Carbon Storage in Plant and Soil Components of Selected Grass Monocultures

NDSU
North Dakota State University
ND Agricultural Experiment Station

D. Macha and L.J. Cihacek, School of Natural Resource Sciences, North Dakota State University, Fargo, ND 58105

Introduction

Recently, there has been interest in utilizing grasslands as pathways for terrestrial carbon (C) sequestration to mitigate the effects of CO_2 on global warming as well as utilizing grassland biomass to produce biofuels to reduce our dependence on fossil fuels. These interests appear to be in conflict with each other. However, it is entirely reasonable to believe that grasslands can be used in both roles while still maintaining their ability to provide environmental services without degradation of the grasslands.

This raised a number of research questions. In areas of the northern Great Plains, grasslands have definite potential for C sequestration but at times productivity may be limited by wide swings in climatic conditions. Our study objectives evolved from the following research questions:

1. How much C is sequestered in the biomass of different common species of grass?
2. How much C is sequestered in roots of these species of grass?
3. How much C is sequestered in the soils on which these grasses grow?
4. How much total C is sequestered by the grasses and the soils that they grow on?

Materials and Methods

In 2007, areas of monoculture stands of smooth bromegrass (B), crested wheatgrass (CWG), indiangrass (IG), switchgrass (SG) and big bluestem (BBS) were located in central Hand County, South Dakota. These areas were within one-half to two miles from each other and located on similar soils on nearly level to sloping landscapes. Additional details are shown in Table 1. Vegetation was sampled from four 1-meter-square quadrats by hand within a 20-meter-diameter area in early August (at or just after anthesis). The above-ground biomass was separated into standing materials (vegetation) and materials lying on the ground (residue). Eight soil cores (5.7 cm dia.) were taken to a depth of 24 inches (60 cm) from each quadrat using a vehicle-mounted hydraulic soil probe. The soil cores were erased in plastic sleeves, capped and sealed with duct tape to prevent moisture loss. The cores were then transported to an on-campus refrigerated facility for storage until they could be processed.

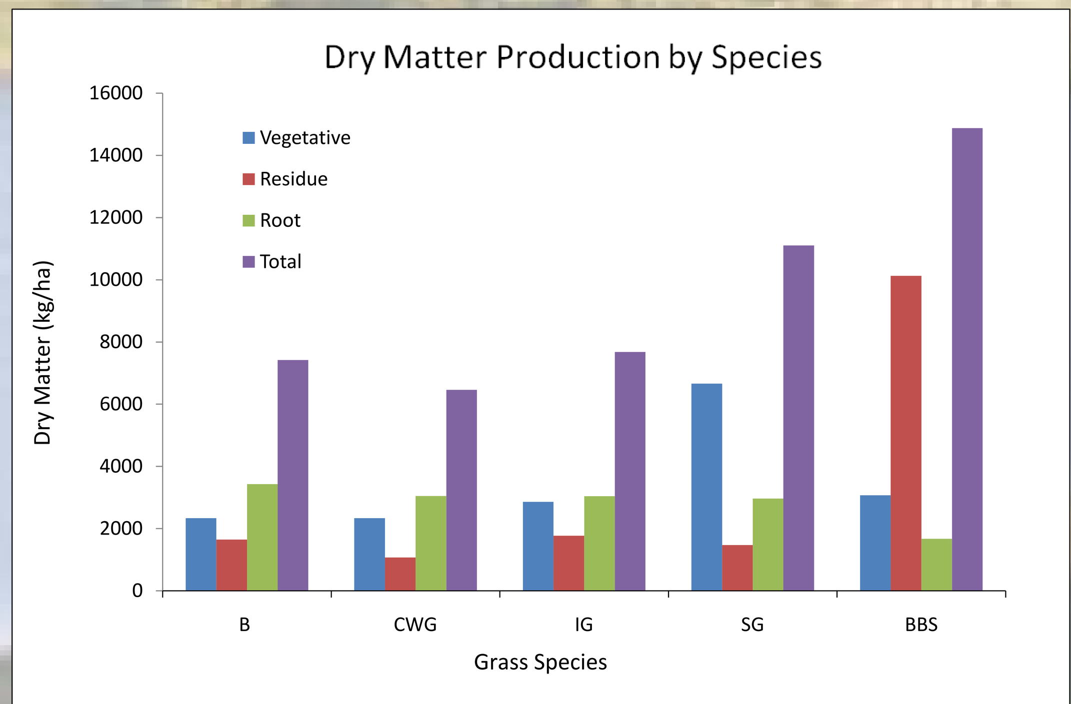
All plant materials were bagged and dried at 60 C to determine dry matter production. Subsamples of plant materials were ground to pass a 2-mm screen, and carbon (C) content was determined by high-temperature combustion. Carbon mass in the plant materials was determined by multiplying percent C by the dry matter mass.

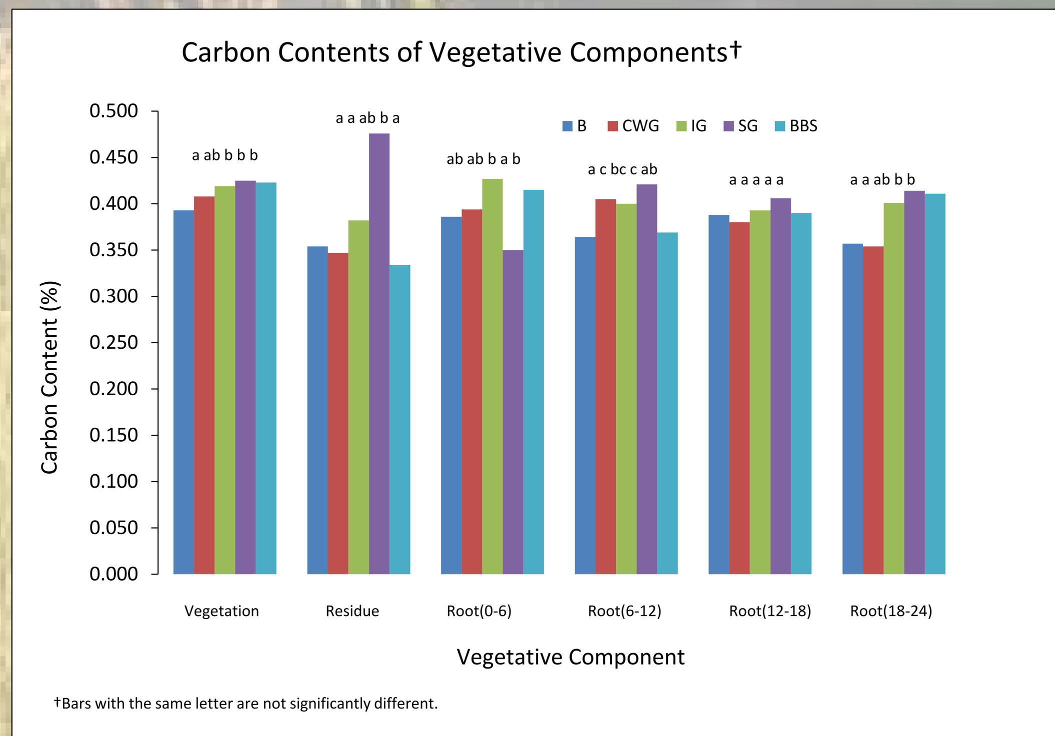
Seven soil cores were separated into 6-inch (30-cm) segments. Segments from six cores were washed to extract the roots. Root samples were composited by depth for each quadrat and dried at 60 C to determine dry matter content. The root samples were then handled like the aboveground vegetation to determine C content and mass. Segments from the seventh core were air-dried and crushed to pass a 2-mm screen, subsampled for C analysis and milled to pass a 100-mesh screen. Total C in the soil samples was determined by high-temperature combustion while inorganic C was determined from CO_2 evolved by acid addition to the sample. Organic C was determined by subtracting inorganic C from total C. The eighth core was used for soil profile description.

Results

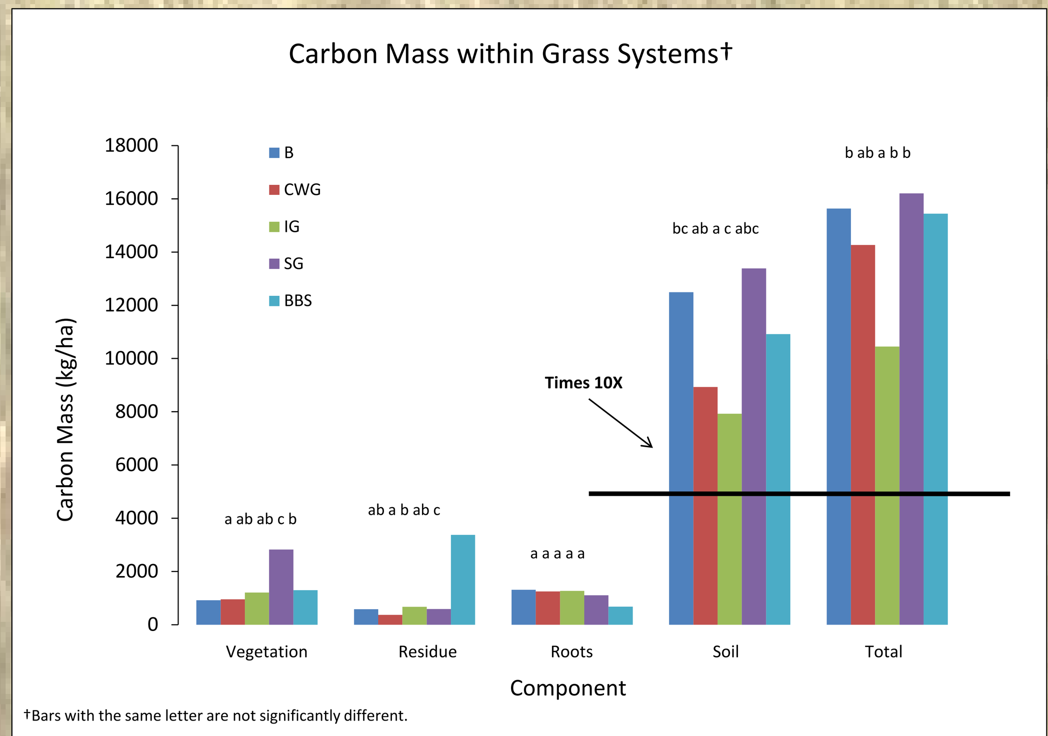
Table 1. Grass Site Characteristics.

Common Grass Name	Scientific Name	Cool/Warm Season	Stand Age	Management History
Smooth Bromegrass (B)	*Bromus inermis* Leyss.	Cool	30+ years	Occasional haying
Crested Wheatgrass (CWG)	*Andropogon cristatum* (L.) Gaertn.	Cool	30+ years	Grazed/occasional haying
Indiangrass (IG)	*Sorghastrum nutans* (L.) Nash	Warm	15+ years	Seed production-burning/haying
Switchgrass (SG)	*Panicum virgatum* L.	Warm	20+ years	Seed production-burning/haying
Big Bluestem (BBS)	*Andropogon gerardii* Vitman.	Warm	18+ years	Seed production-burning/haying





†Bars with the same letter are not significantly different.



†Bars with the same letter are not significantly different.

Proportion of soil organic C as a part of the total C in a grass-soil system to a profile depth of 60 cm.

Grass Species	Soil Organic C Proportion (%)
Bromegrass (*Bromis inermis* Leyss.)	97.6
Crested Wheatgrass (*Andropogon cristatum* (L.) Gaertn.)	95.5
Indiangrass (*Sorghastrum nutans* (L.) Nash)	96.7
Switchgrass (*Panicum virgatum* L.)	97.9
Big Bluestem (*Andropogon gerardii* Vitman.)	96.8
Average	96.8

Summary

- Switchgrass and big bluestem contained the highest amounts of C in the aboveground portion of the plants both as a percentage of dry matter weight as well as total C mass.
- There were no significant differences in root C content between the grass species.
- The soil was the largest pool of sequestered C. The lower C in the soils of the indiangrass site may reflect effects of past erosion. This was the most sloping of the 5 sites.
- Bromegrass, switchgrass and big bluestem had the highest amounts of C sequestered in the total soil-plant system.
- Harvesting biomass from these grass species most likely will not cause decline in C sequestered in soils as long as the integrity of the grass cover is maintained, soil is not disturbed and soil erosion is prevented.

Acknowledgments

The authors gratefully acknowledge the partial support of US-DOE Plains CO_2 Reduction (PCOR) Partnership and Ducks Unlimited, Inc. The assistance of Gabriel Aher, Deepti Annam, Kevin Brown, Carlee Elke, Shawn Koltes, Keith Jacobson, Jason Riopel, and Amar Singh is also gratefully acknowledged.

PCOR Partnership

EERC Energy & Environmental Research Center® Putting Research into Practice