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Impact of Tillage and Crop Rotation Systems on Soil Carbon Storage

Mahdi Al-Kaisi
Iowa State University, malkaisi@iastate.edu

Mark A. Licht
Iowa State University, lichtma@iastate.edu

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Abstract
Carbon storage (sequestration) is an issue worth exploring for its potential impact on, and benefits for, agriculture and climate change. Where soil conservation and plant residue management have been implemented, agriculture can be part of a potential solution to the problem of global warming. The concept of carbon sequestration is highly linked to soil management practices, soil conservation practices, and crop rotation. The benefits of soil carbon sequestration as a result of soil conservation practices to the soil system are enormous and include improvement of soil aggregate stability, water holding capacity, nutrient availability, and microbial activities. The need for evaluating different tillage and crop rotation systems is essential for understanding soil potential for carbon sequestration. The objectives of this research are to evaluate the effects of different crop rotations, tillage practices, and residue quality on soil carbon sequestration.

Keywords
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Mahdi Al-Kaisi, assistant professor,
Mark Licht, research assistant,
Department of Agronomy

Introduction

Carbon storage (sequestration) is an issue worth exploring for its potential impact on, and benefits for, agriculture and climate change. Where soil conservation and plant residue management have been implemented, agriculture can be part of a potential solution to the problem of global warming. The concept of carbon sequestration is highly linked to soil management practices, soil conservation practices, and crop rotation. The benefits of soil carbon sequestration as a result of soil conservation practices to the soil system are enormous and include improvement of soil aggregate stability, water holding capacity, nutrient availability, and microbial activities. The need for evaluating different tillage and crop rotation systems is essential for understanding soil potential for carbon sequestration. The objectives of this research are to evaluate the effects of different crop rotations, tillage practices, and residue quality on soil carbon sequestration.

Materials and Methods

This study is part of a statewide project begun in September of 2000 and being conducted on several research farms in Iowa. The experiment at this location consists of three different crop rotations—cool-season pasture, warm-season pasture, and corn–soybean/corn–meadow/meadow–meadow (CSCMMM). The study has a completely randomized design. Both cool- and warm-season pastures have four replications and are placed in existing experiments. The cool-season pasture consists of broomgrass, and the warm-season pasture is switchgrass. The CSCMMM crop rotation consists of four replications. The site for CSCMMM rotation was planted to alfalfa. The alfalfa stand was killed last fall, and the site was split in two equal halves and planted with corn and soybeans.

Soil samples were collected at depths of 0–2, 2–4, 4–6, 6–12, and 12–24 inches. The samples were analyzed for total nitrogen, total carbon, and pH. Soil bulk density was estimated for the same depths. Plant residue samples were collected to determine the amount of plant residue left on the field after harvest and to estimate total carbon and total nitrogen. Grain yields and dry matter were measured.

Results and Discussion

Crop rotation is a factor that affects soil organic matter. Comparison of different crop rotations for the Monona–Ida–Hamburg (MIH) Soil Association showed that grass rotations generally have greater total soil carbon content than row crops of a meadow crop rotation (Table 1). However, soil under cool season grass showed greater total soil carbon compared to all crop rotations. The C:N ratio is lower (less than 10:1) for crop rotations with greater total soil carbon (cool season grass). Plant residue can have an impact on the potential of soil organic matter. The cool-season and warm-season grass residue had a higher amount of total carbon input than the meadow residue.

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Table 1. Comparison of total soil carbon of the top 0-2 inch depth for meadow, cool-season, and warm-season grasses of Monona–Ida–Hamburg Soil Association, with traditional corn–soybean rotation of the Galva–Primghar–Sac Soil Association as a reference point.

Soil Association	Crop rotation	Years	Total soil carbon	Total soil nitrogen	C:N ratio
			- - - lbs ac^{-1} - - -		
M-I-H	Meadow	4	10,747	1,017	10.6
M-I-H	Cool season	10	19,533	2,106	9.3
M-I-H	Warm season	8	12,199	871	14.0
G-P-S	Corn–soybean	7	10,602	799	13.3

Figure 1. Total carbon of three different crop residue covers from the previous growing season on Monona–Ida–Hamburg Soil Association.