Comparison of Organic and Conventional Corn, Soybean, Alfalfa, Oats, and Rye Crops at the Neely-Kinyon Long-Term Agroecological Research (LTAR) Site-1999

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Introduction

Sales of organic products are expected to reach $6 billion industry in the U.S. in the year 2000, showing a continued 20% annual growth rate. In Iowa alone, organic acreage for all crops has increased from 13,000 in 1995 to 120,000 in 1998. The Leopold Center for Sustainable Agriculture has identified the need for dedicated lands throughout Iowa where research on organic practices can be conducted over the long term. Soil health, maintained through crop rotations, organic matter additions (manure/compost), and cover crops, has been the basis of successful organic farming. Theoretically, comparable yields to conventional systems can be obtained once the transition to organic production is complete. In 1998, the first year of the Neely-Kinyon (N-K) Long-Term Agroecological Research (LTAR) experiment, organic corn and soybean yields were similar to conventional yields. In addition, organic products garner a 20-300% premium price in the marketplace, with organic clear-hilum soybeans averaging twice to three times the price of conventional clear-hilum soybeans in 1999. In the second year trials at the N-K LTAR site, we continued our examination of the agronomic and economic performance of conventional and organic systems, using required practices for certified organic production.

Materials and Methods

Experimental Design. The Neely-Kinyon Farm Association has dedicated a 17-acre block for this long-term study. Treatments were assigned in 1998 in a completely randomized statistical design to the forty, quarter-acre plots constituting the experiment. Treatments include the following: Conventional Corn-Soybean rotation; organic Corn-Soybean-Oats (with alfalfa); organic Corn-Soybean-Oats (with alfalfa)-Alfalfa; and organic Soybean-winter Rye (winter rye plowdown in the spring prior to soybean planting each year). All crops in all rotations are planted each year. While the final treatment (soybean-rye) is currently prohibited by certain certification agencies, many farmers are interested in using this rotation in order to continue production of the most lucrative organic crop, clear-hilum soybeans. An adjunct to this study will be the identification of problems associated with this rotation.

Planting Scheme. The planting scheme adopted for this experiment in 1999 was as follows: Wilson 1790W corn was planted at a depth of 1.75 in at a rate of 28,000 seeds/acre on May 27, 1999. A white milling corn variety was selected for 1999 based on requests from farmers who were interested in growing corn for the food-grade market. Soybeans ('IA 2034') were planted at a depth of 2 in at a rate of 175,000 seeds/acre on May 28. Oats ('Jerry') were underseeded with alfalfa (Pioneer 54H69 alfalfa, a potato leafhopper-tolerant variety) at a depth of 0.5 in at a rate of 2.5 bu/acre and 12 lb/acre, respectively, on March 31, 1999. Following harvest in the organic corn (C-SB-O/A and C-SB-O/A-A) plots and in the soybean-rye (SB-R) plots in 1998, winter rye was no-till drilled at a rate of 1 bu/acre on October 26, 1998, per local practices on organic farms. A hay crop (alfalfa, fescue and oats), seeded in 1998 in the 30-ft border strips around each plot and around the perimeter of the experiment, was periodically mowed and maintained as the required buffer between conventional and organic production, per certification standards.

Fertilization Scheme. The fertilization goal in this study was to apply equal rates of nutrients in each treatment. Fertilization rates were adjusted in each plot, based on nitrogen additions from the previous crop (i.e., alfalfa). Organic plots were fertilized to provide approximately 70 lb/acre N to oat plots on March 31 and 120 lb/acre N to corn plots on April 21, using a manure spreader to apply hoop-house compost from the ISU Armstrong Research and Demonstration Farm. The analysis of this compost averaged 1.74, 0.65 and 3.06% N, P, and K, respectively. This compost consisted of deep-bedded swine manure mixed with corn stalks and straw, which was turned, and stored for one year prior to application, in keeping with certified organic standards. Conventional corn plots (in the C-SB rotation) were fertilized with 28% urea at a rate of 120 lb/acre N on May 26.

Pest Management and Sampling. The following pest management applications were made in the 1999 season, according to local practices. Force® 1.5 G was applied for extended diapause corn rootworm control at a rate of 9 lb/acre at planting in the conventional corn plots. Herbicides included Harness® applied on May 26 in the conventional corn plots at a rate of 2.5 pt/A and Atrazine® at 2.0 pt/acre. Accent® was applied at 0.67 oz/acre and Buctril® at 1 pt/A on June 15. In the conventional soybean plots, Prowl® was applied at a rate of 3 pt/acre on May 26; Prestige® and Galaxy® were applied at a rate of 2 pt/acre on June 21.

Because of the wet weather, additional mechanical tillage operations were conducted in the organic plots in the 1999 season. Organic corn plots were rotary-hoed on June 3, 9, and 25, and cultivated on June 7 and 18 and on July 6. A propane flame-burner was used on July 9 in the corn plots. Because soybeans were clear-hilum varieties for the tofu market, plots were hand-weeded (walked) on July 8 and August 3, to remove any remaining weeds from plots. Quality in tofu beans is equated with clean seed, free of weed seeds.

Weed counts were taken on June 17 and July 7 in the corn and soybean plots on 30 feet of row at three randomly selected areas within a plot to mitigate the extent of variability in weed counts. Crop staging also occurred on June 17 for corn and soybeans. We monitored for corn earworm populations on August 31 by sampling the ear of three plants per plot and recording presence of corn earworm larvae and damage. We sampled for soybean cyst nematode on September 21 by collecting 1 pint of soil (four cores) from each soybean plot to a 6 in depth. Samples were then analyzed for SCN egg populations at the Plant Disease Lab at ISU.

Soil Health Indicators. Soil sampling occurred (six samples to a 6 in depth) on November 11, 1998, and on April 21, 1999, at pre-plowing. Post-harvest soil sampling occurred on November 12, 1999. Five intact soil cores, 7.5 cm in diameter, were collected to a depth of 0-7.5, 7.5-15 and 15-30 cm from randomly located points in each of the 40 plots in the April and November sampling. Soils were analyzed for carbon, nitrogen and key elements of soil health, according to the methods of Cambardella and Elliott (2).

Plant Performance Indicators. Stalk nitrate sampling (corn) occurred on October 15 by following the methods described by Blackmer and Mallarino (1). All tissue samples were analyzed in the ISU Agronomy Plant Analysis Labs. Oats were harvested in three random 6 x 8 ft sections in each plot, using a small combine. Samples were bulked on a per-plot basis for analysis. Whole plots were combined on July 19, and straw square-baled on July 21. Alfalfa was harvested on June 3and July 11. Corn and soybeans were harvested on October 15, using a combine with a built-in scale. Samples were collected from each plot for grain analysis.

Corn grain quality analyses for protein, oil and starch was conducted at the ISU Grain Quality Lab for each corn and soybean plot. Oats were evaluated for protein content only.

Results and Discussion

Plant Performance. Second-year results from the Neely-Kinyon LTAR site were very encouraging for organic soybean production. As seen in the first year production (1998), there were no statistically significant differences between the organic (average of 47 bushels/acre) and conventional soybean yields (average of 48 bushels/acre) (P=.05) (Table 1). Because of the wet weather, mechanical cultivation for weed control did not occur under appropriate conditions in the early growing season, which particularly affected organic corn survival and yields. Organic corn yields averaged 121 bushels/acre compared with conventional corn at 161 bushels/acre. The greatest organic white corn yield was 134 bushels/acre. Several factors may have been involved in the reduction of organic corn yields: it is known that white corn varieties can produce less corn yield than conventional feed varieties; untimely cultivation lowered crop stand and subsequent yields (see Crop Stand results below), and/or the greater activity of soil-seed pathogens in the wet soil may have created an advantage for the treated corn seed in the conventional plots compared with the untreated organic seeds in the organic plots.

Table 1. Yield analysis from organic vs. conventional corn and soybeans, 1999.

Treatment	Rotation	Yield Bu/A	Standard Error
Conventional Corn	C-SB	160.6*	1.03
Organic Corn	C-SB-O	121.8	6.60
Organic Corn	C-SB-O-A	120.3	2.08
Ave. Conventional Corn		160.6	
Ave. Organic Corn		121.1	

Conventional soybeans	SB-C	48.4	1.11
Organic Soybeans	SB-O-C	45.3	1.21
Organic Soybeans	SB-O-A-C	48.4	0.86
Organic Soybeans	SB-R	46.8	1.46
Ave. Conventional Soybeans		48.4	
Ave. Organic Soybeans		46.8	

*There were no statistically significant differences in soybean yields; corn differed by 12.93 (LSD), P=.05).

Rotations:

Rotations:	C-SB	Corn-Soybean
	C-SB-O	Corn-Soybean-Oat (with alfalfa)
	C-SB-O-A	Corn-Soybean-Oat (with alfalfa)-Alfalfa
	SB-R	Soybean with Rye plowdown

Organic oat yields averaged 85 bushels/acre, and 1.78 tons of straw/acre. Because of the excessive rainfall during the growing season, the test weight of the oats was less than required for food-grade milling (36 lb/bushel). The organic oats test-weighed 32.7 lb/bushel before screening (organic farmers usually screen oats to remove unfilled oats and increase test-weight), which reflected averages in the Greenfield area. The average protein content of the oats was 12.4%, a good level for food-grade oat products (Iowa Oat Mills, Chelsea, IA). Total Digestible Nutrients averaged 62.5%.

Herbicides appeared to exert the most weed control in the wet growing season of 1999 compared with mechanical cultivation. Weed populations were significantly greater in the organic corn system (Figure 1) on June 17, 1999, when early control is critical. Weed populations in organic soybean plots (Treatments SB-O/A-C and SB-O/A-A-C), however, were not significantly different than the conventional plots (Figure 2). Weed populations in the organic soybean plots did not significantly impact yields. As in 1998, broadleaf weeds predominated in both systems. Organic and conventional soybean plots exhibited similar levels of weed populations prior to harvest (data not shown), with an average of two hr for hand-weeding needed per acre. This corresponded with area organic farmers' average time for hand-weeding clear-hilum soybeans, a prerequisite for the food grade market.

As previously discussed, corn stand counts were significantly less in the organic plots (19,625 plants/acre for the average plant stand) (Figure 3) at 21 days after planting (DAP), compared with the conventional plots (26,833 plants/acre). Organic soybean plots also had significantly lower stands (Figure 4), averaging 92,834 plants/acre. Despite this decrease in organic soybean stands, yields were not significantly affected.

Corn earworm larvae were detected at low levels in the milling corn in 1999. Although slightly lower populations were observed in the organic corn plots, differences were not statistically significant (Figure 5). Soybean cyst nematode populations were again observed in 1999 (first observation in 1998) (Figure 6), but levels were below economic injury levels (less than 200 eggs per 100 cc of soil). Population shifts occurred from 1998, however, with the lowest number of SCN eggs detected in the conventional soybean plots (previously in corn in 1998), followed by the organic SB-R plot. The opposite trend was observed in 1998, where the greatest number of SCN was observed in these two treatments. Rotational effects may be responsible for altering SCN populations.

Stalk nitrate content at the end of the season was significantly greater in the conventional system (Figure 7), with some plots exceeding recommended nitrate levels (over 2,000 ppm). As in 1998, the lower stalk nitrate content in the organic corn may reflect the need for additional nitrogen inputs. Adjustments were made in 1999 to more accurately reflect the nutrient needs of the organic corn crop, by incorporating an additional 4 tons of compost per acre. Mineralization of nitrogen from compost in the first year may be less than previously assumed, however, and additional compost may be required for maximum yields. In both years, where corn followed leafhopper-tolerant alfalfa (in the O/A-C rotation), stalk nitrate content was within recommended levels, while corn following oats with an annual type alfalfa did not meet recommended levels.

Soil quality. After one growing season under organic management (1998), microbial biomass carbon was 128% greater in the organic system; maggroaggregate stability 15% greater; organic carbon 6% greater; particulate organic matter carbon 8% greater; and N mineralization potential 7% greater in the organic system. Nitrate-N was 44% greater in the conventional system, as reflected in the excess corn stalk nitrate in some plots.

Grain Analysis. There were no significant differences in corn grain quality between conventional and organic corn (Figure 8). Protein levels averaged 7.2-7.3%, oil averaged 3.8-4.1% and starch content averaged 61-61.3%. Soybean grain analysis (Figure 9) also demonstrated no significant differences between conventional and organic systems, with an average protein content of 40.8-41.8% (in the organic systems). Protein levels in 1999 were slightly greater than the 1998 average of 39%. The soybean variety selected for the 1999 study was IA 2034 vs. IA 3006 in 1998. Tofu manufacturers prefer a 40%+ soybean protein content.

Results from the second year at the Neely-Kinyon LTAR site were very promising for the organic soybean crop, with an average yield of 47 bushels/acre and a 41% protein content.. Organic corn yields were lower than yields obtained in 1998, but the $2.00/bushel premium for organic corn could offset any decrease in yield. Cost of production studies are currently in progress, but it is anticipated that 1999 costs will be similar to 1998 costs, where organic costs of production were similar to conventional. We expect to see greater differences in the systems, in terms of insect, weed and nematode populations, as rotational effects occur over time. As was anticipated, soil quality was greater after only one season of organic management. With longer crop rotations, and additions of organic matter from compost and cover crops, yields are expected to improve in the organic systems.

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