Comparison of Organic and Conventional Crops at the Neely-Kinyon Long-term Agroecological Research (LTAR) Site, 2016

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Materials and Methods

The Neely-Kinyon 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-SB-C-O/A). Oat/alfalfa plots were field cultivated on March 30, 2016, and 'Saber' oats were underseeded with 'Viking 370HD' alfalfa (Albert Lea Seed, Albert Lea, MN) at a rate of 90 lbs/acre and 15 lb/acre, respectively. Plots were cultipacked on March 30 after planting. Following harvest of the organic corn plots in 2015, winter rye was no-till drilled at a rate of 75 lb/acre on October 24, 2015.

Conventional corn plots were injected with 32% UAN on May 6, 2016, at 140 lb N/acre, disked on May 6 and field cultivated on May 19. Chicken manure (S.W. Iowa Egg Cooperative, Massena, IA) was applied to organic corn plots at a rate of 6.9 tons/acre on March 28 in the organic C-S-O/A and C-S-O/A-A plots, and at a reduced rate of 2.9 tons/acre in the C-S-C-O/A plots on the same day. Corn and soybean variety selection and planting methods in 2016 were as follows: Viking 0.24-02N 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, on May 20, 2016. Conventional soybean plots were disked on May 6 and field cultivated on May 19. Viking 0.2399AT 12N soybeans were planted at a depth of 2 in. in organic and conventional plots at a rate of 175,000 seeds/acre on May 20, 2016. Conventional corn plots were sprayed on May 21, 2016, with Dual II™ at 3/4 pt/acre. Conventional corn plots were cultivated on June 16 to deal with weed problems. Conventional soybeans received applications of Sonic™ at 3.5 oz/acre, Round-up™ at 32oz/acre, and Sharpen™ at 1.5 oz/acre on May 21, 2016. Conventional soybean plots were cultivated on June 16 and 28 to deal with weeds still emerging after herbicides. On June 30, plots were sprayed with Cadet™ at 0.6 oz/acre, crop oil at 1 gal/100 gal water/acre, and AMS at 2.7 lb/acre to control remaining weeds.

The alfalfa and compost that was applied in the organic corn plots were plowed under on April 11, 2016. Plots were disked on May 6 and field cultivated on May 19. Organic corn plots were rotary-hoed on June 1 and row-cultivated on June 9 and 16, which was a rotary-hoeing less than in 2013, which had optimal weed management.

Rye was disked twice in organic soybean plots on May 6, and field cultivated on May 19, before soybean planting on May 20. Organic soybean plots were rotary hoed on June 1 and June 7, and row-cultivated on June 11, June 16, and June 28. 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 on July 28, August 10 and August 17. There was a problem of weeds in conventional plots in 2016, 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 on June 21, and weeds were counted within square foot quadrats at three randomly selected areas within a plot. Corn stalk nitrate samples were collected on September 18 from three randomly selected plants in each plot. Soybean cyst nematode sampling occurred in all soybean plots on October 3 by All crop and soil analyses were conducted at the Iowa State University Soil and Plant Analysis Laboratory, Ames, IA, and nematode analysis was conducted at the ISU Plant Disease Clinic (Ames, IA).

Alfalfa was harvested by mowing, raking and baling, on June 3, July 8, and August 16. Oat grain was harvested on July 13. Corn and soybean plots were harvested on October 18 and 20, 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, IA.

Results and Discussion

The weather in 2016 was again challenging, but May weather allowed an early planting date, which helped with yields. As a result of rainy weather conditions in June, weed management in organic plots suffered. Corn stands were similar between organic and conventional systems, averaging 36,062 plants/acre (Table 1). Soybean plant populations also were similar between systems, averaging 106,833 plants/acre (Table 2). Grass weed populations were highest in the organic C-S-O/A-A corn plots, averaging 20 weeds/ft^2, and were similar in the C-S-O/A and C-S-O/A-A plots, at 11 weeds/ft^2. All organic plots had significantly greater grass weed populations than conventional plots, which had no grass weeds at the time of the sampling (Table 1). Broadleaf weeds, averaging 5 weeds/ft^2, were similar in both conventional and organic plots. In the soybean plots, the organic plots averaged 12 grass weeds/ft^2, compared to <1 weed/ft^2 in conventional plots (Table 2). Broadleaf weeds were greater in organic soybean plots, averaging 2 weeds/ft^2 compared to <1 weed/m^2 in conventional soybean plots. Weeds in organic fields could be attributed to a delay of 12 days between planting and the first rotary hoeing in corn and soybean plots. For good weed management in organic crops, the first rotary hoeing should occur within 2–3 days after planting. Corn stalk nitrate levels were statistically greater in conventional corn, at 1,945 ppm nitrate-N, compared to 470 ppm nitrate-N in the organic corn, signifying luxury application in conventional plots, and below recommended levels in the organic corn (Table 3). Yields, however, did not correspond to stalk nitrate levels, as the organic corn in the C-S-O/A-A rotation performed better than the conventional corn.

Oat yields were impacted by wet weather, with yields of 58 bu/acre in the three-year rotation, and 63 bu/acre in the four-year rotation (Table 5). Alfalfa yields were excellent, at 5.4 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 August cutting suffering from dry weather. Oat and alfalfa baleage in the O/A plots averaged 1.47 tons/acre.

Organic corn varieties were changed in 2016 and corn was planted earlier–on a date more like the early years of the LTAR experiment, when corn was always planted in mid- to late-May. As a result of these factors, and timely rains, organic corn yield in the C-S-O/A-A plots (166 bu/acre) was statistically greater than the conventional corn yield, which averaged 135 bu/acre (Table 3). The other organic corn yields were statistically similar to the conventional corn yield, but numerically higher, at 151 bu/acre in the three-year rotation, and 136 bu/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, averaging 45 bu/acre over both organic systems, with the four-year rotation statistically equivalent to the conventional soybean yield. The conventional system, which received multiple herbicides, averaged 56 bu/acre, and the organic C-S-O/A-A soybean yield was equivalent at 49 bu/acre (Table 4). There were no soybean cyst nematodes detected in any plots in 2016 (Table 4).

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 $1,328/acre in the C-S-O/A-A rotation, compared to $482/acre for conventional corn. Organic soybeans could have sold for $882/acre in the same rotation, compared to $550/acre for conventional soybeans.

Organic corn grain quality was exceptionally high in 2016. Protein levels were equal to conventional corn, at 8.7% (Table 3). The longer period between corn crops in the organic system lent an additional 0.50% in protein content, as evidenced by the 8.2% protein in the corn-intensive C-S-C-O/A rotation. Corn density was greater in the organic system, at 1.3%. Moisture was lower, averaging 18% in the organic C-S-C-O/A corn at harvest, compared to the other organic rotations and the conventional corn (18.6%). Corn starch was nearly equivalent in both systems, averaging 73%, with the C-S-C-O/A higher at 73.6%. Corn oil content was greater, at 3.6%, in corn from the organic system, compared to 3.5% in the conventional corn.

Soybean moisture levels were not different between systems, averaging 13% (Table 4). Protein levels were equivalent between systems, at 35%. Soybean carbohydrate levels averaged 23%. Oil levels (19%) and fiber content (5%) were also similar across all rotations. Soybean insect pest levels were low in 2016, with stained soybeans averaging 1.8% across all rotations, and no difference between conventional and organic soybeans (Table 4).

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Table 1. Corn plant and weed populations, LTAR experiment, Neely-Kinyon Farm, 6/21/16.

Treatment	Plant populations (plants/acre)	Grass weeds (plants/ft^2)	Broadleaf weeds (plants/ft^2)
Conventional C-SB[x]	36,583	0.00c	4.50
Org. C-SB-O/A	35,583	9.67b	6.67
Org. C-SB-O/A-A	36,250	20.00a	4.50
Org. C-SB-C-O/A	35,833	13.17b	4.83
$LSD_{0.05}$	NS[y]	0.35	NS
p value ($\alpha = 0.05$)	0.8383	<0.0001	0.4244

[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, LTAR experiment, Neely-Kinyon Farm, 6/21/16.

Treatment	Plant populations (plants/acre)	Grass weeds (plants/ft^2)	Broadleaf weeds (plants/ft^2)
Conventional C-SB[x]	111,333	0.17b	0.42b
Org. C-SB-O/A	102,667	9.67a	1.42ab
Org. C-SB-O/A-A	106,500	13.25a	2.58a
$LSD_{0.05}$	NS[y]	7.00	0.55
p value ($\alpha = 0.05$)	0.5771	0.0004	0.0346

[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 yield, stalk nitrate, and grain quality analysis in the LTAR experiment, Neely-Kinyon Farm, 2016.

Treatment	Bu/acre	Stalk NO_3^--N (mg/kg)	Moisture (%)	Protein (%)	Oil (%)	Starch (%)	Density (g/cc)	Ethanol yield (gal/bu)
Conventional C-SB[x]	135.38b[y]	1,945[y]	18.78a	8.75a	3.45b	72.95b	1.29c	2.82b
Org. C-SB-O/A	150.45b	648b	18.40a	8.75a	3.58a	73.25ab	1.31a	2.82b
Org. C-SB-O/A-A	166.04a	706b	18.58a	8.70a	3.58a	73.33ab	1.31a	2.83b
Org. C-SB-C-O/A	136.13b	54.5b	17.63b	8.23b	3.58a	73.60a	1.30b	2.85a
$LSD_{0.05}$	0.067	82.3	0.69	0.23	0.02	0.25	0.00241	0.00684
p value ($\alpha = 0.05$)	0.0030	0.0249	0.0008	0.0048	0.0471	0.0313	0.0002	0.0013

[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. Soybean yield, soybean cyst nematodes, and grain quality analysis, LTAR experiment, Neely-Kinyon Farm, 2016.

Treatment	Bu/acre	Nematodes (eggs/100 cc soil)	Moisture (%)	Protein (%)	Oil (%)	Fiber (%)	Carbohydrates (%)	Stained soybeans (%)
Conventional C-SB[x]	55.77a[y]	0	13.07	35.05	18.55	4.83	23.60	1.35
Org. C-SB-O/A	41.33b	0	13.30	35.13	18.60	4.83	23.50	2.28
Org. C-SB-O/A-A	48.90ab	0	13.50	35.10	18.68	4.80	23.43	1.90
$LSD_{0.05}$	5.01	--	NS	NS	NS	NS	NS	NS
p value ($\alpha = 0.05$)	0.0221	--	0.1425	0.9652	0.4777	0.6224	0.5969	0.3657

[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 5. Oat and alfalfa harvests in the LTAR experiment, Neely-Kinyon Farm, 2016.

Treatment	Oats (bu/acre)	Alfalfa (tons/acre)
Org. C-SB-O/A[x]	57.96	
Org. C-SB-O/A-A	62.74	5.42
Org. C-SB-C-O/A	49.72	

[x]Org.= Organic, C = corn, SB = soybeans, O = oats, A = alfalfa