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

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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 March 21, 2017, and Deon oats were underseeded March 22 with Viking 372HD 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 2016, winter rye was no-till drilled at a rate of 75 lb/acre October 24, 2016.

Conventional corn plots were disked May 5, 2017, injected with 32 percent UAN May 12, at 150 lb/acre, and field cultivated May 13. Plots were planted and sprayed May 15 with Dual II Magnum™ at 1 pt/acre and Atrazine 4L™ at 1 qt/acre. Conventional corn plots were rotary hoed May 26 to deal with crusting problems. Plots were sprayed with Status™ at 7 oz/acre, Succeed™ at 1 pt/acre, and AMS at 8 oz/acre June 20.

Conventional soybean plots were disked May 5 and field cultivated May 13. Plots were planted and received applications of Sonic™ at 4 oz/acre May 15. Plots were cultivated May 13 and July 3 to deal with weeds still emerging after herbicides. Plots were rotary hoed May 26 to deal with crusting problems. On June 20, plots were sprayed with Flexstar™ at 1 pt/acre, AMS at 8 oz/acre, Fusilade™ at 5 oz/acre, and MSO™ at 1.5 qt/acre to control remaining weeds.

Chicken manure (S.W. Iowa Egg Cooperative, Massena, IA) was applied at a rate of 3,105 lb/acre April 4 to organic C-S-O/A and C-S-O/A-A plots. Manure was applied to C-S-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 11, 2017. Plots were disked May 5 and field cultivated May 13. Organic corn plots were rotary-hoed May 25, 31, and June 5, and row-cultivated June 13, 20, 26, and July 3.

Corn and soybean variety selection and planting methods in 2017 were as follows: Viking VEF6102 (Albert Lea Seed, Albert Lea, MN) corn was planted at a depth of 2.5 in. as untreated seed at a rate of 34,000 seeds/acre in the organic and conventional plots May 15, 2017. IA3051RA12 (ISU, Ames, IA) soybeans were planted at a depth of 2 in. in organic and conventional plots at a rate of 170,000 seeds/acre May 15, 2017.

In the organic soybean plots, rye was disked May 5 and twice May 13 before soybean planting May 15. Organic soybean plots were rotary hoed May 25, 31, and June 5 and row-cultivated June 13, 20, July 3, and 18. The length of time between planting and the first rotary hoeing (10 days) was damaging to weed management, so considerable time was invested in "walking" each organic soybean plot for large weeds above the canopy from June 26 to July 7. There was a problem with weeds in conventional plots in 2017, even after repeated herbicide applications, but these were not "walked" in keeping with the protocol of herbicide applications only in conventional plots.

Corn and soybean stands were counted June 2 and 22, and weeds were counted within square foot quadrats at three randomly selected areas within a plot. Corn borer populations and damage were estimated July 18, SPAD readings also were taken on this date. Soybean pest and beneficial insects were collected August 4 by sweeping across randomly selected soybean rows 20 times with a 15-in. sweep net. Corn stalk nitrate samples were collected September 30 from three randomly selected plants in each plot. Soybean cyst nematode sampling occurred in all soybean plots November 14 by sampling at a 6-in. depth in three randomly selected areas in soybean rows in each plot. All plant and soil fertility analyses were conducted at the Iowa State University Soil and Plant Analysis Laboratory, Ames, Iowa. Nematode analysis was conducted at the ISU Plant Disease Clinic, Ames, Iowa. Soil quality was determined by sampling soil at a 6-in. depth in three randomly selected areas in each plot every fall before tillage and analyzed by Cynthia Cambardella, soil scientist, USDA-ARS (Ames, IA). The amount of stained soybeans was determined in the laboratory from a random 200-g sample of harvested soybeans from each plot.

Alfalfa was harvested by mowing, raking, and baling June 2, July 3, and August 2. Oat grain was harvested July 21. Corn and soybean plots were harvested November 3 and October 25, respectively. Grain samples were collected from each corn and soybean plot for grain quality analysis, which was conducted at the ISU Grain Quality Laboratory.

Results and Discussion

The weather in 2017 was challenging, with a wet spring and drought conditions in mid-summer. Corn and soybean stands were much lower than previous years, due to cool, wet weather and slow emergence. Similar corn plant populations were observed between organic and conventional systems at the first sampling June 2, averaging 24,625 plants/acre (data not shown), compared with an average of 36,062 plants/acre in 2016. On June 22, corn populations averaged 26,250 plants/acre between systems (data not shown). Early grass weed populations were equivalent in conventional plots where multiple herbicides were applied, and in the C-S-C-O/A rotation (data not shown), but higher in the other organic C-S-O/A and C-S-O/A-A rotations, which averaged 14 weeds/m^2. Broadleaf weeds, averaging three weeds/m^2, were similar in both conventional and organic plots. At the later sampling, the same pattern remained, with less grass weeds in the conventional and C-S-C-O/A rotations compared with an average of four weeds/m^2 in the other organic rotations (data not shown).

Soybean plant populations were greatest in the C-S-C-O/A rotation and averaged 95,500 plants/acre June 2 (data not shown), compared with an average of 106,833 plants/acre in 2016. Conventional and the other organic C-S-O/A and C-S-O/A-A rotations were lower, at an average of 77,417 plants/acre. Usually, with a population of at least 74,000 plants/acre, the expense of re-planting is not warranted. At the June 22 sampling date, there was no difference between organic and conventional soybean stands, which were reduced to an average of 65,167 plants/acre (data not shown). At the early sampling, grass weeds averaged three weeds/m^2 with no difference between rotations (data not shown). Broadleaf weeds also were similar between conventional and organic soybean plots, averaging six weeds/m^2 compared with previous years where conventional soybean plots typically had less weeds than organic plots. At the second sampling, the early pattern remained, with equivalent grass weeds (averaging 1 weed/m^2) and broadleaf weeds (averaging 4 weeds/m^2) in both conventional and organic systems. As in recent years, many broadleaf weeds remained in conventional plots, even after multiple herbicide applications.

No corn borers (CB) were detected in corn plants July 18, but CB damage was observed, averaging less than 1 percent, across all plots (data not shown). SPAD readings, signifying chlorophyll content, were similar between rotations, averaging 59 across all plots (data not shown). Corn stalk nitrate levels also were equivalent between systems, averaging 942 ppm nitrate-N (Table 1). The rotation with the greatest stalk nitrate levels (C-S-O/A-A) had the highest yields in 2017 (Table 2).

Soybean insect pest levels were low in 2017, with no difference in pest insects between conventional and organic soybeans (data not shown). Aphids averaged one aphid/20 sweeps and bean leaf beetles averaged six beetles/20 sweeps. Corn rootworm beetles were observed at the highest levels ever recorded, averaging 11 beetles/20 sweeps, which had not been observed previously in soybean plots. Thrips also averaged 11 thrips/20 sweeps, but this level was not damaging. Beneficial insects in the soybean plots, including minute pirate bugs and green lacewings, did not differ between rotations (data not shown). Soybean cyst nematodes averaged nine eggs/75 cc of soil, with no differences between systems (data not shown). Stained soybeans (from insect-vectored diseases or other pathogens) averaged 1.6 percent, signifying low populations of damage.

Oat yields were impacted by wet weather, with yields of 73 bushels/acre in the three-year rotation, and 92 bushels/acre in the four-year rotation (Table 3), although the county average was only 77 bushels/acre. Alfalfa yields were excellent at 4.1 tons/acre over the entire season, similar to the 4.6 tons/acre yields in 2014 and 2015. The June harvest was the highest, with the July and August cuttings suffering from dry weather.

Organic corn yield in the C-S-O/A-A plots (151 bu/acre) was statistically greater than the conventional corn yield, which averaged 134 bushels/acre (Table 2). The other organic corn yields were statistically similar to the conventional corn yield, but numerically higher, at 140 bushels/acre in the three-year rotation, and 136 bushels/acre in the rotation with the reduced rate of compost (C-S-C-O/A).

Despite insufficient mechanical weed management in organic soybean plots due to weather impacting field operations, the subsequent high weed populations in the organic soybeans were managed through manual removal (“walking”) and yields were high. The average organic soybean yield (47 bu/acre) was equivalent to the conventional soybean yield (45 bu/acre), which received multiple herbicides (Table 2).

If crops were sold as certified organic, as they were in previous years (and can continue to be, since the fields are certified every year), premium organic corn prices would have brought in $1,359/acre in the C-S-O/A-A rotation, compared with $422/acre for conventional corn. Organic soybeans could have been sold for $852/acre in the same rotation, compared with $415/acre for conventional soybeans.

Organic corn grain quality was exceptionally high in 2017. Protein levels, averaging 9.1 percent, were equal to conventional corn, at 8.7 percent (Table 4). The longer period between corn crops in the organic system lent an additional 0.35 percent in protein content, as evidenced by the 8.88 percent protein in the corn-intensive C-S-C-O/A rotation compared with 9.23 percent in the C-S-O/A-A rotation. Corn density was greater in the organic system, at 1.3 percent. Moisture was equivalent between systems, averaging 17 percent. Corn starch also was equivalent in both systems, averaging 72 percent. Oil content was similar between conventional and organic corn, averaging 4.2 percent.

Soybean moisture levels were equivalent between systems, averaging 10.5 percent (Table 5). Protein levels were greater in the organic soybeans, averaging 38.7 percent, compared with 36.4 percent in conventional soybeans. Protein levels in the C-S-C-O/A rotation (39.2%) were greater than the conventional and C-S-O/A-A rotation (38.1%). Soybean carbohydrate levels were greater in the conventional C-S rotation (22.7%) compared with the organic rotations, which averaged 21.6 percent. Oil levels also were greater in the conventional C-S rotation (18.2%) compared with the organic rotations, which averaged 17.2 percent. Fiber content in the conventional soybeans (4.7%) was greater than the organic rotations, which averaged 4.6 percent (Table 5).

Soil quality determinations at the LTAR site were found to be consistently higher in the organic rotations relative to the conventionally managed corn-soybean rotation. In 2015 and 2016, soil quality of the organic soils had more microbial biomass C and N, higher P, K, Mg, and Ca concentrations, and lower soil acidity than conventional soils. The long-term 4-yr organic rotation had more microbial biomass C and stable macroaggregates than the 3-yr organic rotation in the fall of 2016 (Table 6), which suggests the extra year of alfalfa 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).

In the soil microbial community structure analysis of LTAR soils, data suggested bacterial communities in the organic soil differed from conventional soils. Because the organic soils were shown to have significantly higher microbial biomass C and N and more biologically active organic matter than the conventional soil, this suggests organic management provides a rich resource of food for the soil microbes, which fuels microbial growth, and subsequently increases microbial biomass.

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Table 1. Corn stalk nitrate in the LTAR experiment, ISU Neely-Kinyon Farm, 9/30/17.

Treatment	NO_3^--N (mg/kg)
Conventional C-SB[x]	543
Org. C-S-O/A	1,008
Org. C-S-O/A-A	1,469
Org. C-S-C-O/A	348
$LSD_{0.05}$	NS[y]
P value (α = 0.05)	0.4608

[x]Org.= organic, C = corn, S = soybeans, 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. Corn and soybean yields in the LTAR experiment, ISU Neely-Kinyon Farm.

Treatment	Corn yield (bu/acre)	Soybean yield (bu/acre)
Conventional C-S[x]	133.58b[y]	44.81
Org. C-S-O/A	139.71ab	48.97
Org. C-S-O/A-A	151.22a	47.71
Org. C-S-C-O/A	136.43b	44.88
$LSD_{0.05}$	12.67	NS
P value (α = 0.05)	0.0479	0.3857

[x]Org.= organic, C = corn, S = soybeans, 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. Oat and alfalfa yields in the LTAR experiment, ISU Neely-Kinyon Farm.

Treatment	Oats (bu/acre)	Alfalfa harvest dates (tons/acre)		
	7/21/17	6/5/17	7/7/17	8/8/17
C-S-O/A	72.56	--	--	--
C-S-O/A-A	91.93	2.36	1.17	0.57

[x]Org.= organic, C = corn, S = soybeans, O = oats, A = alfalfa.

Table 4. Corn grain quality in the LTAR experiment, ISU Neely-Kinyon Farm.

Treatment	Moisture (%)	Protein (%)	Oil (%)	Starch (%)	Density (g/cc)	Ethanol yield (gal/bu)
Conventional C-SB[x]	16.88	8.68	4.08	72.35	1.30b	2.81
Org. C-S-O/A	16.83	9.15	4.25	71.90	1.32a	2.78
Org. C-S-O/A-A	17.18	9.23	4.28	71.78	1.32a	2.78
Org. C-S-C-O/A	16.88	8.88	4.15	72.20	1.31ab	2.80
$LSD_{0.05}$	NS	NS	NS	NS	0.009	NS
P value (α = 0.05)	0.0566	0.2707	0.1533	0.2534	0.0261	0.3078

[x]Org.= organic, C = corn, S = soybeans, 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 5. Soybean grain quality in the LTAR experiment, ISU Neely-Kinyon Farm.

Treatment	Moisture (%)	Protein (%)	Oil (%)	Fiber (%)	Carbohydrates (%)
Conventional C-S[x]	10.15	36.38c	18.23a	4.70a	22.70a
Org. C-S-O/A	10.68	38.75ab	17.20bc	4.53b	21.53bc
Org. C-S-O/A-A	10.60	38.08b	17.53b	4.58b	21.85b
Org. C-S-C-O/A	10.73	39.23a	16.95c	4.53b	21.33c
$LSD_{0.05}$	NS[y]	0.95	0.49	0.09	0.43
P value (α = 0.05)	0.0720	0.0002b	0.0008	0.0039	<0.0001

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

Table 6. ISU Neely-Kinyon LTAR soil quality, fall 2016 (depth 0-15 cm).

	SOC gkg^{-1}	TN gkg^{-1}	pomC gkg^{-1}	pomN gkg^{-1}	mbc $mgkg^{-1}$	mbn $mgkg^{-1}$	pminN $mgkg^{-1}$	no3N $mgkg^{-1}$	P $mgkg^{-1}$	K $mgkg^{-1}$	Mg $mgkg^{-1}$	Ca $mgkg^{-1}$	Ec µS cm^{-1}	ph	Aggs %	bd gcm^{-3}
Conv C-S	22.7b	2.3b	2.75b	0.23c	285c	15.4b	36.6b	10.7a	22.9c	252b	358c	3368b	161b	6.11c	23.1b	1.18
Organic C-S-O/A	24.5a	2.5a	3.62a	0.33a	334b	19.8ab	47.6a	10.5a	110.2a	357a	434ab	4271a	211a	7.19a	23.1b	1.16
Organic C-S-O/A-A	24.3a	2.6a	3.60a	0.34a	369a	20.5a	50.0a	11.6a	77.8ab	288b	428b	4157a	214a	6.93b	29.5a	1.16
Organic C-S-C-O/A	24.0ab	2.6a	3.11b	0.29b	343b	20.7a	46.4a	9.8a	45.0bc	254b	493a	4045a	200a	7.00b	30.8a	1.18
$LSD_{0.05}$	1.4	0.1	0.41	0.040	32	4.8	4.2	NS	35.6	37.5	60	243	36	0.13	5.4	NS

[x]C = corn, S = soybeans, O = oats, A = alfalfa.
[y]Means followed by the same letter in a column are not significantly different at $P \leq 0.05$ (Fisher's Protected LSD Test).