Agroecosystem Performance at the Neely-Kinyon Long-Term Agroecological Research (LTAR) Site

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Beginning in 1998, Iowa State University set out to develop research-based recommendations for suitable crop rotations that provide high yields, grain quality, and adequate soil fertility during the transition to organic production and beyond certified status. Information gained from Focus Groups was used to define the cropping systems that were established at the Iowa State University Neely-Kinyon Long-Term Agroecological Research (LTAR) site in Greenfield, Iowa. The predominant soil at the LTAR site is a moderately well-drained Macksburg silty clay loam (fine, smectitic, mesic Aquic Argiudolls). The experimental site is located on a 17-acre ridge top with a uniform slope of 0 to 2%. Research plots are 70 ft. x 140 ft. in size. The experimental design is completely randomized with four replications of four different cropping system treatments and all crops in all rotations are planted each year of the experiment. Cropping system treatments consist of the following crop rotations: conventional corn (*Zea mays* L.)–soybean [*Glycine max* (L.) Merr.] (C-S); organic corn–soybean–oat (*Avena sativa* L.)–alfalfa (*Medicago sativa* L.) (C-S-O/A); organic corn-soybean-oat/alfalfa-alfalfa (C-S-O/A-A), and organic soybean-rye (*Secale cereale* L.) or wheat (*Triticum aestivum* L) (S-R or S-W). Following harvest in all organic corn plots, winter rye is planted as a winter cover crop and weed management strategy, per local practices on organic farms. From 1998 to 2000, winter rye followed soybean harvest in the fourth cropping system treatment (S/R), but the rye was destroyed the following spring and soybean planted again. In 2001, the rye component was replaced with winter wheat and a frost-seeding of crimson clover (*Trifolium incarnatum* L.) (S-W/CC) and the wheat was taken to harvest the following growing season. This change in crop rotations was initiated in order to gain organic certification in 2000. When the experiment was established in 1998, the S/R system was permitted on organic farms, but new organic certification rules in 2000 required that a second crop in the rotation be grown an entire season, thus disqualifying the winter rye component as a complete crop year. Identical crop varieties were planted in organic and conventional systems each year, including food-grade soybean to provide the most economical returns. A hay crop [alfalfa, red fescue (*Festuca rubra* L.) and oat] was seeded in 1998 in the 30-ft. strips around each plot and around the perimeter of the experiment to maintain the required buffer between the certified organic and conventional plots.

The entire experimental area was moldboard plowed, disked and field cultivated to prepare a seedbed at the initiation of the experiment in May 1998. Crop varieties are determined on an annual basis, based on the Neely-Kinyon Farm Association's recommendations for varieties with desired market traits. Varieties are changed annually as improved varieties for yield or pest resistance became available. Identical crop varieties and planting dates were used in all treatments each year to minimize initial differences between systems. Corn varieties included Pioneer 34W67 in 2000 and 2001, 34M94 in 2002 and 2003, and 34D71 in 2004. 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 as soon as sufficient ground temperatures were obtained after May 1 (planting dates ranged from May 4 to May 28). Rye ('Rhymin') was no-till drilled at a rate of 1 bu/acre as a winter cover crop and weed management strategy in all organic corn plots in the fall of each year. Soybean varieties were Pioneer 9305 in 2000, Northrup-King 2412 in 2001 and 2002, and Schillinger 240F.Y in 2003 and 2004. Soybean seeds were planted at a 2-in. depth in organic and conventional plots at a rate of 175,000 to 190,000 seeds/acre over the course of the experiment. Planting dates ranged from to May 15 to June 16 when soybeans had to be re-planted after flooding in 2001. The O/A component of the organic rotations were oats underseeded with Pioneer 54H91 leafhopper-tolerant alfalfa at a depth of 0.5 in. at a rate of 3.5 bushels/acre and 18 lb/acre, respectively. Wheat was fall-planted at 90 lb/acre and red clover was frost-seeded into the wheat plots in March at a rate of 15 lb/acre. Alfalfa in the O/A component of the C-S-O/A rotation remained as a cover throughout the winter of its seedling year and was disked under the following spring, prior to corn planting. Oat varieties included Jerry, Don, Blaze and Reeves, and wheat varieties included Arapahoe and Wesley over the course of the experiment. Alfalfa varieties included 'Nitro', Pioneer 53H81 and 54H69, the latter varieties selected for tolerance to potato leafhopper [*Empoasca fabae* (Harris)]. Alfalfa was harvested each year from all A plots when sufficient alfalfa biomass accumulated, while the underseeded alfalfa in the O/A component was left unmowed to supply maximal nitrogen to the succeeding corn crop. Alfalfa yields are reported as total amount of hay cut from each plot per year.

Compost (local hoop-house swine manure) was applied at a rate of 12 tons/acre to organic corn plots a month before planting in April and at 4 tons/acre to oat plots in the spring. Average nutrient content of the compost was 7.8, 9.6, and 13.7 g kg^{-1} N, P, and K, respectively, over the course of the experiment. Conventional corn plots were fertilized in May with 28% urea at 140 lb/acre N. Soil in corn plots was sampled for late spring nitrate and all plots were sampled in the fall of each year for soil quality parameters. Conventional corn and soybean plots were treated with synthetic herbicides, such as Balance™, Prowl™, Pursuit™, and Select™ in May and June of each year, according to ISU recommendations, while organic corn plots were harrowed (once), rotary hoed (one to two times) and cultivated (one to two times) from May to June, depending on weather conditions and weed populations. Before harvest, large weeds above the soybean canopy were hand-pulled while walking across each plot, per regional practices for organic soybean crops. Stand counts were taken, along with weed counts, using square meter quadrats at three randomly selected areas within a plot. Corn borer populations were monitored when corn plants were at V-6 to V-8 stage. Soybean plots were sampled for bean leaf beetles two to three times from July to September. Soybean cyst nematode sampling was conducted in September by collecting 1 pint of soil from each soybean plot to a 6-inch depth. Samples were analyzed for SCN populations at the Plant Disease Clinic at ISU. Corn stalk nitrate sampling was conducted each year 3 wk before harvest and analyzed in the Iowa State University Agronomy and Horticulture Plant Analysis Laboratories, Ames, Iowa. Oat, corn, wheat and soybean grain was harvested using a field-scale combine. Alfalfa was mowed and raked to dry to proper storage moisture (less than 20%) in the field. When adequately dried (averaging 15% moisture), alfalfa was baled using a field-scale baler and bales were individually weighed. Oat straw was baled when dry (averaging 12% moisture) and removed from the plot area each year. Three randomly collected 2-pint corn and soybean grain samples were collected at harvest from each plot. Compositional analysis was conducted at the Iowa State University Grain Quality Laboratory, Ames, Iowa, using a Foss Infratec Model 1229 analyzer (Eden Prairie, MN) to determine grain quality. All data were subjected to analysis of variance (Proc ANOVA). Means were separated using Fisher's PLSD test at $P \leq 0.05$ (SAS, 1992).

Results from the first seven years of the Neely-Kinyon LTAR show no significant differences between organic and conventional corn yields when organic corn follows two years of alfalfa. Organic soybean yields were consistently equal to conventional yields in all rotations in all years. In the three years of transitioning and obtaining certified organic status (1998–2000), and in the fourth year following a full rotation of organic corn (*Zea mays* L.)–soybean [*Glycine max* (L.) Merr.]–oat (*Avena sativa* L.), and alfalfa (*Medicago sativa* L.) (2001), corn yield in the organic system (C-S-O/A and C-S-O/A-A rotations) was 91.8% of conventional corn yield in the C-S rotation. Soybean yield in the organic system (C-S-O/A, C-S-O/A-A and S/R) was 99.6% of conventional soybean yield. In 2002, organic corn yields were significantly greater after a full year of alfalfa (171 bu/acre) compared to the organic C-SB-O/A rotation (161 bu/acre). Soybean yields were highest in the C-SB-O/A and C-SB-O/A-A organic plots, averaging 47 bu/acre. Organic oat and wheat yields averaged 116 bu/ac and 69 bu/acre, respectively. The drought during late summer 2003 affected both corn and soybean yields, but particularly soybeans. Organic corn yields averaged 119 bushels/acre and organic soybean yields averaged 33.7 bushels/acre. There were no significant differences between organic corn yields in the rotation with two years of alfalfa (C-S-O/A-A) and the conventional C-S rotation. There was no significant difference between organic and conventional soybean yields. Organic soybean protein content averaged 37.6% compared with 37.0% in the conventional soybeans. The sixth year of organic production (2003) marked the first year that significantly greater protein content was found in the organic soybeans.

Over the course of the experiment there were significantly fewer grass and broadleaf weeds in the conventional C-S plots compared to organic plots, but limited effect on yield was observed due to weed populations. Late-spring nitrate levels in organic corn plots were generally reduced compared to the conventional plots, as was corn stalk nitrate at season's end. Insect pest populations were generally equal among rotations, with the exception of 2002, when a significantly lower average bean leaf beetle population was observed in the organic C-S-O/A-A plots. Corn borers were not a problem in any year of the study. Soybean cyst nematodes were consistently below economic threshold levels over the course of the experiment, with no significant differences among treatments.

Publications Resulting From This Work

Delate, K. and C. Cambardella. 2004. Agroecosystem performance during transition to certified organic grain production. Agronomy Journal 96: 1288–1298.

Delate, K., C. Cambardella, and D. Karlen. 2002. Transition strategies for post-CRP certified organic grain production. Published 28 August 2002. Crop Management www.plantmanagementnetwork.org/pub/cm/research/postcrp/