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

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Materials and Methods

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). Oat/alfalfa plots were field cultivated April 11, 2018. On April 12, Deon oats were underseeded with Viking 3800 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 2017, winter rye was no-till drilled at a rate of 75 lb/acre November 10, 2017.

Conventional corn plots were injected with 32 percent UAN April 13 at 150 lb/acre, disked May 7, 2018, and field cultivated May 10. Plots were planted May 10 at 32,000 seeds/acre, and sprayed May 15 with Dual II Magnum™ at 1 pt/acre and Atrazine 4L™ at 1 qt/acre. Conventional corn plots were row cultivated June 6 and June 14 to control weeds. Plots were sprayed with Laudis™ at 3 oz/acre June 27.

Conventional soybean plots were disked May 10 and May 16 and field cultivated May 17. On the same day, plots were planted at 172,000 seeds/acre, and received applications of Sonic™ at 4 oz/acre May 18. Plots were cultivated June 15 and July 10 to deal with weeds still emerging after herbicides. On June 27, plots were sprayed with Flexstar™ at 1.5 pt/acre, and Select™ at 9 oz/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 9 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 was plowed under April 24, 2018. Plots were disked May 7 and field cultivated May 10. Organic corn plots were rotary-hoed May 16 and 24, and row-cultivated June 5 and 14.

Corn and soybean variety selection and planting methods in 2018 were as follows: Viking O86-03-UP (Albert Lea Seed, Albert Lea, MN) corn was planted at a depth of 2.5 in. as untreated seed at a rate of 32,000 seeds/acre in the organic and conventional plots, May 10, 2018. Soybeans (BR 27AC5, Blue River Hybrids, Ames, IA) were planted at a depth of 2 inches in organic and conventional plots at a rate of 172,000 seeds/acre May 17, 2018.

Rye was disked in organic soybean plots May 10 and twice on May 16 before soybean planting May 17. Organic soybean plots were rotary hoed May 29 and June 5 and row-cultivated June 15, July 5, and 10. The length of time between planting and the first rotary hoeing (12 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 31. There was a problem of weeds in conventional plots in 2018, 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 20, and weeds were counted within square foot quadrats at three randomly selected areas within a plot. Corn borer populations and damage were estimated July 11 by examining three randomly selected plants/plot. 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 18 from three randomly selected plants in each plot. Soybean cyst nematode sampling occurred in all soybean plots October 12 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 AgSource Labs, Ellsworth, Iowa, and nematode analysis was conducted at the ISU Plant Disease Clinic, Ames, Iowa. Soil quality occurred October 17 by sampling soil at a 6-in. depth in three randomly selected areas in each plot before tillage and analyzed by Cynthia Cambardella, soil scientist, USDA-ARS, Ames, Iowa. The amount of stained soybeans was determined in the laboratory from a random 100-g sample of harvested soybeans from each plot.

Alfalfa was harvested by mowing, raking, and baling June 1, July 6, and August 13. Oats were mowed July 31 and baled August 2. Corn and soybean plots were harvested October 25 and October 23, 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 2018 was again challenging, with a cold, wet spring and drought conditions in mid-summer. Similar corn plant populations were observed between organic and conventional systems at the first sampling June 20, averaging 34,959 plants/acre (Table 1). Early grass weed populations were significantly different between the conventional and organic rotations (Table 1). Corn plots in the conventional rotation averaged less than one grass weed/m^2, while the organic rotations averaged three weeds/m^2 (Table1). The C-S-C-O/A rotation plots, however, averaged less than one grass weed/m^2, which was equivalent to conventional plots. Broadleaf weeds, averaging four weeds/m^2, were similar in both conventional and organic plots.

Soybean stand counts were taken June 20. Plant populations were equivalent in all of the rotations, averaging stand of 94,042 plants/acre, with the conventional rotation having a numerically greater stand, at 97,667 plants/acre (Table 2). Grass weeds averaged six weeds/m^2, with no difference between rotations (Table 2). Broadleaf weeds were more prevalent in the organic rotations, averaging five weeds/m^2 compared with the average of one weed/m^2 in the conventional rotation.

No corn borers or corn borer damage were detected in corn plants July 11 (data not shown). Corn stalk nitrate (SN) levels were greater in the organic C-SB-O/A and organic C-SB-O/A-A systems, averaging 5,286 ppm nitrate-N (Table 4), although in all the previous years, SN samples were analyzed at the ISU Agronomy Department, Soil and Plant Analysis Lab and never exceeded 2,000 ppm.

Soybean cyst nematodes averaged 85 eggs/100 cc of soil, with no differences between systems, suggesting low levels of cyst nematodes in any plot (Table 3).

Corn yields averaged 159 bushels/acre across the four rotations. Yields in conventional and organic rotations were not significantly different. The organic C-SB-O/A rotation was numerically higher with a yield of 167 bushels/acre (Table 3). The average organic soybean yield (38 bu/ac) was equivalent to the conventional soybean yield (39 bu/ac), which received multiple herbicides (Table 3). Soybean yields in the organic C-SB-O/A-A rotation, at 40 bushels/acre, were numerically greater than the other rotations.

Oat yields were impacted by wet weather, with yields of 52 bushels/acre in the three-year rotation, and 58 bushels/acre in the four-year rotation (Table 4). Alfalfa yields were excellent, at 3.48 tons/acre over the entire season. The June harvest was the highest, and the August cutting the lowest, at less than one ton/acre, suffering from dry weather.

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 $1,712/acre in the organic C-S-O/A rotation, compared with $573/acre for conventional corn. Organic soybeans could have been sold for $760/acre in the organic C-S-O/A-A rotation, compared with $336/acre for conventional soybeans.

Organic corn grain quality was high in 2018. Protein levels, averaging 8.75 percent, were greater in the organic C-S-O/A-A and organic C-S-O/A rotations compared with conventional corn, at 7.6 percent (Table 5). The longer period between corn crops in the organic system added an additional 1.1 percent in protein content, as evidenced by the 7.7 percent protein in the corn-intensive C-S-C-O/A rotation compared with 8.93 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 73.7 percent. Oil content was similar between conventional and organic corn, averaging 3.8 percent.

Protein levels were greater in the organic soybeans, averaging 34.24 percent, compared with 32.75 percent in conventional soybeans (Table 6). Protein levels in the organic C-S-C-O/A rotation (34.73%) were greater than the conventional and organic C-S-O/A rotation (33.48%). Soybean carbohydrate levels were greater in the conventional C-S and the organic C-S-O/A rotation, averaging 23.91 percent, compared with the other organic rotations, which averaged 23.32 percent. Oil levels also were greater in the conventional C-S rotation and the organic C-S-O/A rotation, averaging 20.12 percent, compared with the other organic rotations, which averaged 19.3 percent. Fiber content was 4.9 percent in the conventional soybeans, compared with the average of 4.8 percent in the organic rotations.

Soil quality determinations are currently in process at the USDA-ARS lab. In all previous years, soil quality was found to be consistently higher in the organic rotations relative to the conventional corn-soybean rotation.

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Table 1. Corn and weed populations in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA, 6/20/18.

Treatment	Plant population (plants/ac)	Grass weeds (plants/m^2)	Broadleaf weeds (plants/m^2)
Conventional C-SB[x]	33,833	0.42b	3.08
Org. C-SB-O/A	34,917	1.92b	4.33
Org. C-SB-O/A-A	36,417	5.42a	3.58
Org. C-SB-C-O/A	34,667	0.75b	4.83
$LSD_{0.05}$	NS[y]	1.91	NS
P value (α = 0.05)	0.3761	<.0001	0.2843

[x]Org. = organic, C = corn, SB = soybeans, O = oats, A = alfalfa.
[y]Means followed by the same letter down the column are not significantly different at $P \leq 0.05$ 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, 6/20/18.

Treatment	Plant population (plants/ac)	Grass weeds (plants/m^2)	Broadleaf weeds (plants/m^2)
Conventional C-SB[x]	97,667	6.75	1.00b
Org. C-SB-O/A	90,333	6.50	5.17a
Org. C-SB-O/A-A	93,167	4.67	5.08a
Org. C-SB-C-O/A	95,000	7.08	6.08a
$LSD_{0.05}$	NS[y]	NS	3.49
P value (α = 0.05)	0.6544	0.3829	0.0250

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

Table 3. Corn and soybean yields, corn stalk nitrate concentrations, and soybean cyst nematode populations in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA, 2018.

Treatment	Corn yield (bu/ac)	NO_3^--N (ppm)	Soybean yield (bu/ac)	Soybean cyst nematodes (eggs/100 cc soil)
Conventional C-SB[x]	154.29	2,298b	39.11	100
Org. C-SB-O/A	167.08	5,135a	36.92	113
Org. C-SB-O/A-A	156.16	5,438a	40.19	50
Org. C-SB-C-O/A	157.21	461.20c	37.97	75
$LSD_{0.05}$	NS[y]	1168.6	NS	NS[y]
P value (α = 0.05)	0.2629	<0.0001	0.7804	0.6148

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

Table 4. Oat and alfalfa yields in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA. 2018.

Treatment	Oats (bu/ac)	Alfalfa[y] harvest dates (tons/ac)		
		6/1/18	7/6/18	8/13/18
C-SB-O/A	51.68	--	--	--
C-SB-O/A-A	58.11	1.60	1.57	0.31

[x]Org. = organic, C = corn, SB = soybeans, O = oats, A = alfalfa.
[y]Alfalfa (seasonal total) 3.48 tons/acre.

Table 5. Corn grain quality in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA, 2018.

Treatment	Protein (%)	Oil (%)	Starch (%)	Density (g/cc)
Conventional C-SB[x]	7.575b	3.575	73.275a	1.2415b
Org. C-SB-O/A	8.575a	3.825	72.7b	1.2915a
Org. C-SB-O/A-A	8.925a	3.75	72.45b	1.287a
Org. C-SB-C-O/A	7.65b	3.85	73.65a	1.29575a
$LSD_{0.05}$	0.4249	NS[y]	0.4283	0.0111
P value (α = 0.05)	<.0001	0.0518	0.0002	<.0001

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

Table 6. Soybean grain quality in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA, 2018.

Treatment	Moisture (%)	Protein (%)	Oil (%)	Fiber (%)	Carbohydrates (%)
Conventional C-SB[x]	9.95	32.75c	20.28a	4.900a	24.08a
Org. C-SB-O/A	9.85	33.48bc	19.95a	4.85ab	23.73ab
Org. C-SB-O/A-A	9.88	34.50ab	19.35b	4.80bc	23.45bc
Org. C-SB-C-O/A	10.23	34.73a	19.25b	4.750c	23.18c
$LSD_{0.05}$	NS[y]	1.0641	0.5795	0.0629	0.4857
P-value	0.1616	0.0054	0.0064	0.0014	0.0100

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