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

RFR-A20109

Kathleen Delate, professor
Henry Franzen, 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 1, 2020. Also on April 1, Hayden 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 2019, winter rye was no-till drilled at a rate of 75 lb/acre October 29, 2019.

Conventional corn plots were injected with 32 percent UAN April 9, at 150 lb/acre and disked May 29, 2020. Plots were planted May 30, at 35,000 seeds/acre, and sprayed June 3 with Outlook™ at 18 oz/acre and Round-up™ at 32 oz/acre. On June 24, plots were sprayed with Dual II Magnum™ at 1 pt/acre and Atrazine 4L™ at 1 qt/acre. Conventional corn plots were row-cultivated on July 6 to control weeds.

Conventional soybean plots were disked May 29, 2020. On May 30, plots were planted at 190,000 seeds/acre, and received applications of Outlook™ at 18 oz/acre and Round-up™ at 32 oz/acre. On June 24, plots were sprayed with Pursuit™ at 3 oz/acre. Plots were cultivated July 8 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 March 30 to organic corn plots in the C-S-O/A and C-S-O/A-A treatments. On the same day, manure was applied to C-S-C-O/A corn plots at a rate of 1,290 lb/acre. The alfalfa and manure in plots going to corn were plowed under April 22 and 23, 2020. Plots were disked May 7 and May 29. Corn and soybean variety selection and planting methods in 2020 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 plots May 30, 2020. Organic corn plots were rotary-hoed June 2 and 9 and row-cultivated June 16 and 29. Rye was disked twice in organic soybean plots May 7 and 29 before soybean planting. Soybeans (IA3051RA12, Blue River Hybrids, Ames, IA) were planted at a depth of 2 in. in organic and conventional plots at a rate of 190,000 seeds/acre May 30, 2020.

Organic soybean plots were rotary hoed June 2 and 9; and row-cultivated June 16, 29, and July 8. Weeds above the canopy were removed by “walking” from August 5 to August 7. There was a problem with weeds in conventional plots in 2020, 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 and weeds were counted June 30 at three randomly selected areas within a plot. Soybean cyst nematode sampling occurred in all soybean plots September 24 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. Soil samples were analyzed by Midwest Labs, Omaha, Nebraska.

Alfalfa was harvested by mowing, raking, and baling June 2, July 6, and August 8 (Table 4). Oats were sampled for yields July 15. Corn and soybean plots were harvested October 19 and October 5, 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 2020 was challenging, with a wet spring and drought conditions in mid-summer. Similar corn plant populations were observed between organic rotations, averaging 33,750 plants/acre June 30, compared with numerically lower conventional corn populations of 30,750 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, suggesting more weed prevention with longer organic rotations (Table 2). Broadleaf weeds were similar in conventional and organic plots. Soybean plant populations were numerically greater in the conventional C-S rotation, averaging 151,000 plants/acre, compared with an average of 142,500 plants/acre in the organic rotations (Table 2). Grass and broadleaf weeds were similar in the organic rotations (Table 2).

Soybean cyst nematodes were numerically lower in organic rotations, averaging 37.5 eggs/100 cc of soil, compared with the conventional system, which averaged 50 eggs/100 cc of soil (Table 3). Stained soybean percentages, representing damage from bean leaf beetle feeding, averaging 8.09 percent, were equivalent across all rotations, and were significantly lower than 2019.

Corn yields were greatest in the C-S-O/A-A rotation, averaging 158.86 bushels/acre, compared with 134.72 bushels/acre in the conventional C-S rotation (Table 3). The organic C-S-O/A rotation, yielding 152.28 bushels/acre, also was greater than the conventional corn yields. Although there were no statistical differences in soybean yields, the organic soybean yield in the C-S-O/A rotation (49.15 bu/ac) was numerically lower than the conventional soybean yield (49.35 bu/ac), which received multiple herbicides and cultivation (Table 3).

Oat yields were impacted by wet weather, with yields of 78.09 bushels/acre in the three-year rotation, and 106.17 bushels/acre in the four-year rotation (Table 4). Alfalfa yields, at 2.57 tons/acre, were similar to 2019 yields, which averaged 2.52 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 these were in previous years (and can continue to be, since the fields are certified every year), premium organic corn prices would have brought in $1,505/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.

Corn protein levels, at 7.93 percent, were greatest in the organic C-S-O/A rotation, compared with conventional corn, at 7.15 percent (Table 5). Overall, organic rotations average protein levels were 0.67 percent higher than conventional corn protein levels. The longer period between corn crops in the organic system lent an additional 0.3 percent in protein content, as evidenced by the 7.63 percent protein in the corn-intensive C-S-C-O/A rotation compared with 7.93 percent in the C-S-O/A-A rotation. Corn density was greater in the organic system, averaging 1.29 percent, compared with 1.25 percent in conventional corn. Corn starch was higher in the conventional rotations, averaging 61 percent, compared with 60.5 percent in the organic rotations. Oil content was highest in the C-S-O/A-A corn at 3.83 percent compared with the conventional at 3.55 percent.

Protein levels were greatest in the organic C-S-O/A-A rotation soybean, averaging 35.15 percent, compared with 32.2 percent in conventional soybean (Table 6). Protein levels in the organic C-S-O/A rotation also were greater than the conventional rotation (32.2%), at 34.28 percent. Soybean carbohydrate levels were greater in the conventional C-S rotation, averaging 24.95 percent. Oil levels were greater in the conventional C-S rotation, averaging 19.85 percent, compared with the next highest organic C-S-O/A rotation, which averaged 19.05 percent. Fiber content averaged 5.00 percent in the conventional rotation, compared with the average of 4.81 percent in the organic rotations.

Table 7 shows average seasonal precipitation and temperatures for 2019-2020, as well as the 30-yr monthly and seasonal averages at the Neely-Kinyon Research Farm. The highest total precipitation, at 39 in., occurred in 2019, with May 2019 having the most rain at 8.68 in. In 2020, total seasonal precipitation was only 20.32 in., with July having the highest precipitation for the season at 3.51 in., but August had only 0.35 in. The 30-yr average seasonal precipitation for 2019-2020 was 32.70 in., showing 2020 to be 12.38 in. below normal. The average temperatures for 2019 and 2020 showed 2020 to be 2.44^{o}F warmer than 2019, with July 2020 having the highest temperature for both years, at 75.16^{o}F. Although there were warmer months in June and July 2020 compared with the 30-yr average, the overall seasonal 30-yr average temperature was higher than 2019 and 2020, at 53.80^{o}F.

Soybean insect pest populations were relatively low in 2020, with no statistical differences between conventional and organic soybean. Bean leaf beetles averaged 14 beetles/20 sweeps in conventional plots and were numerically lower, at 5 beetles/20 sweeps, across all organic plots (Table 8). Rootworm beetle populations were equivalent in conventional and organic plots, averaging 14 beetles/20 sweeps.

Acknowledgements

We would like to thank the Leopold Center for Sustainable Agriculture and the Nutrient Research Center for support of the Neely-Kinyon LTAR site. Thanks also to Bob Turnbull and Dallas Maxwell for their help in production, data collection, and analytical aspects of this project. We also thank Kathy Rohrig and the Adair County Extension and Outreach office, Charles Hurburgh and Glen Rippke of the ISU Grain Quality Lab, Albert Lea Seed, and Blue River Hybrids for their support.

Table 1. Corn plant and weed populations in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA, 6/30/20.

Treatment	Plant population (plants/ac)	Grass weeds (plants/m^2)	Broadleaf weeds (plants/m^2)
Conventional C-S[x]	30,750	17d	0
Org. C-S-O/A	34,250	7c	1
Org. C-S-O/A-A	33,000	0a	1
Org. C-S-C-O/A	34,000	3b	0
P value (α = 0.05)	NS[y]	0.0021	NS

[x]Org. = organic, C = corn, S = 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, 6/30/20.

Treatment	Plant population (plants/ac)	Grass weeds (plants/ m^2)	Broadleaf weeds (plant/m^2)
Conventional C-S[x]	151,000	2	0.5
Org. C-S-O/A	147,500	1	0.5
Org. C-S-O/A-A	137,500	0	0
P value (α = 0.05)	NS[y]	0.1004	NS

[x]Org. = organic, C = corn, S = 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, soybean cyst nematode populations, and stained soybean in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA, 2020.

Treatment	Corn yield (bu/ac)	Soybean yield (bu/ac)	Soybean cyst nematodes (eggs/100 cc soil)	Stained soybean (%)
Conventional C-S[x]	134.72d [y]	49.35	50.0	8.10
Org. C-S-O/A	152.28b	49.15	37.5	9.03
Org. C-S-O/A-A	158.86a	46.37	0.0	7.13
Org. C-S-C-O/A	145.48c	N/A	N/A	N/A
P value (α = 0.05)	0.0387	NS	NS	NS

[x]Org. = organic, C = corn, S = 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, 2020.

		Harvest date (tons/ac)		
Treatment	Yield (bu/ac)	6/2/20	7/6/20	8/8/20
Org. C-S-O/A [x]	78.09b	--	--	--
Org. C-S-O/A-A	106.17	1.26	0.69	0.62

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

Table 5. Corn grain quality in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA, 2020.

Treatment	NIR Moisture (%)	Protein (%)	Oil (%)	Starch (%)	Density (g/cc)
Conv. C-S[x]	14.20	7.15d	3.55d	61.03a	1.25c
Org. C-S-O/A	14.10	7.93a	3.70c	60.43c	1.29a
Org. C-S-O/A-A	14.60	7.90b	3.83a	60.20d	1.28b
Org. C-S-C-O/A	13.90	7.63c	3.73b	60.78b	1.29a
P-value (α = 0.05)	NS[y]	0.0005	0.0156	0.0002	0.0001

[x]Org. = organic, C = corn, S = 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, 2020.

Treatment	Moisture (%)	Protein (%)	Oil (%)	Fiber (%)	Carbohydrates (%)
Conventional C-S[x]	12.88	32.2c	19.85a	5.00a	24.95a
Org. C-S-O/A	11.85	34.28b	19.05b	4.85c	23.83b
Org. C-S-O/A-A	12.08	35.15a	18.70c	4.78b	23.40c
P value (α = 0.05)	NS[y]	0.0015	0.0082	0.0025	0.0018

[x] Org. = organic, C = corn, S = 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 7. Precipitation and temperature averages, Neely-Kinyon Farm, Greenfield, IA, 2019-2020.

	Monthly precipitation (in.)			Average air temperature (ºF)		
Month	2019	2020	30-yr avg.	2019	2020	30-yr avg.
January	1.06	1.17	0.88	19.34	23.34	22.30
February	1.98	0.08	1.21	15.70	26.86	26.69
March	2.51	2.88	2.12	30.65	41.15	38.91
April	0.88	2.40	3.84	50.55	47.32	50.67
May	8.68	3.22	5.11	56.66	57.85	61.34
June	3.92	2.25	4.79	69.27	73.2	71.17
July	1.15	3.51	3.92	74.98	75.16	74.95
August	6.97	0.35	4.20	69.90	72.94	73.01
September	5.76	2.57	3.81	68.97	62.73	65.78
October	6.14	1.89	2.82	47.82	47.29	53.21
Total seasonal precipitation and seasonal average air temperature	39.05	20.32	32.70	50.38	52.82	53.80

Table 8. Soybean insect populations in the LTAR experiment, Neely-Kinyon Farm, Greenfield, IA, 2020 (number/20 sweeps).

Treatment	BLB[z]	Stink bug	MPB[y]	Wasp	Nabid	Rootworm beetle	Flea beetle	Tarnished plant bug	Spider	Lace wing
C-S[x]	14	4	1	0	1	14	1	0	0	0
Org. C-S-O/A	6	2	0	2	0	16	6	1	1	1
Org. C-S-O/A-A	3	2	0	0	0	13	0	0	1	0
P value ($\alpha = 0.05$)	NS[w]	NS	NS	NS	NS	NS	NS	NS	NS	NS

[z]BLB = bean leaf beetles.
[y]MPB = minute pirate bugs.
[x]Org. = organic, C = corn, S = soybean, O = oats, A = alfalfa.
[w]Means followed by the same letter in a column are not significantly different at $P \leq 0.05$ or not significant (NS) (Fisher's Protected LSD Test).