Comparison of Organic and Conventional Crops at the Neely-Kinyon Long-Term Agroecological Research Site

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Kathleen Delate, professor
Daniel Korhonen, research assistant
Lauren Bilek, research assistant
Departments of Horticulture and Agronomy
Randy Breach, ag specialist

Introduction

The ISU Neely-Kinyon Farm, Greenfield, Iowa, Long-Term Agroecological Research (LTAR) site was established in 1998 to study the long-term effects of organic production in Iowa. Treatments at the LTAR site, replicated four times in a completely randomized design, include the following rotations: conventional Corn-Soybean (C-S), organic Corn-Soybean-Oats/Alfalfa (C-S-O/A), organic Corn-Soybean-Oats/Alfalfa-Alfalfa (C-S-O/A-A), and organic Corn-Soybean-Corn-Oats/Alfalfa (C-S-C-O/A).

Materials and Methods

Oat/alfalfa plots were field cultivated April 8, 2019. On April 12, Reins oats were underseeded with Viking 340 M alfalfa (Albert Lea Seed, Albert Lea, MN) at a rate of 90 lb/acre and 15 lb/acre, respectively. Plots were cultipacked on the same day as planting. Following harvest of the organic corn plots in 2018, winter rye was no-till drilled at a rate of 75 lb/acre October 29, 2018.

Conventional corn plots were injected with 32 percent UAN April 9, at 150 lb/acre, disked April 24, 2019, and field cultivated May 15. Plots were planted May 16, at 35,000 seeds/acre, and sprayed May 16 with Dual II Magnum™ at 1 pt/acre and Atrazine 4L™ at 1 qt/acre. Conventional corn plots were row cultivated June 20 and July 1 to control weeds. Plots were sprayed with Laudis™ at 3 oz/acre June 11. Conventional soybean plots were disked April 24 and May 15. On May 16, plots were planted at 190,000 seeds/acre, and received applications of Zidua™ at 6 oz/acre May 16. On June 11, plots were sprayed with Pursuit™ at 3 oz/acre. Plots were cultivated July 1, 8, and 19 to deal with weeds still emerging after herbicides.

Chicken manure (S.W. Iowa Egg Cooperative, Massena, IA) was applied at a rate of 3,105 lb/acre April 10 to organic C-SB-O/A and C-CB-O/A-A plots. On the same day manure was applied to C-SB-C-O/A plots at a rate of 1,290 lb/acre.

The alfalfa and compost applied in the organic corn plots were plowed under April 15, 2019. Plots were disked April 24 and field cultivated May 15. Organic corn plots were rotary-hoed June 3 and 10, and row-cultivated June 13 and 20.

Corn and soybean variety selection and planting methods in 2019 were as follows: Viking VEF 6102 (Albert Lea Seed, Albert Lea, MN) corn was planted at a depth of 2.5 in. as untreated seed at a rate of 35,000 seeds/acre in the organic and conventional plots, May 16, 2019. Soybean (IA3051RA12, Blue River Hybrids, Ames, IA) were planted at a depth of 2 inches in organic and conventional plots at a rate of 190,000 seeds/acre May 16, 2019.

Rye was disked twice in organic soybean plots May 15 before soybean planting May 16. Organic soybean plots were rotary hoed June 3 and 10 and row-cultivated June 13, July 1, 8, and 19. The length of time between planting and the first rotary hoeing (18 days) was damaging to weed management, so considerable time was invested in “walking” each organic soybean plot for large weeds above the canopy from August 5 to August 9. There was a problem of weeds in conventional plots in 2019, even after repeated herbicide applications, but these were not "walked" in keeping with the protocol of herbicide applications only in conventional plots.

Oat and alfalfa biomass was estimated May 24 in all O/A plots by cutting at ground level all biomass in a square-foot quadrat in three randomly selected areas of each plot. Corn and soybean stands were counted June 17, and weeds were counted within square foot quadrats at three randomly selected areas within a plot. Corn borer populations and damage were estimated July 12 by examining three randomly selected plants/plot. Soybean cyst nematode sampling occurred in all soybean plots October 11 by sampling at a 6-in. depth in three randomly selected areas in soybean rows in each plot. Nematode analysis was conducted at the ISU Plant Disease Clinic, Ames, Iowa. The amount of stained soybean was determined in the laboratory from a random 100-g sample of harvested soybean from each plot. Soil quality sampling occurs each fall in the LTAR experiment, after harvest and before any tillage or cover crop planting, by sampling soil at a 6-in. depth in three randomly selected areas in each plot, with samples transported on ice to Cynthia Cambardella, Soil Scientist, USDA-ARS, Ames, Iowa.

Alfalfa was harvested by mowing, raking, and baling June 13, July 13, and August 18. Oats were mowed July 15 and baled July 19. Corn and soybean plots were harvested October 25 and October 9, respectively. Grain samples were collected from each corn and soybean plot for grain quality analysis, which was conducted at the ISU Grain Quality Laboratory, Ames, Iowa.

Results and Discussion

The weather in 2019 was again challenging, with a cold, wet spring and drought conditions in mid-summer. Similar corn plant populations were observed between organic rotations, averaging 31,528 plants/acre June 17, compared with higher conventional corn populations of 35,583 plants/acre (Table 1). Grass weed populations were lower in the conventional and organic C-S-O/A rotations, compared with the other organic rotations (Table 1). Broadleaf weeds were similar in conventional and organic C-S-O/A-A plots, suggesting more weed prevention with longer organic rotations. Soybean plant populations were greater in the conventional C-S rotation, averaging 142,833 plants/acre, compared with an average of 108,167 plants/acre in the organic rotations (Table 2). Grass and broadleaf weeds were numerically greater in the organic rotations (Table 2), but the organic C-S-O/A rotation had equivalent broadleaf weeds as the conventional rotation.

Limited numbers of corn borers or corn borer damage were detected in corn plants July 12 (Table 3). Soybean cyst nematodes averaged 113 eggs/100 cc of soil, with no statistical differences between systems, but numerically higher levels (200 eggs/100 cc of soil) in the conventional soybean plots (Table 3). Stained soybean, representing damage from bean leaf beetle feeding, was equivalent across all rotations, and averaged 17 percent.

Corn yields were greatest in the C-S-O/A-A rotation, averaging 177 bushels/acre, compared with 131 bushels/acre in the conventional C-S rotation (Table 3). The organic C-SB-O/A rotation also was more productive than the conventional, with a yield of 150 bushels/acre. The organic soybean yield in the C-S-O/A rotation (46 bu/ac) was equivalent to the conventional soybean yield (49.7 bu/ac), which received multiple herbicides and cultivations (Table 3).
Oat yields were impacted by wet weather, with yields of 53 bushels/acre in the three-year rotation, and 60 bushels/acre in the four-year rotation (Table 4). Alfalfa yields, at 2.52

tons/acre, were lower than yields in 2018, which averaged 3.48 tons/acre. The June harvest was the highest, with the July and August cuttings, at less than one ton/acre, suffering from dry weather.

If crops were sold as certified organic, as they were in previous years, premium organic corn prices would have brought in $1,505/acre in the organic C-S-O/A-A rotation, compared with $498/acre for conventional corn. Organic soybean could have been sold for $877/acre in the organic C-S-O/A rotation, compared with $441/acre for conventional soybean.

Organic corn grain quality was excellent in 2019. Protein levels, at 9.5 percent, were greatest in the organic C-S-O/A-A rotation, compared with conventional corn, at 7.1 percent (Table 5). Over all organic rotations, average protein levels were 1.3 percent higher than conventional corn protein levels. The longer period between corn crops in the organic system lent an additional 2.5 percent in protein content, as evidenced by the 7.0 percent protein in the corn-intensive C-S-C-O/A rotation compared with 9.5 percent in the C-S-O/A-A rotation. Corn density was greater in the organic system, at 1.3 percent, compared with 1.2 percent in conventional corn. Corn starch was higher in the organic C-S-C-O/A and conventional rotations, averaging 72.7 percent. Oil content was highest in the organic C-S-O/A and C-S-O/A-A corn, averaging 4.6 percent.

Protein levels were greatest in the organic C-S-O/A-A rotation soybean, averaging 37.4 percent, compared with 35.7 percent in conventional soybean (Table 6). Protein levels in the organic C-S-O/A rotation (36.8%) were equivalent to the conventional rotation. Soybean carbohydrate levels were greater in the conventional C-S and the organic C-S-O/A rotation, averaging 22.9 percent. Oil levels also were greater in the conventional C-S rotation and the organic C-S-O/A rotation, averaging 18.1 percent, compared with the other organic rotation, which averaged 17.9 percent. Fiber content averaged 4.7 percent in the conventional and organic C-S-O/A soybean, compared with the average of 4.6 percent in the other organic rotation.

Soil quality at the LTAR site has been consistently higher in the organic rotations relative to the conventionally managed corn-soybean rotation. In Fall 2017, soil quality of the organic soils had more microbial biomass C and N, higher P, K, Mg, and Ca, and lower soil acidity than conventional soils (Table 7). The organic rotation had more microbial biomass C and stable macroaggregates than the conventional C-S rotation, which suggests having oats and alfalfa in the rotation enhances soil structural stabilization and microbial activity. Soil quality enhancement was particularly evident for labile soil C and N pools, such as N mineralization potential and particulate organic matter, which are critical for maintenance of N fertility and efficient carbon cycling in organic systems, and for basic cation concentrations, which control nutrient availability through the relationship with cation exchange capacity (CEC).

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Table 1. Corn plant and weed populations in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA, 6/17/19.

Treatment	Plant population (plants/ac)	Grass weeds (plants/m^2)	Broadleaf weeds (plants/m^2)
Conventional C-SB[x]	35,583a	0.06b	0.09c
Org. C-SB-O/A	30,667b	0.18b	0.22ab
Org. C-SB-O/A-A	31,917b	0.62a	0.12bc
Org. C-SB-C-O/A	32,000b	0.90a	0.28a
$LSD_{0.05}$	2,228[y]	0.31	0.10
P value (α = 0.05)	0.0004	<0.0001	0.0013

[x]Org. = organic, C = corn, SB = soybean, O = oats, A = alfalfa.
[y]Means followed by the same letter in a column are not significantly different at P ≤ 0.05 or not significant (NS) (Fisher's Protected LSD Test).

Table 2. Soybean plant and weed populations in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA, 6/17/19.

Treatment	Plant population (plants/ac)	Grass weeds (plants/ft^2)	Broadleaf weeds (plants/ft^2)
Conventional C-SB[x]	142,833a	0b	0.06b
Org. C-SB-O/A	114,500b	0.20a	0.15ab
Org. C-SB-O/A-A	101,833b	0.38a	0.24a
$LSD_{0.05}$	15,285[y]	0.19	0.16
P value (α = 0.05)	<0.0001	0.0001	0.0077

[x]Org. = organic, C = corn, SB = soybean, O = oats, A = alfalfa.
[y]Means followed by the same letter in a column are not significantly different at P ≤ 0.05 or not significant (NS) (Fisher's Protected LSD Test).

Table 3. Corn and soybean yields and soybean cyst nematode populations in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA, 2019.

Treatment	Corn yield (bu/acre)	Soybean yield (bu/acre)	Soybean cyst nematodes (eggs/100 cc soil)	Stained soybean (%)	Corn borer damage	Corn borer numbers
Conventional C-SB[x]	130.85c	49.67a	200	10.5	0.17b	0
Org. C-SB-O/A	150.40b	45.56a	100	20.8	0.58a	0.08
Org. C-SB-O/A-A	177.19a	33.58b	37.5	20.8	0.08b	0
Org. C-SB-C-O/A	91.65d	N/A	N/A	N/A	0.42ab	0.17
$LSD_{0.05}$	14.76	8.43	NS[y]	NS	0.36	NS
P value (α = 0.05)	<0.0001	0.0060	0.4380	0.1129	0.0288	0.2860

[x]Org. = organic, C = corn, SB = soybean, O = oats, A = alfalfa, N/A = crop not grown in that rotation in 2019.
[y]Means followed by the same letter in a column are not significantly different at P ≤ 0.05 or not significant (NS) (Fisher's Protected LSD Test).

Table 4. Oat and alfalfa yields in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA, 2019.

		Harvest date (tons/ac)		
Treatment	**Yield (bu/ac)**	6/13/19	7/13/19	8/18/19
Org. C-SB-O/A [x]	53.08	--	--	--
Org. C-SB-O/A-A	60.08	1.20	0.49	0.83

[x]Org. = organic, C = corn, SB = soybean, O = oats, A = alfalfa.

Table 5. Corn grain quality in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA, 2019.

Treatment	Moisture (%)	Protein (%)	Oil (%)	Starch (%)	Density (g/cc)
Conventional C-SB[x]	19.08b	7.12c	4.24c	72.59a	1.23c
Org. C-SB-O/A	18.50c	8.79b	4.53ab	71.06b	1.27a
Org. C-SB-O/A-A	18.40c	9.50a	4.68a	70.28c	1.27a
Org. C-SB-C-O/A	19.85a	7.00c	4.35bc	72.79a	1.25b
$LSD_{0.05}$	0.559[y]	0.461	0.183	0.620	0.011
P value (α = 0.05)	0.0004	<0.001	0.0001	<0.0001	<0.0001

[x]Org. = organic, C = corn, SB = soybean, O = oats, A = alfalfa.
[y]Means followed by the same letter in a column are not significantly different at P ≤ 0.05 or not significant (NS) (Fisher's Protected LSD Test).

Table 6. Soybean grain quality in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA, 2019.

Treatment	Moisture (%)	Protein (%)	Oil (%)	Fiber (%)	Carbohydrates (%)
Conventional C-SB[x]	12.13b	35.68b	18.33a	4.76a	23.22a
Org. C-SB-O/A	13.48a	36.75ab	17.95ab	4.68ab	22.63ab
Org. C-SB-O/A-A	13.48a	37.38a	17.85b	4.63b	22.18b
$LSD_{0.05}$	1.21[y]	1.16	0.46	0.11	0.72
P-value	0.0505	0.0026	0.0094	0.0036	0.0029

[x]Org. = organic, C = corn, SB = soybean, O = oats, A = alfalfa.
[y]Means followed by the same letter in a column are not significantly different (S) at P ≤ 0.05 or not significant (NS) (Fisher's Protected LSD Test).

Table 7. Neely-Kinyon LTAR soil quality, fall 2017 (depth 0-15 cm).

Rotation	Aggregation (%)	pH	Microbial biomass C	POM C	Ca	P	PMN
				(mg/kg soil)			
Conventional C-SB[x]	26.5 ± 4.3	5.9 ± 0.2	299 ± 27	3146 ± 520	3306 ± 140	24 ± 8	39 ± 12
Org. C-SB-O/A	27.8 ± 6.8	6.9 ± 0.1	363 ± 60	4580 ± 736	4206 ± 157	111 ± 20	51 ± 5
Org. C-SB-O/A-A	30.2 ± 6.0	6.8 ± 0.3	385 ± 40	4075 ± 622	4103 ± 188	82 ± 32	49 ± 7
Org. C-SB-C-O/A	32.2 ± 4.5	6.8 ± 0.2	377 ± 48	3739 ± 336	4037 ± 181	55 ± 14	47 ± 6

[x]Org. = organic, C = corn, SB = soybean, O = oats, A = alfalfa; POM C = particulate organic matter carbon, PMN = potentially mineralizable N.