Use of Biochar Originating From Gasified Wood and Temperate Grass Feedstocks as a Soil Amendment

EFFECTS ON WHEAT GROWTH

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INTRODUCTION

•On-farm gasification of agricultural residues, the non-food byproducts from crop harvests, could provide a means to generate value-added income from the production of fuel or electrical generation.

•Char produced during the process also has potential value as a soil amendment for a variety of purposes including field crop production.

•Char produced from gasification is different from that produced by pyrolysis because gasification is conducted in the presence of a restricted amount of oxygen, which promotes partial combustion at temperatures of 650°C to 800°C. In contrast, pyrolysis is conducted under anaerobic to extremely low oxygen conditions at temperatures between 400°C and 500°C.

•Relative to the current knowledge of the chemical characteristics and utility of char produced from pyrolysis, there is a scarcity of data concerning char produced from the gasification of biomass, especially with respect to its use as a soil amendment. There are even fewer studies of gasification char produced from non-woody biomass, such as that resulting from temperate grasses.

•Due to the lack of data characterizing gasification char produced from grassy biomass, particularly with regards to its use as a soil amendment and subsequent effects on soil chemistry and plant growth, this study characterized char produced by gasification of Kentucky bluegrass seed screenings (KBss) and compared it to char produced from wood biomass.

•Wood char was included because it's the most commonly studied type of char and serves a useful comparison of gasification-derived char from grassy biomass.

•The KBss char under study here was produced in an on-farm gasifier where the biomass was converted to a syngas containing methane, carbon monoxide, and hydrogen and used to partially fuel a diesel generator that produced electricity.

•We recognized that the KBss char byproduct could have utility as a soil amendment if it had characteristics which protected against damaging acid soil conditions, provided crop nutrients, sequestered C, or helped trap and conserve soil water under dryland farming conditions.

•If demonstrated under controlled conditions, we reasoned that this utility could enhance farm profit, soil quality, and resource conservation.

RESEARCH OBJECTIVE

The main objective of this study was to test the hypothesize that low acid farm soils can be mitigated using high temperature-produced biofeedstock chars to reduce plant Al uptake and toxicity by effectively rising soil pH to more optimal levels for plant nutrient acquisition and growth of wheat.

METHODS

Experimental

•Wheat (*Triticum aestivum* L. cv. Madsen)
•Grown for 74 days (Feekes 5 growth satge) in plastic pots
•Soil used was either a Freeman or Bernhill soil from a farm site in Spokane County, WA
•KBss or wood char conc. 0, 2.6, 6.7, 14.4, and 33.7% by volume
•Due to slight differences KBss and wood char density, the final mass concentration of KBss char to soil was 0, 4, 12, 25, and 58 g kg^{-1} and for wood char, 0, 7, 17, 37, and 86 g kg^{-1}
•Plants were grown in a greenhouse at Corvallis, OR, U.S.A.
•No supplemental nutrients were added during the entire study
•All treatments were replicated five times and randomly distributed on the greenhouse bench. The complete experiment was repeated twice

Char source

•The KBss char was produced using a small-scale gasification unit located on a farm near Rockford, WA, U.S.A. (Banowetz et al., 2010)
•The stainless steel reactor was air-blown and operated at temperatures ranging from 600 to 650°C at a feed rate of 60 to 80 kg h^{-1}
•The KBss were produced during the seed cleaning operation and consisted largely of small straw components, immature seeds, and remnants of seed coats
•The pre-ignited mixture had water content of 14% and the predominant particles in the feedstock were less than 5 cm in length
•The wood char was produced from conifer tree cuttings of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), Ponderosa pine (*Pinus ponderosa* C. Lawson), white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.), sugar pine (*Pinus lambertiana* Douglas), and incense cedar (*Calocedrus decurrens* (Torr.) Florin) was produced in a downdraft gasifier at 1200ºC

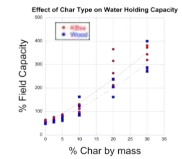
Analyses.

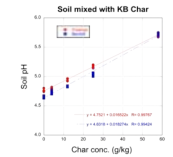
•Soil and plant tissue chemistries were determined that included nutrient content, soil pH & conductivity, minerals and some metals

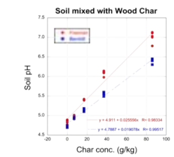
RESULTS (selected data set)

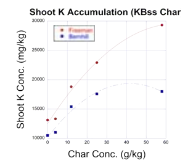
Elemental Analysis of KBss Char

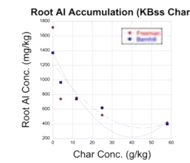
	Char	Soil
	--- mg kg^{-1} ---	
K	48203	3468
Ca	13580	2954
P	11680	474
Mg	5702	3586
S	3879	112
Cl	2268	176
Fe	1,031	20303
Mn	703	658
B	27.2	nd[2]
Na	275	587
Zn	89.5	41.9
Cu	25.1	18.3
Mo	nd	nd
Ni	nd	nd
Al	869	14500
As	nd	nd
Cd	nd	nd
Hg	nd	nd
Pb	nd	nd

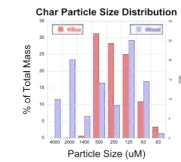


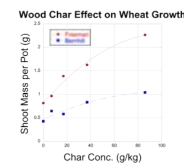


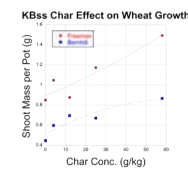




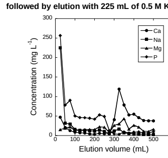








Aqueous elution of Ca, Mg, Na, and P from KBss char column. For presentation purposes, P data are depicted in the figure at 0.5-fold of actual concentration. Double de-ionized water was used for the initial 250 mL elution followed by elution with 225 mL of 0.5 M K_2SO_4.



SUMMARY

- Chemical analysis of the soil and char alone showed the presence of varying concentrations of NO_3-N, NH_4-N, P (Bray-P), K, and total C and N, as well as numerous minerals substantiating their fertile nature.
- The KBss and wood chars have nearly 5-fold higher CEC then the two soils alone.
- Wood and KBss char amendments did not significantly affect wheat seedling emergence when mixed with Freeman or Bernhill soils.
- Wheat shoot dry mass accumulation increased significantly with increasing concentrations of soil amendment by wood or KBss char.
- Addition of char generally lowered Al uptake by wheat in both soils.
- At the conclusion of the wheat growth experiment, 74 days after planting, increase in pH of the Freeman and Bernhill soils was linearly correlated (R=0.998) with increasing KBss and wood char.
- Soil analysis at the commencement of the experiment showed that soil Ca, K, and P concentrations were consistently higher with increasing concentrations of KBss and wood char.
- In addition, the rise in soil pH associated with char addition likely increased uptake of certain minerals by the wheat plants. Interestingly, and not predicted, was that plant Ca uptake declined in plants grown in higher pH soils and higher char concentrations than plants grown under lower pH. This might be explained from recent evidence of column elution studies with mixtures of acid soil and KBss char show selective binding of Al, Cu, S, Zn, to some extent Ca, Mg, Mn, and Na, but not Fe and P.
- Added char to soil increased the soil's water holding capacity.