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Evaluation of Popcorn, Adzuki Beans, and Triticale under Certified Organic Production--McNay Trial, 2004

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Abstract
Organic farming has increased to a $13 billion industry in the United States and continues to expand approximately 20% annually. In Iowa alone, organic acreage has increased from 13,000 in 1995 to 120,000 in 2001. Across the north central region, 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. This project was started in 1999 with the objective of evaluating the biological and economic outcomes of different tillage systems for transitioning CRP land into organic production. Spring moldboard plowing provided the greatest yields over four years of experimentation at the McNay Research Farm. In 2004, after two cycles of a three-year rotation, the organic fields were transitioned to organic adzuki bean, popcorn, and triticale as potential alternative crops for southern Iowa.

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Introduction

Organic farming has increased to a $13 billion industry in the United States and continues to expand approximately 20% annually. In Iowa alone, organic acreage has increased from 13,000 in 1995 to 120,000 in 2001. Across the north central region, 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. This project was started in 1999 with the objective of evaluating the biological and economic outcomes of different tillage systems for transitioning CRP land into organic production. Spring moldboard plowing provided the greatest yields over four years of experimentation at the McNay Research Farm. In 2004, after two cycles of a three-year rotation, the organic fields were transitioned to organic adzuki bean, popcorn, and triticale as potential alternative crops for southern Iowa.

Materials and Methods

This project involved the establishment of a long-term agroecological research (LTAR) site in south central 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 ft × 60 ft each, were laid out in a completely randomized 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. In 2004, plots that would have been planted to corn in the original crop rotation were planted to popcorn, soybeans to adzuki beans, and oats to triticale.

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 2004 season was accomplished by October 29, 2003. Winter rye was broadcast on corn plots with a three-point mounted spreader on October 21, 2003, at a rate of one bushel per acre to serve as a ground cover to prevent erosion and mitigate weed populations in 2004 bean plots. Spring plowing was completed on April 13, 2004, and the rye in adzuki bean plots was disked on April 15. Manure was applied to all plots planted to popcorn at a rate of 5,000 lb/acre on April 16, 2004. Triticale plots were disked and harrowed on April 7, and Trimark 37812 triticale was planted on April 8, 2004, at a rate of 100–120 lb/acre. Mammoth red clover was interseeded in the triticale plots on April 9 at a rate of 8lb/acre.

Erimo adzuki beans were planted at populations of 80,928 seeds/acre, 101,303 seeds/acre, 119,263 seeds/acre, and 139,089 seeds/acre on May 17, 2004. The Crookham popcorn varieties 95103, 97474, 101MR, and 128YH were also planted on May 17 at a rate of 32,000 seeds/acre. Popcorn was rotary-hoed on May 24 and cultivated on June 24. Adzuki beans were cultivated on June 24. Per local organic practices to remove any potentially staining weeds prior to harvest, Adzuki bean plots were "walked" (large weeds removed by hand) from July 8–14 and from August 13–24. Triticale was harvested by combine on July 27, 2004, while popcorn was harvested on October 15. Adzuki beans were harvested on November 8, 2004.

Sampling. Sampling for soil, plant performance, weeds, insects, and nematodes followed methods developed for the Neely-Kinyon LTAR site. Popcorn and adzuki bean crop stand counts were taken on June 17, 32 days after planting (DAP). Weed counts (3 m^2 quadrats per plot) were taken in popcorn and adzuki plots on June 17 and July 8. Corn borer populations in popcorn were sampled by removing three randomly selected corn whorls per plot and recording number of corn borer feeding holes and actual larvae on July 8. Triticale biomass samples were taken on May 20, 2004, by randomly placing 3 ft^2 quadrats in each plot and cutting all vegetation inside the quadrat at soil level. Samples were dried for three days in a dryer at 152.6°F (67°C). After drying, dry weights were taken. Triticale dead seed head data were taken on June 17 by randomly placing 3 ft^2 quadrats in each plot and counting the number of dead seed heads. Postharvest soil samples (five random samples per plot to a depth of 8 in.) were taken on October 18 and 20, 2004.

Results and Discussion

No significant differences were observed among popcorn varieties in plant stands or broadleaf and grass weeds (Table 1). No corn borers were detected on July 8 (Table 1).

Adzuki bean emergence and survival rates after rotary hoeing were not consistent with plant populations planted at 139,089 and 119,263 seeds/acre compared with the 101,303 and 80,928 seeds/acre rates. No significant differences were observed among seeding rates in broadleaf or grass weeds in the adzuki plots (Table 2).

No significant differences were observed among treatments in number of dead triticale seed heads, which ranged from 1.5 to 2.4 dead seed heads per square foot (Table 3). There were no significant differences in biomass produced 42 DAP, but there was a trend toward greater biomass in the previously spring-plowed (non-Rotavator) treatment.

No significant differences were observed in popcorn yield (Table 4), but there was a trend toward greater yield in the 97474 variety (3,449 lb/acre) compared with the other varieties, which averaged 2,741 lb/acre (Table 4). There were significantly greater adzuki bean yields in the two higher planting rates (139,089 and 119,263 seeds/acre), averaging 1,384 lb/acre, compared with the two lower planting rates, averaging 512 lb/acre (Table 4). There were no differences in triticale yields based on previous tillage treatments, with triticale yields averaging 38 bu/acre (Table 4).

Popcorn variety and adzuki bean plant population numbers did not significantly impact soil carbon and nutrient concentrations (data not presented). Mean total soil carbon for popcorn and adzuki bean plots was 24.4 mg/g and mean soil nutrient concentrations were 5.0, 28, 130, and 313 μg/g for soil nitrate-N, Bray P, extractable K, and extractable Mg respectively.

We evaluated the effect of tillage treatment on soil properties in the plots planted to triticale in 2004. Total soil carbon and nitrogen, soil nitrate-N, extractable K and Mg, and electrical conductivity were significantly greater in the plots that had been moldboard plowed in the fall for three years compared with other tillage treatments (Table 5).

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Table 1. Popcorn stands, weed populations, and corn borers at McNay, 2004.

Variety	Stand (plants/ac)	Corn borer damage (borers/plant)	Weed population June 17, 2004 (weeds/m^2)		Weed population July 8, 2004 (weeds/m^2)	
			Grasses	Broadleaves	Grasses	Broadleaves
101MR	30,583	0.00	7.58	55.3	7.67	25.4
128YH	30,417	0.00	8.42	49.3	4.83	29.7
95103	30,417	0.00	9.67	38.9	6.42	17.8
97474	31,083	0.00	9.08	36.3	2.92	26.0
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS

Table 2. Adzuki bean population and weeds at McNay, 2004.

Seeding rate (seeds/ac)	Stand (plants/ac)	Weed population June 17, 2004 (weeds/m^2)		Weed population July 8, 2004 (weeds/m^2)	
		Grasses	Broadleaves	Grasses	Broadleaves
139,089	58,080a	7.33	28.92	4.56	8.67
119,263	50,820ab	6.67	22.08	4.75	5.92
101,303	45,375bc	4.25	29.58	2.40	10.27
80,928	39,930c	5.17	30.83	2.75	10.58
$LSD_{0.05}$	7,857	NS	NS	NS	NS

Values with the same letter do not differ.

Table 3. Triticale dead seed heads and biomass at McNay, 2004.

Treatment [z]	Dead seed heads/ft^2	Dry weight(lb/acre)
Fall plow	2.42	1491.0
Spring plow	1.92	2045.2
Fall plow (formerly Kverneland)	2.25	1861.5
Spring plow (formerly Rotavator)	1.50	1616.4
$LSD_{0.05}$	NS	NS

[z] Treatments were analyzed based on previous year's (2002–2003) tillage.

Table 4. Popcorn, adzuki bean, and triticale yields at McNay, 2004.

Popcorn		Adzuki beans		Triticale	
Variety	Yield (lb/acre)	Seeding Rate (seeds/acre)	Yield (lb/acre)	Treatment[z]	Yield (bu[x]/acre)
101MR	2,811.4	101,303	506.4b	Fall plow	36.88
128YH	2,116.9	119,263	1,416.5a	Spring plow	38.63
95103	3,293.6	139,089	1,351.2a	Fall plow (formerly Kverneland)	39.54
97474	3,449.1	80,928	517.9b	Spring plow (formerly Rotavator)	36.04
$LSD_{0.05}$	NS	$LSD_{0.05}$	530.9	$LSD_{0.05}$	NS

[x] Triticale test weight was calculated at 48 lb/bu.
[z] Treatments were analyzed based on previous year's (2002–2003) tillage.

Table 5. Triticale plots postharvest soil parameters at McNay, 2004. [z]

Treatment[y]	Total Carbon (mg/g)	Total Nitrogen (mg/g)	Nitrate-N (µg/g)	P (µg/g)	K (µg/g)	Mg (µg/g)	PH (µg/g)
Fall plow	25.7a	2.3a	5.2a	29	148a	398a	6.3
Spring plow	22.5b	2.0b	2.5b	28	124b	293b	6.6
Fall plow (formerly Kverneland)	23.3b	2.1ab	2.3b	27	130ab	289b	6.4
Spring plow (formerly Rotavator)	22.6b	2.0b	2.8b	28	117b	290b	6.6
$LSD_{0.05}$	1.8	0.2	2.1	NS	20	77	NS

[y] Treatments were analyzed based on previous year's (2002–2003) tillage.
[z] Soil samples were taken on October 10 and 20, 2004, at a depth of 8 in.