Wheat Straw Yield and Soil Chemical Changes in Two Coastal Plains Ultisols Amended with Uncharred and Pyrolyzed Sorghum Residues

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BACKGROUND

Current concerns about rising global population growth combined with global food security necessitate major optimization in agricultural management. This will require preservation and replenishment of soil organic matter to sustain nutrient cycling, improve water- and nutrient-use efficiency and mitigate against climate change. The fertility of highly weathered Ultisols in the southeastern Coastal Plains region of United States is low. In this region, intensive crop production depletes soil nutrients and reduces soil organic carbon (C).

Application of crop residues in agricultural systems is an important factor in the control of soil fertility and nutrient cycling. Other agronomic interventions would include addition of C sequestering minerals to soil and addition of pyrolyzed organic residues.

Pyrolysis of crop biomass generates a by-product called "biochar", which can be recycled to sustain nutrient and C concentrations in biomass production fields. The use of biochar as a soil amendment enhances soil fertility and offset expenses for fertilizer and lime.

Research Hypothesis and Objective

We hypothesized that sorghum biochars would deliver more positive effects on winter wheat biomass than sorghum residues. The objectives of this study were to evaluate the effects of uncharred (SR) and pyrolysed sorghum residues (SB), with or without supplemental P fertilizer on soil chemical changes and biomass of winter wheat grown in two Coastal Plains Ultisols.

MATERIALS AND METHODS

I. Soils, Feedstock and Biochar Production – Two soils were used in the study: Norfolk soil (fine loamy, kaolinitic,thermic, Typic Kandiudults and Dunbar soil (fine, kaolinitic, thermic, Aeric Paleaquults). Grain sorghum (*Sorghum vulgaris* L.) stovers were hand collected from a 7.7-ha field at the Coastal Plains Soil, Water, and Plant Research Center in Florence County, SC. The raw sorghum residues was hammer milled to approximately 6 mm particle size.

Pyrolytic runs of the raw sorghum residues were performed at 500 °C. Prior to a run, the sorghum was oven-dried (103°C) overnight and then loaded into a mesh basket and placed into a Lindburg electric box furnace equipped with a gas tight retort (Model 51662; Lindburg/MPH, Riverside, MI). Chemical properties of sorghum residues and sorghum biochars are shown below.

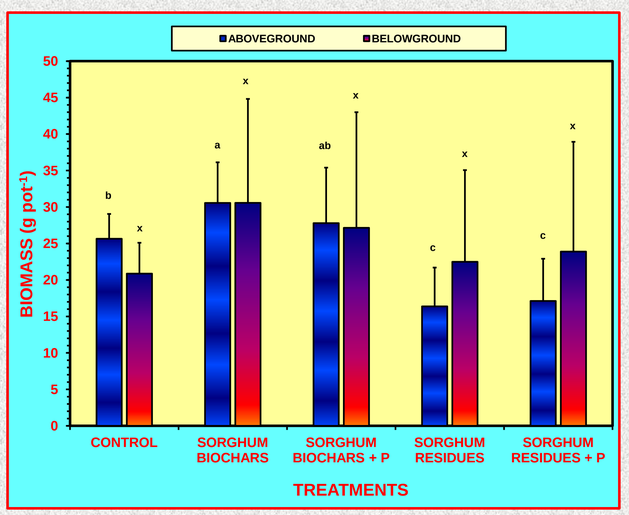
Properties	Sorghum Residues	Sorghum Biochars
N (g/kg)	9.9	13.0
P (g/kg)	1.1	3.5
K (g/kg)	24.2	66.9
Ca (g/kg)	2.6	8.5
Mg (g/kg)	2.0	6.2
S (g/kg)	1.4	2.2
Na (mg/kg)	26.0	146.0
Fe (mg/kg)	75.0	217.0
Cu (mg/kg)	5.0	11.0

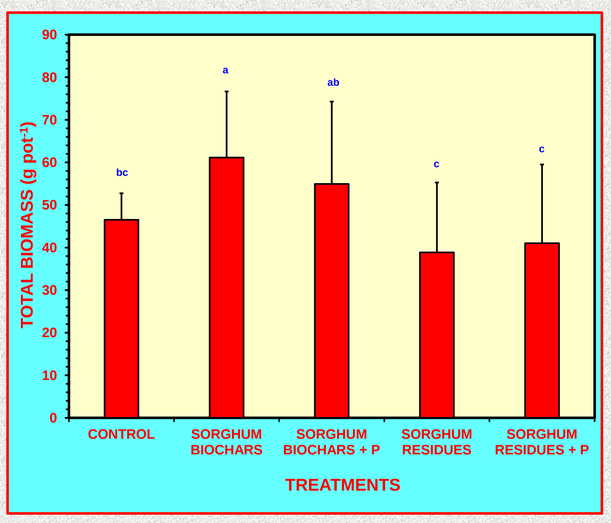
2. The application Rate: 13 Mg/ha for Sorghum Residues (SR) and Sorghum Biochars based on 200 bushels/ha yield goal; 40 kg P/ha

3. Experimental Design and Greenhouse Set-Up: (2 x 5 split plot in complete block design)

RESEARCH HIGHLIGHTS and FINDINGS

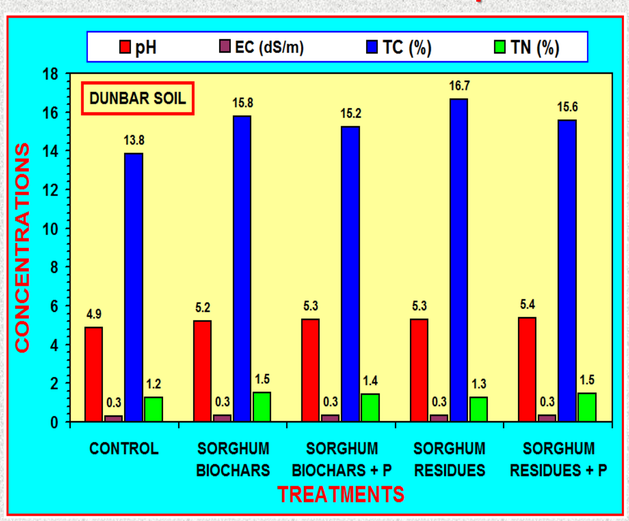
1. Effects on Wheat Biomass

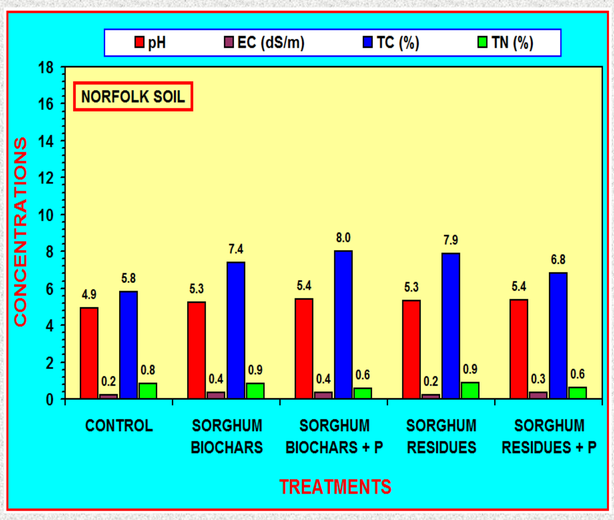




Addition of sorghum biochars with or without P increased total biomass of winter wheat by about 31% over the control plants. Results have shown greater beneficial effects of sorghum biochars than sorghum residues on aboveground and belowground biomass of winter wheat.

2. Effects on Soil Chemical Properties





Soil pH and EC varied significantly with sorghum treatment. Incorporation of sorghum residues with or without P and sorghum biochars with or without P in Dunbar soils resulted in significantly higher soil pH than in the control. Overall, sorghum treatments had small, but significant effects on soil TC and TN. Average increased of TC (Dunbar: 16%; Norfolk: 27%).

Concentrations of Mehlich extractable P, K, Ca and Mg varied significantly with sorghum treatments. There were greater increase for treatments with sorghum biochars + P compared with the control soil. These results demonstrate favorable effects of SB in augmenting soil P, K, Ca and Mg.

	Dunbar Soil				Norfolk Soil			
Treat	P	K	Ca	Mg	P	K	Ca	Mg
	mg/kg							
Cont	97.8c	66.9c	443.1c	116.2b	17.3b	34.5b	211.4c	38.0b
SB	106.6b	175.4b	448.0c	118.1b	20.5b	91.8a	228.8bc	48.9a
SB+P	117.7a	170.3b	479.3ab	122.9ab	30.2a	79.3a	255.7a	49.4a
SR	105.9b	250.4a	471.1bc	132.9a	19.4b	78.6a	233.5b	51.1a
SR+P	120.3a	246.1a	507.7a	136.3a	28.3a	75.8a	256.1a	50.3a

SUMMARY AND CONCLUSION

- Our results fully support our hypothesis that sorghum biochars (SB) would deliver more positive effect on the biomass of winter wheat than the sorghum residues (SR).
- In highly weathered Coastal Plains Ultisols, addition of pyrolyzed SB has provided agronomic benefits and has no negative consequences in terms of wheat biomass.
- Our results may seem to indicate that the conversion of sorghum residue into sorghum biochar is a better strategy for both environmental and crop productivity improvement.