Evaluation of an Organic No–Till System for Organic Corn Production–Neely-Kinyon Farm Trial, 2010

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Introduction

Reduced tillage has been proposed as a method to conserve soil while maintaining yields in organic systems. Organic farming has been suggested by some as promoting poor soil stewardship because of the perception that intensive tillage practices are needed for weed control and contribute to excessive erosion and overall soil degradation (Kuepper, 2001). Conservation tillage including no-till crop production addresses the concerns of tillage and has improved soil quality (Uri, 2000). Because conventional no-tillage systems rely on herbicides, which are disallowed in organic systems, a roller/crimper system was developed to mechanically terminate cover crops, leading to a non-herbicidal method for no-till. The first roller-crimper consisted of steel blades welded onto a cylindrical drum that was used in conservation tillage systems (Ashford and Reeves, 2003). The Rodale Institute (Kutztown, PA) began experimenting with an Organic No–Till Plus system in 2004, where commercial crops (corn, soybean, pumpkin) were no-till drilled or planted into cover crops that were terminated with a roller/crimper. The roller consists of a large steel cylinder (10.5 ft. wide x 16 in. diameter) filled with water to provide 2,000 lb. of weight. The Rodale Institute supplied Iowa State University with a roller in 2005 for experimentation in Iowa and research began on organic no-till systems.

Mixed results have occurred in Iowa and across the nation since the roller/crimper has been used in organic systems. In 2007, no-till organic soybeans yielded 45 bu/acre, compared to a 50 bu/acre yield in the tilled soybeans (Delate et al., 2007). Organic no-till corn in Iowa yielded as low as 10 bu/acre compared with a 124 bu/acre average for the tilled corn, although in Pennsylvania yields have been reported as high as 153 bu/acre from planting corn into a rolled hairy vetch cover crop (Mischler et al., 2010). Additional research is needed to better synchronize cover crop termination with grain crop planting. The objectives of this experiment were to analyze the role of specific cover crops in a no-till system in weed management and yield enhancement relative to a conventionally tilled system.

Materials and Methods

Cover crops for the organic no–till corn experiment were planted on September 24, 2009, in a randomized complete block design. The two main treatments of the experiment were no-till and conventional tillage. The six cover crop sub-treatments included hairy vetch (planted at 30 lb/acre), winter rye (240 lb/acre), winter triticale (240 lb/acre), Austrian winter peas (30 lb/acre), a combination of hairy vetch (20 lb/acre) and winter rye (180 lb/acre), and a control with no cover. Because of wet weather and a delay in planting, the cover crops in the tilled treatment were disked on May 25, June 17, and two days before planting on July 10. In the no-till plots, cover crops were rolled with a roller/crimper front-mounted on a John Deere 4240 tractor on July 12. Organic corn seed (Blue River 44R57) was planted in all plots on July 12 at 35,000 seeds/acre in 30-inch rows. The tilled corn plots were row-cultivated on July 27 and August 12.

Cover crop stand and weed counts were taken on October 19, 2009, and on April 19, 2010, by counting the number of living plants per square

foot in five randomly selected areas within each plot. Cover crop height and visual percent ground coverage of stand was estimated on May 19. Cover crop biomass was taken on May 27 by harvesting the biomass within three randomly selected square-foot sections and drying until at a constant weight. Corn population counts and weed counts were taken on August 5. Corn height was measured on August 16. Additionally, European corn borer damage was recorded on August 16 by counting the number of living corn borers per five plants and providing an overall estimation of the plants with corn borer damage in the plot.

Due to late planting and subsequent failure of corn plants to reach maturity, plots were harvested for corn silage biomass on September 30 using a 5730 John Deere forage chopper. Soil samples were taken on September 10 to determine soil quality in the two tillage treatments and cover crop sub-treatments.

Results and Discussion

Cover Crops

Germination and stand of the winter annual grasses was excellent in the fall of 2009; however, hairy vetch and winter pea stands were limited (Table 1). Many of the winter peas winter-killed, with fall stands of 8.3 and 7.2 plants/ft^2 reduced to 2.4 and 3.8 plants/ft^2, respectively, in the spring (Table 1). Weeds, including dandelions, velvetleaf, and lambsquarters, that germinated in the fall appeared to be reduced by spring. The winter pea plots were the only cover crop plots that had an increase in weeds, presumably due to poor competition from a limited stand. In addition to stand counts, an estimation of percent ground cover overall before planting revealed a 100% cover in the winter rye and triticale plots, except for the winter rye in the tilled treatment, which had a 93% cover that was not statistically less than the other grass cover crop plots (Table 1). Hairy vetch covered 84% of the ground in the no-till plots and 63% in the plots that would be tilled, which was significantly lower. Winter pea cover was significantly lower than all other treatments, with 16% and 25% ground cover in plots to be no-tilled and tilled, respectively. Winter triticale produced the greatest amount of biomass at 3.7 tons/acre dry matter, followed by winter rye at 3.5 tons/acre, and the winter rye/hairy vetch mix at 3.3 tons/acre (Table 3), with no significant differences among these treatments. Hairy vetch alone produced a biomass of 1.5 tons/acre, which was not statistically different than the Austrian winter peas at 0.94 tons/acre and the weed biomass in the control at 0.5 tons/acre (Table 3). Weed biomass was highest in the control with 10.5 grams/0.25m^2 and in the Austrian winter pea plots with 3.8 grams/0.25m^2 compared to there being no significant biomass in the other treatments (Table 3).

Corn

Although corn plant populations a month after planting were not significantly different between treatments, corn plants in the no-till treatments suffered from competition with weeds and cover crops, as demonstrated by differences in corn height (Table 2). Corn height in the tilled plots averaged 64 inches compared to an average of 35 inches in the no-tilled plots. The corn in the no-till hairy vetch plots were significantly taller than the other no-till plots, averaging 46 inches, compared to the other 5 cover crop treatments at 33 inches.

Because weed populations were so high in the no-till plots, an estimation of percent ground cover of weeds was used to determine which cover crops provided the most competition with weeds after being rolled. The tilled plots had minimal grass weeds present, while the range in the no-till plots was 1.5% to 29% grass cover (Table 2). Due to large variations in cover between plots, there was no statistical difference between cover crop treatments (Table 2). Broadleaf weeds in the no-till plots were greater than grass weed populations. The winter rye

and winter rye/hairy vetch plots exhibited the lowest weed populations of the no-till cover crop treatments, with 19% and 25% cover, respectively. Broadleaf weeds in the tilled cover crop treatments were more easily managed through cultivation, with the highest weed populations in the winter rye treatment at 30 broadleaf weeds/ft^2 (Table 2).

Corn borer damage was observed in the corn plants, particularly in the no-till plots. Damage ranged between 10 and 22%, with no significant difference between treatments.

Corn silage yields in the no-till treatments were significantly lower than in the tilled cover crop treatments. No-till biomass yields ranged between 5 and 9 tons/acre, while the tilled yields ranged from 22 to 28 tons/acre of biomass. There was no statistical yield difference between cover crops sub-treatments, but biomass yield in the no-till hairy vetch treatment averaged 9 tons/acre, which was over 3 tons/acre higher than the next highest treatment of hairy vetch and winter rye at 6 tons/acre (Table 3).

Discussion

Overall, the organic no-till system experienced many setbacks in Iowa in 2010, including wet weather preventing timely planting and subsequent weed and insect infestation. The tilled plots yielded approximately three times the corn silage biomass as the no-till plots. The later planting date prevented rolling/crimping the cover crops at the ideal stage (e.g., anthesis for the grass cover crops and flat-pod stage for the vetch) and, combined with excessive precipitation, led to high populations of weeds in the cover crop mulch. Nitrogen fixed by the hairy vetch cover crop did tend to increase corn silage yield, since no additional nitrogen was added to any of the plots. These results were similar to previous no-till experiments in Iowa, where the largest constraint for a successful organic no-till system for organic corn was planting at a typical planting date and obtaining sufficient kill of the cover crops through rolling/crimping at the same time.

The organic no-till system for corn needs greater modification before recommending as a broad-scale approach for organic growers in all regions. Future recommendations may include a high-residue cultivator for a one-pass rescue tillage system if the cover crops are not adequately terminated from the rolling/crimping and/or weeds continue to emerge through the cover crop mulch. Methods for adding nutrients into the system also need to be addressed to determine if organic–compliant amendments can offset corn yield reductions from weeds and cover crop competition.

Literature Cited

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Table 1. Cover crop parameters in organic no-till experiment, Neely-Kinyon Farm, Greenfield, IA, 2010.

Treatment	Cover crop	Cover crop stand (Plants/0.25 m^2)		Weeds (Plants/0.25 m^2)		Cover crop height (in)	Ground coverage (%)
		10/19/09	4/19/10	10/19/09	4/19/10	5/19/10	5/19/10
No Till	Hairy Vetch	9.25c	10.45d	2.50abcd	0.00c	20.67d	83.75b
	Winter Rye	26.40ab	21.85bc	0.80cd	0.00c	42.20ab	100a
	Winter Triticale	26.45ab	23.95ab	0.80cd	0.00c	36.36c	100a
	Austrian Winter Peas	8.30c	2.35e	1.25bcd	2.45a	12.83e	15.75d
	Rye/Vetch	33.75b	20.10c	0.60d	0.00c	38.25bc	100a
	Control	0.00d	0.00f	3.50ab	1.50ab	0.00f	0.00e
Till	Hairy Vetch	9.70c	10.95d	3.10abc	0.85bc	20.57d	63.00c
	Winter Rye	29.50a	24.00ab	2.60abcd	0.00c	43.76a	92.50ab
	Winter Triticale	28.55a	24.35a	2.75abcd	0.00c	37.46c	100a
	Austrian Winter Peas	7.20c	3.80e	3.20abc	1.40ab	12.95e	25.00d
	Rye/Vetch	22.80b	22.90ab	3.15abc	0.10c	44.49a	100a
	Control	0.00d	0.00f	4.90a	2.35a	0.00f	0.00e
	LSD 0.05	4.66	2.16	2.44	1.15	4.71	9.34

Table 2. Corn parameters in organic no-till experiment, Neely-Kinyon Farm, Greenfield, IA, 2010.

Treatment	Cover crop	Corn Stand (Plants/acre)	Weeds 8/5/10				Corn Height (in)
			Weeds/0.25 m^2		% Ground cover		
		8/5/10	Grasses	Broadleaves	Grasses	Broadleaves	8/16/10
No Till	Hairy Vetch	26,750	---	---	18.38	38.75b	45.67b
	Winter Rye	29,500	---	---	14.38	19.00bc	29.15c
	Winter Triticale	29,875	---	---	7.88	42.50b	32.91c
	Austrian Winter Peas	29,125	---	---	29.25	80.38a	33.35c
	Rye/Vetch	28,000	---	---	1.50	25.25bc	33.50c
	Control	30,000	---	---	4.00	7.13c	37.05bc
Till	Hairy Vetch	27,500	0.00	11.75ab	---	---	63.43a
	Winter Rye	27,000	0.00	30.38a	---	---	61.06a
	Winter Triticale	28,500	0.00	13.62ab	---	---	65.85a
	Austrian Winter Peas	26,250	0.00	7.75b	---	---	64.68a
	Rye/Vetch	26,875	0.00	5.50b	---	---	65.79a
	Control	29,000	0.00	2.75b	---	---	64.84a
LSD 0.05		NSD	NSD	21.57	NSD	24.59	9.33

Table 3. Biomass, insect and yield parameters in organic no-till experiment, Neely-Kinyon Farm, Greenfield, IA, 2010.

Treatment	Cover Crop	Weed Biomass (grams/0.25m^2) 5/27/10			Cover Crop Biomass (tons/acre)	Corn Borer Damage 8/16/10		Biomass yield (tons/acre)
		Annual grasses	Annual broadleaves	Perennial broadleaves		# Living corn borers / 5 plants	Plants with damage (%)	
No Till	Hairy Vetch	0.00b	0.00	0.00b	1.53b	0.20	22.50	9.31b
	Winter Rye	0.00b	0.00	0.00b	3.53a	0.00	2.50	4.98b
	Winter Triticale	0.00b	0.00	0.00b	3.70a	0.15	8.75	5.14b
	Austrian Winter Peas	0.33a	1.56	2.24ab	0.94b	0.05	7.50	4.96b
	Rye/Vetch	0.00b	0.00	0.00b	3.25a	0.15	5.00	6.11b
	Control	3.76a	1.34	5.41a	0.505b	0.10	22.50	8.68b
Till	Hairy Vetch	---	---	---	---	0.15	15.00	25.76a
	Winter Rye	---	---	---	---	0.10	11.75	22.35a
	Winter Triticale	---	---	---	---	0.05	10.00	22.99a
	Austrian Winter Peas	---	---	---	---	0.20	13.75	27.93a
	Rye/Vetch	---	---	---	---	0.20	18.75	22.08a
	Control	---	---	---	---	0.10	10.00	25.95a
	LSD 0.05	1.68	NSD	4.50	1.12	NSD	NSD	11.62