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

Kathleen Delate—professor, Department of Horticulture

Henry Franzen—research assistant, Department of Horticulture

Randy Breach—agricultural specialist

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-S-C-O/A). Oat/alfalfa plots were field cultivated on April 1, 2021. On April 2, 'Hayden' oats were underseeded with 'Swift' alfalfa (Albert Lea Seed, Albert Lea, Minnesota) at a rate of 90 lbs. per acre and 15 lbs. per acre, respectively. Plots were cultipacked on the same day as planting. Following harvest of the organic corn plots in 2020, winter rye was no-till drilled at a rate of 75 lbs. per acre October 20, 2020.

Conventional corn plots were injected with 32% UAN April 20, at 150 lbs. per acre, and disked twice May 4 and 12, 2021. Plots were planted May 13, at 35,000 seeds per acre, and sprayed May 14 with CorvisTM at 5.6 oz. per acre, AtrazineTM at 1 qt per acre, and Round-upTM at 32 oz. per acre. Conventional corn plots were row cultivated June 22 to manage weeds that herbicides did not control. Conventional soybean plots were disked May 12. On May 13, plots were planted at 190,000 seeds per acre, and received applications of Authority Edge™ at 8 oz. per acre and Round-up™ at 32 oz. per acre. On July 1, plots were sprayed with Cobra™ at 12 oz. per acre and Volunteer™ at 8 oz. per acre. Plots were cultivated July 14 to manage weeds still emerging after herbicides.

Chicken manure (S.W. Iowa Egg Cooperative was applied at a rate of 3,105 lbs. per acre April 12 to organic C-SB-O/A and C-SB-O/A-A plots. On the same day manure was applied to C-SB-C-O/A plots at a rate of 1,290 lbs. per acre. The alfalfa and compost applied in the organic corn plots were plowed under April 22. Plots were disked May 4 and 12. Organic corn plots were rotary-hoed June 2 and 9, and row-cultivated May 25 and June 1. Corn and soybean variety selection and planting methods in 2021 were as follows: Viking 0.51-04GS (Albert Lea Seed, Albert Lea, Minnesota) corn was planted at a depth of 2.5 in. as untreated seed at a rate of 35,000 seeds per acre May 13, 2021. Soybean (29DC5, Blue River Hybrids, Ames, Iowa) was planted at a depth of 2 in. at a rate of 190,000 seeds per acre May 13.

Rye was disked twice in organic soybean plots May 4 and 12 before soybean planting May 13. Organic soybean plots were rotary hoed May 25 and June 1, and row-cultivated June 9, 16, and July 1. 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 July 16 and 17. There was a problem of weeds in conventional plots in 2021, 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 June 1 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 were counted June 23, and weeds were counted within square foot quadrats at three randomly selected areas within a plot. Soybean cyst nematode sampling occurred in all soybean plots October 5 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. 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, on October 18. Samples were transported on ice to the lab and then mailed to Midwest Labs in Omaha, Nebraska, for analysis.

Alfalfa was harvested by mowing, raking and baling, June 8, July 14, August 6, and September 9. Oats were combined with a plot combine July 28, then plots were mowed for straw August 2, and baled August 6. Soybean and corn plots were harvested September 29 and October 12, respectively. Grain samples were collected from each corn and soybean plot for grain quality analysis, which was conducted at the Grain Quality Laboratory.

Results and Discussion

The weather was challenging, with a cold, wet spring that continued with wet conditions in early summer (Table 1). Rainfall averaged 31.32 in. in 2021 compared with the 30-year average of 32.81 in. Temperatures were 1°F lower over the year compared with the 30-year average. Similar corn plant populations were observed between organic rotations, averaging 27,750 plants per acre June 23, compared with higher conventional corn populations of 31,583 plants per acre (Table 2). Grass weed populations were lower in the conventional and organic C-S-O/A rotations, compared with the other organic rotations (Table 2). Broadleaf weeds were lower in conventional and organic C-S-O/A-A plots compared with other rotations, suggesting greater weed prevention with longer organic rotations. Soybean plant populations were greater in the conventional C-S rotation, averaging 89,250 plants per acre, compared with an average of 58,860 plants per acre in the organic rotations (Table 3). Grass weeds were numerically similar across all rotations. Broadleaf weeds were lower in the conventional rotation compared with the organic rotations, except the organic C-S-O/A rotation had equivalent broadleaf weeds as the conventional rotation.

Soybean cyst nematodes averaged 62.50 eggs per 100 cc of soil in the C-SB-C-O/A rotation, with no statistical differences with other rotations, from which no SCN were recovered (Table 4). Stained soybean, representing damage from bean leaf beetle feeding, was not significantly different across all rotations in 2021, and was significantly lower than 2020, with an overall average of 4.16%.

Table 1. Precipitation and temperature averages, Neely-Kinyon Memorial Research and Demonstration Farm, Greenfield: 2019, 2020, 2021.

	Monthly precipitation (inches)				Average air temperature (°F)			
Month	2019	2020	2021	30-year average	2019	2020	2021	30-year average
January	1.06	1.17	1.26	0.86	19.34	23.34	24.56	22.07
February	1.98	0.08	0.72	1.21	15.70	26.86	12.59	26.09
March	2.51	2.88	3.11	2.07	30.65	41.15	43.50	38.96
April	0.88	2.40	0.92	3.85	50.55	47.32	49.12	50.64
May	8.68	3.22	4.56	5.10	56.66	57.85	58.89	61.37
June	3.92	2.25	4.88	4.75	69.27	73.2	72.90	71.19
July	1.15	3.51	6.66	3.98	74.98	75.16	73.00	74.92
August	6.97	0.35	2.58	4.22	69.90	72.94	73.68	72.99
September	5.76	2.57	1.08	3.83	68.97	62.73	66.30	65.68
October	6.14	1.89	5.55	2.93	47.82	47.29	54.81	53.19
Total seasonal precipitation and seasonal average air temperature	39.05	20.32	31.32	32.81	50.38	52.82	52.93	53.71

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

Treatment	Population (plants/acre)	Broadleaf weeds (plants/ft²)	Grass weeds (plants/ft²)
Conventional C-SB[x]	31,583a[y]	0.33a	0.17a
Org. C-SB-O/A	27,500c	1.00c	0.33b
Org. C-SB-O/A-A	27,083d	0.75b	2.17d
Org. C-SB-C-O/A	28,667b	1.75d	1.08c
p value (a=0.05)	0.0001	0.0093	0.0002

[x] Org.= Organic, C = corn, SB = 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: corn plant and weed populations.

Treatment	Stand (plants/acre)	Broadleaf weeds	Grass weeds (plants/ft²)
(plants/ft²)	Grass weeds	0.33a	0.17a
(plants/ft²)	27,500c	1.00c	0.33b
Conventional C-SB[x]	89,250a[y]	1.33a	0.50
Org. C-SB-O/A	60,250b	1.33a	1.25
Org. C-SB-O/A-A	56,500d	2.17b	1.25
Org. C-SB-C-O/A	59,833c	2.58c	1.08
p value (a=0.05)	0.0001	0.0187	0.1723

[x] Org.= Organic, C = corn, SB = 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).

Corn yields were greatest in the C-S-O/A-A rotation, averaging 176.78 bushels per acre, compared with 129.82 bushels per acre in the conventional C-S rotation (Table 4). The organic C-SB-O/A and C-SB-C-O/A rotations also were more productive than the conventional, with an average yield of 162.56 bushels per acre. The organic soybean yield in the C-S-C-O/A rotation (58.26 bushels per acre) was numerically higher than the conventional soybean yield (56.60 bushels per acre), which received multiple herbicides and cultivations (Table 4), representing a yield increase from longer rotations.

Oat yields were higher than previous years, with yields of 103.15 bushels per acre in the three-year rotation, and 120.49 bushels per acre in the four-year rotation (Table 5). Alfalfa yields, at 2.75 tons per acre, were similar to 2020's yields, which averaged 2.57 tons per acre. The June and September harvests were the highest, with an average of 0.88 ton. The July and August cuttings, at 0.50 ton per 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 $1,591.02 per acre in the Org. C-S-O/A-A rotation, compared with $755.55 per acre for conventional corn. Organic soybean could have been sold for $1,864.32 per acre in the Org. C-S-C-O/A rotation, compared with $710.90 per acre for conventional soybean.

Corn protein levels, at 7.93%, were greatest in the Org. C-SB-O/A-A rotation, compared with conventional corn, at 6.95% (Table 6). Over all organic rotations, average organic protein levels were 0.79% higher than conventional corn protein levels. The longer period between corn crops in the organic system meant an additional 0.18% in protein content, as evidenced by the 7.75% protein in the corn-intensive C-S-C-O/A rotation compared with 7.93% in the C-S-O/A-A rotation. Corn density was greater in the organic system, averaging 1.29 g per cc, compared with 1.23 g per cc in the conventional rotation. Corn starch was numerically higher in the conventional rotations, averaging 60.75%, compared with an average of 60.34% across the organic rotations. Oil content was highest in the C-SB-O/A rotation at 3.85%, followed by the C-SB-O/A-A and C-SB-C-O/A rotations, averaging 3.77%, compared with 3.53% in the conventional rotation.

Soybean protein levels were significantly higher in the organic rotations, with the C-SB-O/A-A rotation averaging 34.83%, followed by the C-SB-O/A and C-SB-C-O/A rotations averaging 34.77%, compared with 33.15% in the conventional rotation (Table 7). Soybean carbohydrate levels showed no significant differences between rotations, but were numerically greater in the conventional C-SB rotation, averaging 23.75%, compared

Table 4. LTAR experiment: corn and soybean yields, soybean cyst nematode populations, and stained soybean.

Treatment	Corn yield (bu./acre)	Soybean yield (bu./acre)	Soybean cyst nematodes (eggs per 100 cc soil)	Stained soybean (%)
Conventional C-SB[x]	129.82d[y]	56.60	0.00	2.67
Org. C-SB-O/A	167.51b	55.47	0.00	3.42
Org. C-SB-O/A-A	176.78a	55.63	0.00	6.65
Org. C-SB-C-O/A	157.61c	58.26	62.50	3.90
p value (a=0.05)	<0.0001	0.7631	0.4262	0.4994

[x] Org.= Organic, C = corn, SB = 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 5. LTAR experiment: Oat and alfalfa yields

Treatment	Average Yield (bu./acre)	Harvest date, tons per ac.			
		June 8	July 14	August 6	September 9
Org. C-SB-O/A[x]	103.15				
Org. C-SB-O/A-A	120.49	0.87	0.50	0.50	0.88

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

Table 6. LTAR experiment: corn grain quality.

Treatment	Moisture (%)	Protein (%)	Oil (%)	Starch (%)	Density (g/cc)
Conv. C-SB	16.43b[y]	6.95d	3.53d	60.75	1.23d
Org. C-SB-O/A	17.00c	7.75b	3.85a	60.35	1.30a
Org. C-SB-O/A-A	17.00c	7.93a	3.78b	60.15	1.29b
Org C-SB-C-O/A	16.08a	7.55c	3.75c	60.53	1.28c
p value (a=0.05)	0.0436	0.0300	0.0057	0.4142	<0.0001

[x] Org.= Organic, C = corn, SB = 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 (%)
Conventional C-SB[x]	10.98d[y]	33.15d	20.30a	4.80	23.75
Org. C-SB-O/A	11.33c	34.78b	19.13c	4.75	23.35
Org. C-SB-O/A-A	11.40b	34.83a	13.13d	4.75	23.30
Org. C-SB-C-O/A	12.65a	34.75c	19.20b	4.73	23.33
p value (a=0.05)	0.0330	0.0018	0.0002	0.4262	0.0502

[x] Org.= Organic, C = corn, SB = 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).

with an overall average of 23.33% in the organic rotations. Oil levels were greater in the conventional C-SB rotation, averaging 20.30%, followed by the organic C-S-C-O/A rotation, which averaged 19.20%. Fiber content showed no significant differences and averaged 4.80% in the conventional rotation, compared with the average of 4.74% across all organic rotations.

Soybean insect pest populations were relatively low in 2021, only showing statistical differences between rotations in rootworm beetles. Rootworm beetle populations were highest in the C-SB-C-O/A rotation, averaging 43 beetles per 20 sweeps. The other organic rotations had an overall average of 26 beetles per 20 sweeps, which was lower than the conventional rotation, which averaged 30 beetles per 20 sweeps. Bean leaf beetles averaged three beetles per 20 sweeps in conventional plots and showed no significant differences across the organic rotations, with an average of seven beetles per 20 sweeps (Table 8). Beneficial insects collected from these plots included spiders, lady bugs and lacewings, with lacewings the most abundant, at one per plot. There was no significant difference in beneficial insect populations between conventional and organic rotations.

Soil samples were taken post-harvest in the LTAR experiment to assess differences in soil properties across rotations (Table 9). There were no differences in organic matter across rotations, averaging 3.63%. Potassium levels were significantly higher in the C-SB-O/A and C-SB-O/A-A rotations, with an average of 245.13 ppm, compared with 171.88 ppm in the conventional rotation. Magnesium levels were highest in the C-SB-C-O/A treatment at 403.00 ppm, followed by the C-SB-C-O/A treatment at 357.13 ppm. Soil pH was numerically greater in organic treatments at an average of 6.97, compared with the conventional rotation at 5.95.

Table 8. Soybean insect populations in the LTAR experiment, 2021 (insect number/20 sweeps).

Treatment	Bean leaf beetle	Stink bug	Rootworm beetle	Flea beetle	Grasshopper	Flies	Tarnished plant bug	Weevil	Green clover worm	Spider	Army worm	Lady bug	Lace wing
Conv. C-SB	2.50	0.50	29.50c	0.75	2.25	8.50	1.00	0.00	0.25	0.00	0.00	0.25	0.00
Org C-SB-O/A	6.50	0.50	17.25d	0.25	2.75	7.00	0.25	0.25	0.50	0.00	0.00	0.00	0.25
Org C-SB-O/A-A	6.00	1.00	33.75b	0.75	1.75	6.75	0.25	0.50	0.25	0.25	0.25	0.00	0.25
Org C-SB-C-O/A	8.25	1.25	42.75a	1.25	3.75	5.25	0.50	0.00	0.00	0.50	0.00	0.00	1.00
p value (a=0.05)	0.4292	0.4262	0.0450*	0.6181	0.2906	0.6745	0.5667	0.2476	0.5174	0.5519	0.4262	0.4262	0.1029

[x] Org.= Organic, C = corn, SB = 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. Soil analysis from the LTAR plots, Neely-Kinyon Memorial Research and Demonstration Farm.

Treatment	Organic matter (%)	P1 (weak Bray) (ppm)	P2 (strong Bray) (ppm)	K (ppm.)	Mg (ppm)	Ca (ppm).	Na (ppm.)	Soil pH	Cation exchange capacity (meq/100g)	K (% saturation)	Mg (% saturation)
Conv. C-SB	3.68	8.50d	12.75d	171.88d	310.75c	2652.25d	9.63d	5.95d	19.59	2.24d	13.18d
Org. C-SB-O/A	3.63	44.75a	89.08a	254.25a	305.92d	3223.00b	14.33b	7.15a	19.59	3.33a	14.00c
Org. C-SB-O/A-A	3.60	37.19b	78.25b	236.00b	357.13b	3327.44a	16.44a	6.96b	20.28	3.01b	14.62b
Org. C-SB-C-O/A	3.59	23.50c	38.13c	179.63c	403.00a	3203.00c	14.25c	6.79c	20.24	2.31c	16.56a
p value (a=0.05)	0.8943	<0.0001	<0.0001	<0.0001	0.0154	<0.0001	0.0066	<0.0001	0.5771	<0.0001	<.0001*

[x] Org.= Organic, C = corn, SB = 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).

Treatment	Ca (% saturation)	H (% saturation)	Na (% saturation)	Surface N (ppm.)	S (ppm.)	Zn (ppm.)	Mn (ppm.)	Fe (ppm.)	Cu (ppm.)	B (ppm.)	Soluble salts (mmhos./cm.)
Conv. C-SB	67.75d	16.64a	0.20d	10.88	4.38d	0.88d	7.88a	55.38a	0.88b	0.20c	0.20d
Org. C-SB-O/A	81.53b	0.00c	0.31b	9.00	6.00b	2.08a	2.92d	34.17d	0.78d	0.30b	0.30a
Org. C-SB-O/A-A	82.03a	0.00c	0.34a	10.56	6.69a	1.98b	3.63c	37.38b	0.84c	0.31a	0.28b
Org. C-SB-C-O/A	79.10c	1.73b	0.30c	9.25	5.50c	1.35c	3.75b	36.88c	0.89a	0.30b	0.26c
p value (a=0.05)	<0.0001	<0.0001	0.0028	0.8052	0.0019	<0.0001	<0.0001	<0.0001	0.0340	<0.0001	0.0334

[x] Org.= Organic, C = corn, SB = 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).

Acknowledgements

We would like to thank the Leopold Center for Sustainable Agriculture and the Iowa Nutrient Research Center for support of the Neely-Kinyon LTAR site. Thanks also go 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 ISU 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.