 2014)¹

Treatment (°C)	pH (H ₂ O)	CEC (cmol/kg)	Mehlich-1 extractable (mg/kg)	
			P	K
Control	7.5 (0.2)a	6.2 (0.7)ac	130 (11)a	21 (2)a
Bagasse (350)	7.6 (0.1)a	5.3 (0.1)a	125 (4)a	26 (2)a
Pine chip (350)	7.6 (0.1)a	5.6 (0.6)ac	125 (5)a	25 (2)a
Hydrochar 1	7.4 (0.0)a	5.2 (0.3)a	129 (8)a	26 (2)a
Hydrochar 2	7.2 (0.0)b	4.7 (0.2)ab	122 (2)a	23 (2)a
Swine solids (350)	7.7 (0.0)a	6.8 (0.6)c	403 (63)b	52 (8)b

¹biochars and hydrochars added at 10 mt/ha (1.73g/450g soil); incubated for 120 d



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Biochars and soil fertility wrap up:



Dr. Jim Frederick, Clemson Univ.

❖ Biochars can improve soil C sequestration because they are C-enriched, but some biochars are nutrient poor because of feedstock and pyrolysis temperature selection.

❖ Some biochars contain excessive plant nutrients and are calcareous, so soil pH and fertility characteristics can be impacted.

❖ These findings lead to the realization that not all biochars are effective at improving all soil quality deficiencies.
