BIOMASS CROPPING EFFECCTS ON SOIL C AND N DYNAMICS IN A SUBTROPICAL ECOSYSTEM

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Introduction

Although perennial crops managed for bioenergy production have been suggested as an important mitigation strategy to reduce greenhouse gas emissions, conversion of low-input pastureland to highly productive bioenergy cropping may have a wide range of potential environmental impacts. Nutrient inputs often required to sustain high productivity levels raises soil quality concerns, particularly in the Southeastern USA where soils are generally by characterized by coarse texture and low soil C levels .

The objective of this study was to evaluate the impacts of converting bahiagrass (*Paspalum notatum* Flüggé) to elephantgrass [*Pennisetum purpureum* (L.) Schum.] for bioenergy production on soil C and N stocks and distribution among the various size-density fractions in a Florida Ultisol.

Materials and Methods

The 4-yr study was conducted at the University of Florida, Plant Science Research and Education Unit in Citra, Florida (29°24'N, 82° 10'W) during 2013 to 2016. Climate was characterized as humid subtropical climate with average temperature of 21.3°C and annual precipitation of ~1200 mm. The predominant soil was a Kanapaha fine sand (loamy, siliceous, semi-active, hyperthermic Grossarenic Paleaquult) (Table 1).

Treatments were: 1) bahiagrass pasture fertilized with 50 kg N ha^{-1} yr^{-1} (BHG); 2) elephantgrass fertilized with 50 kg N ha^{-1} yr^{-1} (E50); 3) elephantgrass fertilized with 50 kg N ha^{-1} yr^{-1} plus 10 Mg ha^{-1} yr^{-1} of lignocellulosic fermentation residual (E50FR); 4) elephantgrass fertilized with 50 kg N ha^{-1} yr^{-1} plus 5 Mg ha^{-1} yr^{-1} of biochar residual (E50BC); and 5) elephantgrass fertilized with 250 kg N ha^{-1} yr^{-1} (E250). Plots were 90 m^2 (10 x 9 m). The experiment was arranged in a randomized complete block design with four replications.

Table 1. Selected soil chemical and physical properties.

Property	Value
pH	6.8
Extractable P (mg kg^{-1})	65
Extractable K (mg kg^{-1})	12
Extractable Ca (mg kg^{-1})	21
Extractable Mg (mg kg^{-1})	925
Cation Exchange Capacity (cmol$_c$ kg^{-1})	7.7
Sand (g kg^{-1})	984
Clay (g kg^{-1})	4
Silt (g kg^{-1})	12
Bulk density (g cm^{-3})	1.6

Five soil cores (0 to 10 and 10 to 20 cm) were collected from each plot and composited by depth for each treatment. Analyses included soil total C and N concentrations, size-density separation, and ^{13}C stable isotope ratio.

Results

After 4 yr following conversion to bioenergy cropping, soil C concentrations increased by as much as 311% (Fig. 1). The largest increases in soil C were associated with treatments receiving biochar (E50BC), particularly at the 0 to 10 cm depth. Bahiagrass managed for bioenergy production (annual N fertilization + mechanically harvested) also promoted soil C accumulation (4.4 g C kg^{-1} soil in 2013 vs. 12.3 g C kg^{-1}soil in 2016) (Fig. 1). Similarly, soil N concentrations also increased in response to bioenergy cropping.

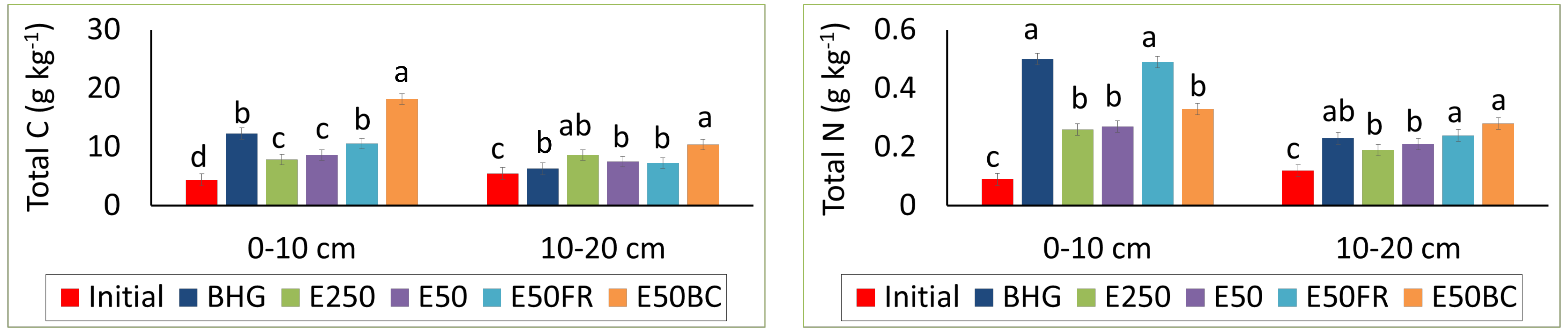

Fig. 1. Soil total C and N concentrations as affected by bioenergy cropping. (BHG = bahiagrass + 50 kg N ha^{-1}, E250 = elephantgrass +250 kg N ha^{-1}, E50 = elephantgrass + 50 kg N ha^{-1}, E50FR = elephantgrass + 50 kg N ha^{-1} + fermentation residual, E50BC = elephantgrass + 50 kg N ha^{-1} + biochar residual.

Biochar generally increased mineral-associated C fraction while bahiagrass promoted soil C accumulation in the particulate organic matter (POM) pool (Table 2). Treatments also affected δ ^{13}C signature of size-density fractions. More negative δ ^{13}C values were generally associated with biochar (-28.4‰) compared to elephantgrass alone (-23.4‰) or bahiagrass (-21.9‰).

Table 2. Soil C concentrations and δ ^{13}C signatures in size-density fractions as affected by bioenergy cropping.

Treatment	Light POM	Heavy POM	Mineral	Light POM	Heavy POM	Mineral
	_________C (g C kg^{-1} soil) _________			_________ δ ^{13}C (‰) _________		
0 to 10 cm						
BHG	1.5b (12)†	4.7a (38)	6.2b (50)	-19.8b	-23.8c	-21.9c
E250	1.2b (16)	2.3b (31)	4.3c (53)	-19.4b	-27.5a	-24.3b
E50	1.1b (16)	2.6b (35)	3.5c (48)	-20.9b	-27.5a	-24.8b
E50FR	3.7a (35)	2.5b (24)	4.3c (41)	-15.7c	-25.0b	-21.0c
E50BC	2.4a (14)	2.7b (16)	11.9a (70)	-22.8a	-27.6a	-28.4a
SE	0.5			0.5		
	_________C (g C kg^{-1} soil) _________			_________ δ ^{13}C (‰) _________		
10 to 20 cm						
BHG	0.7b (11)	1.5a(24)	4.1b (66)	-24.9a	-27.4b	-25.7ab
E250	2.2a (21)	2.0a (26)	4.4b (53)	-23.4b	-28.7a	-26.0a
E50	0.8ab (11)	2.7a (37)	3.6b (52)	-24.1ab	-28.6a	-26.0a
E50FR	1.2ab (11)	2.2a (22)	6.7a (67)	-24.8a	-28.7a	-26.7a
E50BC	1.2ab (16)	2.3a (31)	3.8b (52)	-20.8c	-27.8ab	-25.0b
SE	0.5			0.3		

†Values in parenthesis represent % of total C in the bulk soil. Statistical analysis is valid within soil depth and size-density fraction.

CONCLUSIONS

Conversion of low-input bahiagrass pastures to bioenergy cropping promoted soil C and N accumulation, particularly in the treatments receiving biochar and fermentation residual. Land application of residues generated during the conversion of biomass to biofuels represents a suitable management practice for enhancing soil C sequestration in coarse-textured Florida soils.