Evaluation of Tillage and Crop Rotation Effects in Certified Organic Production—McNay Trial, 2003

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Introduction

Organic farming has increased to a $13 billion industry in the U.S. and continues to expand approximately 20% annually. In Iowa alone, organic acreage has increased from 13,000 acres in 1995 to 120,000 acres in 2001. Across the upper Midwest, there has been a great interest in planting organic soybeans on Conservation Reserve Program (CRP) land, where up to a 300% premium can be obtained compared with conventionally raised soybeans. Regulation of soil organic matter through additions of plant residues and proper crop rotations will determine the long-term sustainability of the system. The objectives of this research and education program included the following: (1) establish plots dedicated to organic farming research on CRP land; (2) implement production and management regimes for opening CRP land and for weed control in organic systems on CRP land; (3) evaluate the biological and economic outcomes of the different systems; and (4) inform through demonstrations, field days, and publications for area farmers and agricultural professionals.

Materials and Methods

This project involved the establishment of a long-term agroecological research (LTAR) site in southern Iowa. The McNay Memorial Research Farm dedicated approximately two acres of a five-year old forage field (bromegrass and alfalfa) for this long-term project in Chariton, Iowa, in 1999. Bromegrass predominated in the field, as is typical of CRP land in this area of the state.

Experimental Design. Forty-eight plots (four tillage treatments, three crops, and four replications), measuring 30 × 60 ft each, were arranged in a randomized complete block design in September 1999. The initial plowing of the CRP land, in the fall of 1999 and spring 2000, consisted of the following treatments: Treatment 1 = fall moldboard plowing; 2 = spring moldboard plowing; 3 = Kverneland® plowing (fall); and 4 = Howard Rotavator® (fall and spring). In 2000, a rotation of corn-soybean-oats/red clover was initiated to meet certified organic requirements. Each crop of the rotation was planted each year beginning in 2000.

Tillage and Mechanical Operations. Plots that were fall plowed in 1999 (fall moldboard and Kverneland®-plowed) were retained as fall plowed plots in 2000, 2001, 2002, and 2003. Fall tillage for the 2003 season was accomplished by November 15, 2002. Winter rye was broadcast on corn plots with a three-point mounted spreader on November 5, 2002, at a rate of one bushel/acre to serve as a ground cover to prevent erosion and mitigate weed populations in 2003 soybean plots. Spring plowing was completed on April 2, 2003, and the rye in soybean plots was disked on April 3. Manure was applied to all plots going to corn at a rate of 5,000 lb/acre on April 2, 2002. 'Reeves' oats and 'Mammoth' red clover were planted on March 26, 2003, at a rate of 100 lb/acre and 8 lb/acre, respectively. Soybeans (Pioneer 9305) were planted at a population of 180,000 seeds/acre on May 22, 2003. The corn variety Pioneer 34M94 was planted on May 20 at a rate

of 32,000 seeds/acre. Corn was rotary-hoed on June 18 and cultivated on June 25. Soybeans were rotary-hoed on June 7 and cultivated on June 18 and 25. Soybean plots were "walked" (large weeds removed by hand) on July 29, per local organic practices to remove any potentially staining weeds prior to harvest. Oats were harvested on July 15, 2003. Corn was harvested on September 29. Soybeans were harvested on October 17.

Sampling. Sampling for soil, plant performance, weeds, insects, and nematodes followed methods developed for the Neely-Kinyon Farm LTAR site. Corn and soybean stand counts were taken on June 12 (23 and 21 days after planting, respectively). Weed counts (3 square meter quadrants/plot) were taken in corn plots on June 12 and July 7, and on June 12 and July 29 in soybean plots. Bean leaf beetles, which are associated with the soybean staining disease complex, were sampled in soybean plots on July 7 and August 20 by sweeping 20 times/plot with a 15-inch diameter net. Corn borer populations were sampled by removing three randomly selected corn whorls/plot, and recording number of corn borer feeding holes and actual larvae on July 7. Soybean cyst nematodes were analyzed by collecting five, 6-inch soil cores/soybean plot for presence of eggs on September 22. Corn stalks were collected on September 22 for stalk nitrate analysis. Soybean samples were analyzed for moisture, protein, oil, fiber, and carbohydrates. Corn samples were analyzed for moisture, protein, oil, starch, and density through the Iowa State University Grain Quality Laboratory. A 250-gram sample of harvested soybeans was analyzed from each plot for percentage of stained soybeans (soybeans with a tan, brown or mottled appearance). Post-harvest soil samples (five random samples/plot) were taken on October 21, 2003.

Results and Discussion

No significant differences were observed in corn plant stands (Table 1). More broadleaf weeds were observed in fall-plowed corn plots on June 12 compared with the other treatments, but a greater number of grasses were found in spring-plowed corn plots on July 7.

No corn borers were detected on July 7 (Table 2). Corn stalk nitrate levels were lowest in the spring-plowed (former Rotavator plots), but adequate levels of end-of-season nitrate were found in all treatments (Table 2).

Soybean plant populations were equivalent among all treatments (Table 3). Weed populations were also similar, but on July 29, there were a significantly greater number of grass weeds in the spring-plowed treatment. Bean leaf beetle populations and subsequently, soybean seed staining, was significantly lower in 2003, compared with previous years (Table 4), with no significant differences among treatments. No cyst nematodes were found in any soybean plots (Table 4).

Yields were affected by low rainfall in July, August, and September. Organic corn yields averaged 128 bushels/acre, with no differences among treatments (Table 5). Soybean yields averaged 22.7 bushels/acre and oats averaged 95.2 bushels/acre (Table 5). Because of lower soybean yields in 2003, organic soybean prices reached $20/bushel. Grain quality remained high in 2003, with significantly greater levels of protein (averaging 9.5%) in spring-plowed corn (Table 6) and soybean protein averaging 37%, with no significant differences among treatments. Organic corn, soybean, and oat crops have been successfully produced on this site for four years. In 2004, we will examine the potential for organic triticale, popcorn, and adzuki beans on this site.

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Table 1. Corn and weed populations at McNay Farm, 2003.

Treatment	Corn stand (plants/ac)	Weed population June 12, 2003 (weeds/m^2)		Weed population July 7, 2003 (weeds/m^2)	
		Grass	Broadleaf	Grass	Broadleaf
Fall plow	28,167	6.42	82.92a	2.42a	16.83
Spring plow	28,250	10.75	39.42b	3.42ab	19.67
Fall plow (formerly Kverneland)	27,750	12.00	35.33b	4.83b	29.92
Spring plow (formerly Rotavator)	28,167	8.17	36.00b	2.33a	16.75
LSD 0.05	NS	NS	26.5	1.67	NS

Table 2. Corn pest population and nitrate content at McNay Farm, 2003.

Treatment	Corn borer damage (borers/plants)	Corn Stalk Nitrate (ppm NO_3-N)
Fall plow	0	2,287.00a
Spring plow	0	2,472.00a
Fall plow (formerly Kverneland)	0	1,752.00ab
Spring plow (formerly Rotavator)	0	1,274.00b
LSD 0.05	NS	960.95

Table 3. Soybean weed and populations at McNay Farm, 2003.

Treatment	Soybean stand (plants/ac)	Weed population June 12, 2003 (weeds/m^2)		Weed population July 29, 2003 (weeds/m^2)	
		Grass	Broadleaf	Grass	Broadleaf
Fall plow	105,500	17.75	65.00	0.92ab	2.92
Spring plow	100,083	15.5	50.17	2.22a	1.56
Fall plow (formerly Kverneland)	111,500	14.17	75.67	0.58b	1.75
Spring plow (formerly Rotavator)	105,167	16.00	52.92	2.00ab	1.17
LSD 0.05	NS	NS	NS	1.22	NS

Table 4. Soybean pest populations and staining at McNay Farm, 2003.

Treatment	Soybean cyst nematode population (eggs/100 cc soil)	Bean leaf beetle populations (beetles/20 sweeps)		Stained soybeans (%)
		July 7, 2003	August 20, 2003	
Fall plow	0.00	0.25	0.25	9.94
Spring plow	0.00	0.50	0.25	6.10
Fall plow (formerly Kverneland)	0.00	0.00	0.25	8.14
Spring plow (formerly Rotavator)	0.00	0.00	0.00	7.15
LSD 0.05	NS	NS	NS	NS

Table 5. Yield of corn, soybeans, and oats at McNay Farm, 2003.

Treatment	Corn yield (bu/acre)	Soybean yield (bu/acre)	Oat yield (bu/acre)
Fall plow	120.90	21.84	84.01
Spring plow	124.76	23.33	91.17
Fall plow (formerly Kverneland)	130.19	20.99	98.33
Spring plow (formerly Rotavator)	136.33	24.86	107.26
LSD 0.05	NS	NS	NS

Table 6. Corn grain quality at McNay Farm, 2003.

Treatment	Grain quality (%)				
	Moisture	Protein	Oil	Starch	Density
Fall plow	16.68	9.35ab	3.11	60.84	1.23
Spring plow	16.01	9.50a	3.15	60.53	1.23
Fall plow (formerly Kverneland)	16.10	9.35ab	3.20	60.50	1.23
Spring plow (formerly Rotavator)	16.13	8.89b	3.11	61.23	1.22
LSD 0.05	NS	0.49	NS	NS	NS

Table 7. Soybean grain quality at McNay Farm, 2003

Treatment	Grain quality (%)				
	Moisture	Protein	Oil	Fiber	Carbohydrates
Fall plow	10.30ab	37.60	18.50	4.58	21.33
Spring plow	9.64c	36.58	18.81	4.60	22.01
Fall plow (formerly Kverneland)	10.58a	36.98	18.51	4.63	21.89
Spring plow (formerly Rotavator)	9.95bc	36.60	18.75	4.65	22.00
LSD 0.05	0.48	NS	NS	NS	NS