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

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Materials and Methods

The Neely-Kinyon long term agroecological research site (LTAR) 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-Oat/Alfalfa, (C-S-O/A), organic Corn-Soybean-Oat/Alfalfa-Alfalfa (C-S-O/A-A), and organic Corn-Soybean-Corn-Oat/Alfalfa (C-S-C-O/A). Oat/Alfalfa plots were field cultivated March 29. On April 4, Reins oats were underseeded with Viking 3800 alfalfa (Albert Lea Seed) at a rate of 90 lbs./acre and 15 lbs./acre, respectively. Plots were cultipacked on the same day as planting. Following harvest of the organic corn plots in 2021, winter rye was drilled at a rate of 75 lbs./acre on October 18, 2021.

In conventional corn plots, Monoammonium Phosphate (MAP) at 125 lbs./acre and potash at 150 lbs./acre were applied March 28. Plots were cultivated and planted May 16 at 35,000 seeds/acre and sprayed May 18 with Corvis™ at 5.6 oz./acre, Atrizine™ at 1 qt./acre, Round-up™ at 32 oz./acre, and 2,4-D at 16 oz./acre. In conventional soybean plots, MAP at 125 lbs./acre and potash at 150 lbs./acre were applied March 28. On May 18, fields were sprayed with Authority Edge™ at 10 oz./acre, Round-up™ at 20 oz./acre, and AMS™ at 2 lbs./acre. The soybeans were planted May 19 at 190,000 seeds/acre. On June 22, the plots were sprayed with Flexstar™ at 1.33 pts/acre MSO™ at 1 pt/acre, NIS™ at 1 pt/acre and AMS™ at 6 lbs./acre. Plots were cultivated July 11 to manage weeds still emerging after herbicides.

In the organic plots, chicken manure (SW Iowa Egg Cooperative) was applied at a rate of 3,105 lbs./plot April 5, in the C-S-O/A and C-S-O/A-A rotations. In the C-S-C-O/A rotation, manure was applied on the same day at a rate of 1,290 lbs./plot. The alfalfa plots with composted manure were plowed under April 12, disked May 15 and field cultivated May 16. Organic corn plots were rotary hoed May 19 and June 1, and field cultivated June 14, 16 and 22. Corn and soybean variety selection and planting methods were: Viking O.18-06 UP (Albert Lea Seed) corn was planted at a depth of 2.5 in. as untreated seed at a rate of 35,000 seeds/acre May 16, 2022. Soybean BR29DC5 (Blue River/Albert Lea Seed) was planted at a depth of 2 in. at a rate of 190,000 seeds/acre May 16.

Rye was disked twice in organic soybean plots May 16 and 19 before soybean planting on May 19. Organic soybean plots were rotary hoed May 23 (eight days after planting), June 1 and 10, and field cultivated June 16, 22, July 11, 20, and 28. The organic soybean plots were walked July 9. There was a problem with weeds in the conventional plots, 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 23, and weeds were counted within square meter quadrants at three randomly selected areas within a plot. Corn borer populations and damage were estimated July 12 by examining three randomly selected plants per plot. On July 13, insect populations were censused by sweeping with a 15 in. net 20 times across three random areas of the plot. Corn stalk nitrate samples were collected October 5 by cutting corn stalks at the 6-14 in. height from three randomly selected corn plants per plot. Soybean cyst nematode sampling occurred in all soybean plots October 13 by sampling at a

6-in. depth in three randomly selected areas in soybean rows in each plot. Nematode analysis was conducted at the Iowa State University Plant and Insect Diagnostic Clinic. Soybean staining was analyzed in the Iowa State organic program laboratory from a random sample of 100 g of soybean from each plot. Soil quality sampling occurs each fall in the LTAR experiment, after harvest and before tillage or cover crop planting, by sampling soil at a 6 in. depth in three randomly selected areas in each plot, on October 11 and 27. Samples were delivered to the M. McDaniel lab at the Iowa State Department of Agronomy and are being processed.

Alfalfa was harvested by mowing, raking and baling June 1-3, July 5-12 and August 23-28. Oats were combined with a plot combine July 22, then plots were mowed for straw July 23 and raked and baled July 26. Soybean and corn plots were harvested October 6 and 25, respectively. Grain samples were collected from each plot for grain quality analysis, which was conducted at the Iowa State Grain Quality Laboratory.

Results and Discussion

The weather this year was challenging, with spring temperatures 4.13°F below the 30-year average and April temperatures averaging 44.37°F, 6°F below the 30-year average (Table 1). Above average temperatures in June were 2.16°F above the 30-year average. During the harvest season, the weather cooled considerably with October 2.11°F below the 30-year average. Drought continued during the year with total precipitation through October of 24.14 in., which was 8.81 in. below the 30-year average. From April to September, precipitation totals were 7.45 in. below the 30-year average.

Similar corn plant populations, averaging 32,000 plants/acre, were observed in the organic C-S-C-O/A and the conventional C-S rotations June 23 (Table 2). The organic rotations averaged 30,444 plants/acre compared with greater conventional corn populations of 33,333 plants/acre. Grass weed populations were lower in the conventional and organic C-S-O/A rotations, averaging one grass weed/m^2, compared with the other organic rotations, which averaged seven grass weeds/m^2. Broadleaf weeds were equivalent in the conventional and organic C-S-O/A and C-S-O/A-A rotations, averaging two broadleaf weeds/m^2 compared with four broadleaf weeds/m^2 in the organic C-S-C-O/A rotation.

Soybean plant populations averaged 97,555 plants/acre, with no significant differences across the organic rotations, but a significantly greater population of 124,667 plants/acre in the conventional C-S rotation (Table 3). Grass weed populations were greater in the organic rotations, averaging 5 weeds/m^2, compared with the conventional rotation, which averaged 1 grass weed/m^2. Broadleaf weed populations were greater in the organic rotations, averaging 6 broadleaf weeds/m^2, compared with the conventional C-S rotation, which averaged 1 broadleaf weed/m^2.

No corn borer damage or corn borers were detected in corn plants on July 12. Soybean cyst nematodes (SCN) averaged 283.33 eggs/100cc of soil in the C-S-C-O/A rotation, with no statistical differences with the other rotations, which averaged 37.5 eggs/100cc of soil in the conventional C-S and 100 eggs/100cc in the C-S-O/A. No

Table 1. Precipitation and temperature, 2022.

	Rainfall, inches		Difference from 30-year average	Average air temperature (F)		Difference from 30-year average
Month	2022	30-year average		2022	30-year average	
January	0.99	0.87	0.12	16.18	22.08	-5.90
February	0.19	1.21	-1.02	22.88	25.71	-2.83
March	3.69	2.07	1.62	36.95	38.76	-1.81
April	2.83	3.66	-1.28	44.37	50.35	-5.98
May	4.54	5.14	-0.6	61.48	61.22	0.26
June	3.05	4.68	-1.63	73.35	71.19	2.16
July	1.71	3.90	-2.19	75.72	74.95	0.77
August	3.75	4.24	-0.49	74.52	73.04	1.48
September	2.62	3.88	-1.26	65.58	65.67	-0.09
October	0.77	2.85	-2.08	51.00	53.11	-2.11
Totals	24.14	32.50	-8.81	52.20	53.61	-14.10

Table 2. LTAR experiment, June 23: corn plant and weed populations.

Treatment (plants/acre)	Population (plants/m^2)	Broadleaf weeds	Grass weeds (plants/m^2)
Conv. C-S[x]	33,333a[y]	1.33b	0.17b
Org. C-S-O/A	30,500b	1.83ab	1.00b
Org. C-S-O/A-A	30166b	2.33ab	5.17ab
Org. C-S-C-O/A	30,666ab	4.17a	8.00a
p value (α=0.05)	0.0107	0.0308	0.0008

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

Table 3. LTAR experiment, June 23: soybean plant and weed populations .

Treatment	Population (plants/acre)	Broadleaf weeds (plants/m^2)	Grass weeds (plants/m^2)
Conv. C-Sx	124667a[y]	1.17b	1.00b
Org. C-S-O/A	95,333b	5.00ab	4.67ab
Org. C-S-O/A-A	94,333b	8.00a	6.67a
Org. C-S-C-O/A	103,000b	5.50a	5.00ab
p value (α=0.05)	<0.0001	0.0010	0.0050

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

SCN were recovered in the C-S-O/A-A rotation (Table 4). The percentage of stained soybeans, representing damage from bean leaf beetle feeding was lower than in 2021, with an overall average of 1.76%. There was a higher percentage of stained soybean in the organic C-S-O/A rotation, at 2.8%, compared with the 1% stained in the organic C-S-C-O/A-A rotation. Corn yields were affected by the drought this year, and were equivalent across all rotations, averaging 109 bushels/acre. The C-S-O/A rotation averaged 116 bushels/acre, compared with 105 bushels/acre in the conventional C-S rotation. The organic C-S-O/A-A and C-S-C-O/A rotations averaged 107 bushels/acre. Corn stalk nitrate (CSN) levels were low, also affected by drought conditions. The average CSN was 684 ppm in the organic rotations and 1,758 ppm in the conventional corn, with no significant differences between treatments (Table 4). The organic soybean yield in the C-S-O/A-A rotation (55 bushels/acre) was statistically greater than the conventional soybean yield (47 bushels/acre), which received multiple herbicides and cultivations (Table 4), representing a yield increase from longer rotations. The other organic rotations averaged 52 bushels/acre.

Oat plots yielded 102 bushels/acre in the three-year rotation, and 106 bushels/acre in the four-year rotation, which was 14 bushels/acre less than in 2021 (Table 5). Alfalfa yields, at 3.57 tons/acre were greater than 2021's yields, which averaged 2.75 tons/acre. The June and August harvests were the highest, with an average of 1.4 tons/acre, but the July cutting, at 0.58 tons/acre, suffered 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 $1,259.11/acre in the organic C-S-O/A rotation, compared with the $678.86/acre for conventional corn. Organic soybean could have been sold for $1,595.84/acre in the organic C-S-O/A-A rotation, compared with $669.06/acre for conventional soybean.

Corn protein levels, averaging 7.4%, were greatest in the C-S-O/A and C-S-O/A-A rotations, compared with conventional corn, at 6.6% (Table 6). The corn protein level in the C-S-C-O/A rotation, at 6.03%, was equivalent to the conventional corn. Comparing the organic rotations with a small grain in the third year of the rotation, the average organic protein was 0.37% greater than conventional corn protein levels. The longer period between corn crops in the organic system lent an additional 1.5% in protein content, as evidenced by the 6% protein in the corn intensive C-S-C-O/A rotation compared with the 7.5% in the C-S-O/A-A rotation. Corn density was greater in the organic system, averaging 1.29 g/cc, compared with the 1.23 g/cc in the conventional rotation. Corn starch was highest in the organic C-S-C-O/A rotation, averaging 62% compared with conventional corn, which averaged 61%. The other organic rotations also averaged 61%. Oil content averaged 3.5% across all rotations, with no significant differences between conventional and organic rotations (Table 6).

Soybean protein levels were significantly greater in the organic rotations, with the organic rotations averaging 36.3%, compared with the 34.6% in the conventional rotation (Table 7). Soybean carbohydrate levels averaged 22.9% in the organic rotations compared with a greater level of 23.8% in the conventional C-S rotation. Oil levels were greater in the conventional rotation, averaging 18.8%, compared with the organic rotations, which averaged 18%. Fiber content averaged 4.8% in the organic rotations, which was less than the 4.9% in the conventional C-S rotation (Table 7).

Table 4. LTAR experiment: corn and soybean yields, stained soybean, corn stalk nitrate, and soybean cyst nematodes.

Treatment	Corn yield, bushels/ac	Soybean yield, bushels/acre	Stained soybeans %	Corn stalk nitrate, ppm	Soybean cyst nematodes, eggs/100cc soil
Conv. C-Sx	105.25a[y]	47.25b	1.23ab	1,757.50a	37.50a
Org. C-S-O/A	115.94a	50.22ab	2.83a	754.25a	100.00a
Org. C-S-O/A-A	110.30a	55.01a	0.90b	1,248.75a	0.00a
Org. C-S-C-O/A	103.48a	53.83ab	2.08ab	50.25a	283.33a
p value (α=0.05)	0.7599	0.0282	0.0162	0.0897	0.1289

[x]Means followed by the same letter down the column are not significantly different at P ≤ 0.05 or not significant (NS) (Fisher's Protected LSD Test).

Table 5. LTAR experiment: oat and alfalfa yields.

Treatment	Yield, bushels/acre	Harvest date, tons/acre		
		Jun1-3	Jul-12	Aug 23-28
Org. C-S-O/A [x]	101.88			
Org. C-S-O/A-A	106.42	1.67	0.58	1.32

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

Table 6. LTAR experiment: corn grain quality.

Treatment	Moisture %	Protein %	Oil %	Starch %	Density, g/cc	Ethanol yield (gal/bu.)
Conv. C-Sx	13.70a[y]	6.55b	3.50a	61.15b	1.23c	2.83b
Org. C-S-O/A	13.38a	7.33a	3.58a	60.80b	1.31a	2.81b
Org. C-S-O/A-A	13.40a	7.49a	3.58a	60.70b	1.31a	2.80b
Org. C-S-C-O/A	13.40a	6.03b	3.48a	61.88a	1.26b	2.88a
p value (α=0.05)	0.2849	0.0001	0.0470	0.0008	<0.0001	0.0006

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

Table 7. LTAR experiment: soybean grain quality.

Treatment	Moisture%	Protein%	Oil%	Fiber%	Carbohydrates%
Conv. C-Sx	11.35a[y]	34.55b	18.77a	4.9a	23.78a
Org. C-S-O/A	11.47a	36.43a	18.03b	4.78b	22.78b
Org. C-S-O/A-A	12.68a	36.23a	18.03b	4.83b	22.93b
Org. C-S-C-O/A	12.33a	36.33a	17.9b	4.8b	22.98b
p value (α=0.05)	0.0908	<0.0001	<0.0001	0.0018	0.0012

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

Table 8. LTAR experiment: Soybean pest insect populations.

Treatment	Bean Leaf Beetle	Thrips	Leaf hopper	Flies	Minute pirate bug	Spring tail	Tarnished plant bug	Grass hoppers	Northern corn rootworm	Flea beetle	Spider mite	Stink bug
Conv. C-S	0.25a	2.00a	0.25a	0.00a	0.50a	0.00a	0.00a	0.75a	0.00a	0.00a	0.00a	0.25a
Org. C-S-O/A	0.50a	0.50a	0.75a	1.25ab	0.25a	5.75a	0.50a	0.00a	0.00a	0.00a	0.25a	0.00a
Org. C-S-O/A-A	0.50a	0.75a	0.75a	3.25a	0.00a	10.25a	0.25a	0.25a	0.50a	0.25a	0.00a	0.00a
Org. C-S-C-O/A	2.00a	0.50a	1.25a	1.25ab	0.25a	0.50a	0.00a	0.00a	0.00a	0.25a	0.25a	0.00a
p value (α=0.05)	0.1558	0.6399	0.6681	0.0208	0.5174	0.0781	0.2476	0.2170	0.4262	0.5885	0.5885	0.4262

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

Table 9. LTAR experiment: Soybean beneficial and neutral insect populations.

Treatment	Lightning bug	Lace wing	Ground beetle	Ant	Ladybug (larva)	Spider	Flies	Minute pirate bug	Parasitic wasp	Damsel bug
Conv. C-S	0.00a	0.33a	0.00a	0.00a	0.25a	0.50a	0.00a	0.50a	0.00a	0.00a
Org. C-S-O/A	0.50a	0.00a	0.00a	0.00a	0.00a	0.75a	1.25ab	0.25a	0.50a	0.00a
Org. C-S-O/A-A	0.25a	0.25a	0.25a	0.25a	0.00a	0.50a	3.25a	0.00a	0.00a	0.00a
Org. C-S-C-O/A	0.00a	0.00a	0.00a	0.00a	0.00a	1.00a	1.25ab	0.25a	0.00a	0.25a
p value (α=0.05)	0.5519	0.5097	0.4262	0.4262	0.4262	0.6399	0.0208	0.5174	0.0728	0.4262

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

Soybean insect pest populations were relatively low with few statistical differences between the rotations. Pest insects included bean leaf beetles, thrips, leafhoppers, corn rootworm beetles, and stink bugs. Bean leaf beetle populations were equivalent across rotations (Table 8). The organic C-S-C-O/A rotation averaged two beetles/20 sweeps, with the other organic rotations and the conventional C-S rotation averaging one beetle/20 sweeps. Beneficial insects collected from these plots included spiders, parasitic wasps, ladybug larvae and lacewings, with spiders the most abundant, averaging one per plot (Table 9). There were no significant differences in beneficial insect populations between conventional and organic rotations.

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