2012

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

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Abstract
The Neely-Kinyon 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-SO/A), organic Corn-Soybean-Oats/AlfalfaAlfalfa (C-S-O/A-A) and Corn-SoybeanCorn-Oats/Alfalfa (C-SB-C-O/A). On April 13, 2011, Badger oats were underseeded with BR Goldfinch alfalfa at a rate of 90 lb/acre and 15 lb/acre, respectively. Following harvest of the organic corn plots in 2010, winter rye was no-till drilled at a rate of 75 lb/acre on October 20, 2010.

Keywords
RFR A11105, Horticulture, Agronomy

Disciplines
Agriculture | Agronomy and Crop Sciences | Horticulture

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Materials and Methods

The Neely-Kinyon 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 Corn-Soybean-Corn-Oats/Alfalfa (C-SB-C-O/A). On April 13, 2011, Badger oats were underseeded with BR Goldfinch alfalfa at a rate of 90 lb/acre and 15 lb/acre, respectively. Following harvest of the organic corn plots in 2010, winter rye was no-till drilled at a rate of 75 lb/acre on October 20, 2010.

Conventional corn plots were injected with 32 percent UAN on May 10, 2011, at 140 lb N/acre. Chicken manure was applied to organic corn plots at a rate of 4.6 tons/acre on April 25. Corn and soybean variety selection and planting methods in 2011 were as follows: Blue River 57H36 corn was planted at a depth of 1.75 in. as untreated seed at a rate of 32,000 seeds/acre in the organic plots and as treated seed in conventional plots, on May 19, 2011. Blue River 29AR9 soybeans were planted at a depth of 2 in. in organic and conventional plots at a rate of 200,000 seeds/acre on May 19, 2011. Conventional corn plots were sprayed with a pre-emergence herbicide on May 24 with 1.5 oz/acre of Balance Pro™, 1 lb/acre of atrazine, and 32 oz/acre of Roundup™. Conventional soybeans received an application of 1 oz/acre of Encompass™, 2 lb/acre AMS, and 32 oz/acre Roundup™ on May 24, and 6 oz/acre of Arrow™, 0.5 oz/acre Classic™, 2 lb/acre AMS and crop oil as a post-emergence herbicide on July 5, 2011.

Soil in corn plots was sampled on July 11, 2011 and analyzed for late-spring nitrate content by the Iowa State University Soil and Plant Analysis Laboratory, Ames, Iowa. Fall soil samples were taken on October 30 for soil quality analysis.

All organic soybean plots were rotary hoed on May 30 before emergence and on June 2 and June 6. All organic soybean plots were cultivated on June 15, June 20, and June 29. Each organic soybean plot was “walked” (hand weeded) once for large weeds from August 1–20. Organic corn plots were rotary hoed on May 30, June 2, and June 6, and cultivated on June 15 and June 20. Corn and soybean stands were counted on June 17. Weed counts were enumerated in corn and soybean plots on June 17, using square meter quadrats at three randomly selected areas within a plot. Soybean plots were sampled for insects on August 15 by sweeping plots 20 times with a 15-in. diameter net, placing contents in a Ziplock™ bag, and freezing until identification was completed. Corn stalk nitrate samples were collected on September 29, and soybean cyst nematode sampling was completed on November 10. Corn stalk nitrate analysis was conducted at the Iowa State University Soil and Plant Analysis Laboratory, Ames, Iowa, and nematode

analysis was conducted at the ISU Plant Disease Clinic (Ames, IA).

Alfalfa was baled on June 6, July 9, August 1, and September 11. Oat grain was harvested on July 19. Plots were mowed on September 6, and straw baled on September 11. Soybean plots were harvested on October 4. Corn plots were harvested on October 24. 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

In the corn plots on June 17, 2011, plant populations were similar in the conventional C-S and organic rotations at 31,896 plants/acre (Table 1). Grass and broadleaf weed populations (0.02 and 0.75 weeds/sq ft, respectively) were similar in corn plots in the conventional and the organic C-S-O/A rotation (Table 2). There were higher numbers of grass weeds (3.52 and 4.75 weeds/sq ft, respectively) in the C-S-O/A-A and the new rotation of C-S-C-O/A, which replaced the old S-W/RC rotation, where weed populations became more of a problem over the years. In soybean plots (Table 2), the conventional rotation had the lowest amount of grass and broadleaf weeds (0.13 and 0.21 weeds/sq ft, respectively), with the grass weeds in the organic C-S-O/A and C-S-O/A-A rotations significantly greater than the conventional C-S rotation at 2.61 and 1.12 weeds/sq ft, respectively. Broadleaf weeds in the C-S-O/A and C-S-O/A-A soybean plots, averaging 0.08 weeds/sq ft, were not significantly different, but were greater than the conventional C-S rotation. Late-spring nitrate levels averaged 4.75 ppm NO_3-N across conventional and organic plots, which is considered low compared with previous years but could be the result of high levels of rainfall (Table 2). Conventional corn and C-S-O/A plots had higher levels of soil nitrate (7.25 and 4.75 ppm, respectively) compared with the other two organic rotations.

Despite high levels of weeds and challenging weather, organic corn yields averaged 160 bushels/acre in 2011, and were equivalent across all rotations (Table 1). The C-S-C-O/A rotation produced numerically lower yields (152 bu/acre) compared with the other organic rotations (averaging 163 bu/acre). Only the conventional corn had a luxury level of nitrogen at the end-of-season (6,243 ppm) compared to an average of 1,553 ppm in the organic rotations (Table 2).

Soybean plant stands averaged 147,667 plants/acre in conventional plots, but were lower in organic plots, averaging 110,167 plants/acre, possibly due to rotary hoeing operations (Table 1). Organic soybean yields averaged 39 bushels/acre (Table 1). The organic three-year rotation and the organic four-year rotation soybean yields, at 37 and 41 bushels/acre, respectively, were statistically equivalent to each other but statistically lower than the conventional two-year rotation yields. A delay in “walking” (hand weeding) soybean plots caused an excess of weeds in 2011 organic soybean plots. Small grain yields were impacted by extended periods of wet weather in 2011. Oats yielded 82 bushels/acre of grain in the organic C-S-O/A rotation and the organic C-S-O/A-A rotation, but were significantly lower (67 bu/acre) in the organic C-S-C-O/A rotation (Table 1). There was an average of 1.6 tons/acre of oat straw, with the organic three-year rotation yielding significantly more straw (1.9 tons/acre) than the other two organic rotations. Alfalfa yielded an average of 4.3 tons/acre. Soybean cyst nematodes were not found in 2011 across all rotations (Table 2).

Corn grain quality was affected by the poor weather conditions in 2011. Corn density

averaged 1.26 percent across all rotations, but the conventional corn was significantly lower at 1.25 percent than the organic rotations, which averaged 1.26 percent (Table 3). No significant difference was observed in corn grain oil content, averaging 3.8 percent across all rotations. Protein levels were equivalent between conventional and C-S-O/A corn (averaging 7.15%), but were lower in the other two organic rotations (Table 3). Soybean carbohydrate levels (24.2%) and oil levels (17.6%) were similar across all rotations (Table 3). Protein levels were also equivalent among rotations at 35.4 percent (Table 3). Oat protein averaged 10.4 percent in 2011 (Table 3).

There was limited damage from corn borer populations in 2011, with an average of <1 plant showing damage in the C-S-O/A-A rotation (Table 4). Other corn and soybean insect pests included corn rootworms, aphids, bean leaf beetles, and thrips. Aphid numbers were very low, averaging 1 aphid per 20 sweeps (Table 4), with no difference between rotations. Bean leaf beetle numbers were higher than 2010 and 2009, with populations averaging 20 beetles per 20 sweeps, compared with an average of 1 beetle per 20 sweeps in the previous two years. Thrips were lower in organic plots, averaging 25 per 20 sweeps, compared with 54 in conventional plots. Corn rootworm beetles were observed on soybean plants in 2011 at low populations (averaging less than 2 beetles per 20 sweeps in the C-S-C-O/A rotation). Beneficial insects included minute pirate bugs (MPB) and spiders and were in larger numbers in 2011 than in 2010. Total beneficial insects averaged 20 per 20 sweeps with a trend towards higher numbers in the organic rotations, which averaged 23 per 20 sweeps. There was a trend towards greater MPB in the organic rotations (averaging 12 per 20 sweeps) compared with 9 MPB in the conventional soybean plots (Table 4). Spiders averaged 4 per 20 sweeps across all rotations. Soybean staining averaged 1.6 percent across all rotations, with no differences between treatments.

Acknowledgements

We would like to thank the Leopold Center for Sustainable Agriculture for their support of the Neely-Kinyon LTAR site. We also thank the Wallace Foundation for their input and support. Thanks also to Bernie Havlovic, Randy Breach, Ning Wang, Ryan Rice, Grace Wang, Evan Duyvejonck, Ben Offenburger, Joshua Petersen, Elease McLaurin, Luke Gray, and Peggy Johnson for their help in production, data collection, and analytical aspects of this project. We also thank Charles Hurburgh and Glen Rippke of the ISU Grain Quality Lab, Kerry Culp of the ISU Soil and Plant Analysis Lab, and Blue River Hybrids for their support.

Table 1. Grain crop performance in Neely-Kinyon LTAR.

	Corn		Soybean		Oat			Alfalfa	
Rotation	Yield (bu/ac)	Population (plants/ac)	Yield (bu/ac)	Population (plants/ac)	Yield (bu/ac)	Straw (tons/ac)	Plant density (g/ft^2)	Yield (tons/ac)	Plant density (g/ft^2)
Conv. C-S [z]	169.3	32,250	48.3a	147,667a	N/A	N/A	N/A	N/A	N/A
Org. C-S-O/A	164.0	32,000	37.3b	113,750b	82.0a	1.91a	9.28a	N/A	N/A
Org. C-S-O/A-A	162.7	31,333	41.4b	106,583b	82.3a	1.63b	8.69a	4.31	48.3
Org. C-S-C-O/A	152.6	32,000	--- [x]	---	67.4b	1.29c	5.91b	N/A	N/A
LSD $_{0.05}$	NS [y]	NS	5.62	14,087	8.43	0.19	1.77	N/A	N/A

[z]C = corn, S = soybean, O = oat, and A = alfalfa.
[y]Means within a column are not significant (NS), or significant at P≤0.05 (Fisher's protected LSD test) if followed by different letters.
[x]Soybean not grown in rotation in 2011.

Table 2. Weed and nematode populations and soil nitrate content in Neely-Kinyon LTAR.

	Corn weeds (plants/ft^2)		Soybean weeds (plants/ft^2)		Soybean	Corn	
	June 17, 2011		June 17, 2011				
Rotation	Grasses	Broadleaves	Grasses	Broadleaves	Cyst nematodes (eggs/100cc)	Stalk nitrate (µg µg^{-1} N-NO$_3$)	Soil nitrate (µg µg^{-1} N-NO$_3$)
Conv. C-S	0.02b	0.05c	0.13c	0.21a	0.00	6,243a	7.25a
Org. C-S-O/A	0.75b	0.07bc	2.61a	0.09b	0.00	1,391b	4.75ab
Org. C-S-O/A-A	3.52a	0.30ab	1.12b	0.07b	0.00	105.5b	3.75b
Org. C-S-C-O/A	4.75a	0.39a	--- [y]	---	0.00	52.80b	3.25b
LSD $_{0.05}$	2.57 [z]	0.27	0.93	0.10	NS	2,308	2.63

[z]Means within a column are not significant (NS), or significant at P≤0.05 (Fisher's protected LSD test) if followed by different letters.
[y]Soybean not grown in rotation in 2011.

Table 3. Grain quality in Neely-Kinyon LTAR corn and soybeans.

	Corn					Soybean				
Rotation	Density (%)	Starch (%)	Oil (%)	Protein (%)	Moisture (%)	Carbos (%)	Fiber (%)	Oil (%)	Protein (%)	Oat protein (%)
Conv. C-S	1.25b	60.85c	3.85	7.20a	16.60	23.87	4.86	17.28	36.00	N/A
Org. C-S-O/A	1.27a	61.00bc	3.83	7.10a	16.05	24.09	4.89	17.50	35.53	10.3
Org. C-S-O/A-A	1.27a	61.43ab	3.73	6.88a	16.15	24.53	4.94	17.90	34.63	10.4
Org. C-S-C-O/A	1.25b	61.83a	3.78	6.23b	16.33	---[y]	---	---	---	N/A
LSD $_{0.05}$	0.01[z]	0.53	NS	0.51	NS	NS	NS	NS	NS	N/A

[z]Means within a column are not significant (NS), or significant at P≤0.05 (Fisher's protected LSD test) if followed by different letters.
[y]Soybean not grown in rotation in 2011.

Table 4. Pest and beneficial insects in corn and soybean, Neely-Kinyon LTAR (number per 20 sweeps).

	Corn	Soybean							
Rotation	Corn borer damage	Aphids	Bean leaf beetles	Thrips	Corn rootworm beetles	Minute pirate bugs	Spiders	Total beneficial insects	Staining (%)
Conv. C-S	0.00	1.50	11.50	53.67a	0.00b	8.75	3.00	14.5	1.83
Org. C-S-O/A	0.00	0.75	22.75	26.98b	0.00b	11.50	5.50	23.25	1.89
Org. C-S-O/A-A	0.08	0.75	24.25	22.17b	1.50a	11.75	4.75	23.50	1.16
Org. C-S-C-O/A	0.00	---[y]	---	---	---	---	---	---	---
LSD $_{0.05}$	NS	NS	NS	20.72	1.19	NS	NS	NS	NS

[z]Means within a column are not significant (NS), or significant at P≤0.05 (Fisher's protected LSD test) if followed by different letters.
[y]Soybean not grown in rotation in 2011.