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Impacts of Rotation Length, Forage Legume Identity, and Composted Manure on Organic Crop Production

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Abstract
Since 1990, the American market for organic foods has grown at a rate of 20% per year or more, and is now worth at least $7 billion annually. Price premiums paid to farmers for organically produced crops can increase their value substantially compared with conventionally produced crops. The potential economic advantages for organic production, coupled with increasing concerns about environmental and human health impacts of conventional farming practices, have sparked interest by farmers and researchers in the development of best management practices for organic farming systems.

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Introduction

Since 1990, the American market for organic foods has grown at a rate of 20% per year or more, and is now worth at least $7 billion annually. Price premiums paid to farmers for organically produced crops can increase their value substantially compared with conventionally produced crops. The potential economic advantages for organic production, coupled with increasing concerns about environmental and human health impacts of conventional farming practices, have sparked interest by farmers and researchers in the development of best management practices for organic farming systems.

This study addresses three questions of relevance to organic production: (1) Do three-year rotations differ from four-year rotations with regard to their impacts on crop yields? (2) How does alfalfa differ from red clover with regard to impacts on crop yields? (3) How does application of composted swine manure affect crop yields in three- and four-year rotations? The experiment in which these questions are being addressed was established in 2000. Data from the 2003 field season are reported here.

Materials and Methods

The experiment contains two different organic crop rotation systems: a three-year system (corn–soybean–oat/legume green manure), and a four-year system (corn–soybean–oat/legume hay—hay). A conventional two-year corn–soybean system is also included as a benchmark. The experiment is laid out in a randomized complete block, split-plot design, with four replicates. Rotation system × rotation phase combinations comprise the main plots and legume (alfalfa vs. red clover) and manure (applied or not applied preceding corn) treatments comprise the split plots. Composted swine manure (57% moisture, 2.6% nitrogen) was applied to appropriate plots at a rate of 10 tons (fresh wt.)/acre on April 24, 2003, and tillage operations were conducted on April 28, 2003. Corn (NC+ 2395) was planted on May 22, 2003. Nitrogen fertilizer was applied at four rates (0, 60, 120, and 180 lb N/acre) to corn in the conventional two-year rotation on June 13, 2003. Soybeans (HP204) were planted on June 5, 2003, and oats (Jerry), alfalfa (Jade II), and red clover (no named variety) were planted on April 15, 2003. Rotary hoeing, interrow cultivation, and hand weeding (estimated at 2 hrs/acre) were used to control weeds in corn and soybean plots. Harvest dates for oats, soybeans, and corn were August 4, October 10, and October 20, 2003, respectively. Hay was removed from the four-year rotation plots, but yields were not determined in 2003.

Results and Discussion

Corn, soybean, and oat yields are presented in Table 1. Yields of the three crops did not differ between the three-and four-year rotation systems, and were not affected by the different forage legume treatments. In contrast, composted manure increased corn yield by 14% ($P<0.0001$), increased soybean yield by 11% ($P<0.0001$), but reduced oat yield by 14% ($P<0.05$). Interactive effects of rotation length, forage legume identity, and composted manure application were not significant.

Corn was not affected by application of synthetic N fertilizer, with a mean yield of 114 bushels/acre in the two-year conventional system (data not shown). The lack of an N response in conventional corn may have been because of the late planting date, the timing of N application, and dry weather conditions. Corn in the organic systems that received composted manure produced an average of 18% more grain (P<0.0001) than did the conventional corn. The increase in corn yield due to composted manure may have resulted from better nutrient availability relative to crop demand, improved soil moisture availability, or other soil-related factors. More research is needed to resolve these issues.

The mean yield of soybeans in organic plots receiving composted manure was 11% higher (P<0.0001) than soybeans in the conventional two-year system, for which the mean yield was 31 bushels/acre (data not shown). The positive influence of composted manure on soybean yield reflected the residual effects of manure applied to the preceding 2002 corn crop.

Reasons for the reduction of oat yields by composted manure are not clear. Informal observations suggested that greater weed pressure occurred in (+) compost plots.

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Table 1. Yields of corn, soybeans, and oats as affected by rotation length, forage legume identity, and composted manure or N fertilizer application to corn, 2003, Sutherland, IA.

Rotation length	Management system	Forage legume	Composted manure	Corn yield (bu/acre)	Soybean yield (bu/acre)	Oat yield (bu/acre)
3-year	organic	alfalfa	–	112	31	67
3-year	organic	alfalfa	+	132	33	48
3-year	organic	red clover	–	113	31	69
3-year	organic	red clover	+	139	35	62
4-year	organic	alfalfa	–	119	29	72
4-year	organic	alfalfa	+	131	34	62
4-year	organic	red clover	–	126	31	69
4-year	organic	red clover	+	140	33	67
Rotation length effect (3-yr vs. 4-yr)				124 vs. 129 NS	33 vs. 32 NS	62 vs. 67 NS
Forage legume effect (alfalfa vs. red clover)				123 vs. 129 NS	32 vs. 33 NS	62 vs. 67 NS
Composted manure effect (– vs. +)				118 vs. 135****	31 vs. 34****	69 vs. 60*

NS: not significant; *: P<0.05; ****; P<0.0001.