Evaluation of an Organic No–Till System for Organic Corn and Soybean Production–Agronomy Farm Trial, 2009

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Introduction

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 rolled 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.

Due to the fact that organic production of crops primarily relies on tillage for weed management, much attention has been focused on an organic no-till system. Tillage may be problematic for soil quality by increasing erosion and carbon loss, but also increasing labor and energy use (Pimentel et al., 2005). Mixed results have occurred in Iowa and across the nation since the inception of roller experimentation. In 2007, no-till organic soybeans were yielded 45 bu/acre, compared to 50 bu/acre in the tilled organic soybeans (Delate et al. 2007). Organic no-till corn in Iowa was not competitive in 2007 with yields as low as 10 bu/acre compared with a 124 bu/acre average for the tilled corn. In Pennsylvania, however, yields have been reported as high as 153 bu/acre after planting corn into a rolled hairy vetch cover crop (Mischler et al., 2010).

Materials and Methods

Soil samples were taken on September 5, 2008, and on November 3, 2009, in all plots to compare soil quality before the experiment and after the first year. Soils were evaluated at the USDA-ARS National Laboratory for Agriculture and the Environment (Ames, IA).

Plots for the organic no–till experiment were laid out in a randomized complete block design of four treatments and four replications: a tilled (control) treatment for corn and soybean (no cover crop/tillage used after planting); a cover crop of rye (56 lb/acre) for soybeans; and a cover crop of hairy vetch (32 lb/acre) for the corn crop. Cover crops were planted on September 17, 2008. Due to a thin hairy vetch stand in the spring (overwintering problems), a crop of field peas was drilled on May 11 (18.75 lb/acre) into the hairy vetch stand. Both cover crops were rolled with a roller/crimper mounted on the front of the tractor on June 4, 2009. Cover crops were crushed at anthesis (pollen shedding in the small grains). The corn and soybeans in the experiment were planted in the cover crop treatments in one pass on the same day as rolling: the soybeans (BR 34A7) at 200,000 seeds/acre in 30-inch row and the corn (BR 63H07) at 30,000 seeds/acre. Corn and soybeans were planted at the same rates in the tilled plots. After planting, it was evident that the hairy vetch cover crop was not killed by the roller/crimper, so the hairy vetch cover crops were rolled again on June 12 and mowed on July 17 before the corn emerged.

Both the corn and soybean tilled plots were rotary hoed on June 12 and June 17, followed by three row cultivations on June 29, July 7, and July 15.

Corn and soybean population counts and weed counts were taken in corn and soybean plots on June 22, July 2 and August 4. Cover crop stands were taken on May 12 and were determined by counting the number of living plants per square foot in three randomly selected areas within each plot. Cover crop height and biomass were taken immediately before planting by harvesting the biomass within three randomly selected square foot sections in each plot and drying until at a constant weight. Weed biomass was taken on September 8 and 14 using the method previously described for biomass collection. Stalk nitrate sampling was conducted on October 12.
Soybean plots were harvested on October 26. Corn plots were harvested on November 4.

Results

Soil Quality

Soil quality in the experimental area before planting occurred showed no significant differences between any soil parameters (Table 1). The average NO_3-N in the plots was 0.40 ppm, with potassium at 139 ppm and a Bray phosphorus test showing 15 ppm of P in the soil. As of this writing, the 2009 soil quality data are currently under evaluation.

Soybean

Weed suppression in the winter rye cover crop treatment and in the tilled (control) plots was adequate (Table 2), but later in the season (July 25) the appearance of a volunteer rye crop was observed in no-till plots; this competition did not appear to adversely affect the soybean yield (Table 2). Broadleaf weeds were initially higher in the control plots, but after two row cultivations, weed pressure was reduced from 3.92 broadleaves/m^2 and 17.08 grasses/m^2 on June 22 to 1.58 broadleaves/m^2 and 5.33 grasses/m^2 by August 4. Soybean plant populations were significantly higher in the rye treatment compared to the control; however, stands in both the control and cover crop treatments were satisfactory, averaging 133,750 plants/acre and 149,083 plants/acre, respectively (Table 2).

Soybean yields in both the rolled cover-crop and tilled treatments were successful in 2009, averaging 42.6 bu/acre in the tilled plots and 36.6 bu/acre in the winter rye treatments, which was exceptional, considering the late planting date (Table 2). Yields were not significantly different between treatments.

Corn

Corn plants in the no-till treatments suffered from competition with the hairy vetch during initial growth stages until the vetch reached maturity. As a result, plant stands in the no-till treatments, averaging19,917 plants/acre, were significantly lower than the tilled treatments (29,250 plants/acre) (Table 2). Weeds were excessive in the no-till system, with broadleaf weed populations three to five times higher than the tilled treatment throughout the entire season (Table 2). The rolled hairy vetch cover crop was able to suppress grass growth at the same level as the tilled plots. Both stalk nitrate tests revealed low levels of nitrogen with the rolled plots, averaging 20 ppm stalk NO_3-N compared to 32.6 ppm stalk NO_3-N in the control plots (Table 2). Both levels were far below ISU's recommended level of 1,500 to 2,000 ppm.

Corn yields in the rolled cover crop treatment averaged 29.9 bu/acre and were as low as 10 bu/acre in some plots compared to 99.4 bu/acre in the tilled treatment.

Cover Crops

Germination and stand of the winter rye cover crop were excellent in 2009 (Table 3). The roller crimper suppressed rye growth throughout the season; however, the hairy vetch was never completely terminated, which impacted corn growth throughout the growing season, eventually leading to significantly reduced yields (Table 2). Both cover crops produced adequate biomass, with the hairy vetch/peas

combination yielding 5,298 lbs/acre and the winter rye yielding 13,794 lbs/acre of above ground growth. Vetch and rye plant height averaged 22 cm and 57.4 cm, respectively, with no differences between plots (Table 3).

Grain Quality

Corn grain quality was not significantly different between the no-till treatments and the tilled control (Table 4). Protein content averaged 6.82% and 7.00% for the tilled and rolled plots, respectively. Both crops were harvested at a high moisture rate (above 40%), due to a later planting date with a longer maturing corn, which did not allow the corn to adequately dry in 2009. Soybean grain quality is not included due to inadvertent delivery to the local grain elevator.

Discussion

Overall, the organic no-till system showed several successes and several potential setbacks in Iowa in 2009. The rolled winter rye cover crop provided comparable weed control to the tilled treatment, and despite a volunteer rye crop later in the season, the soybean yields were not adversely affected. These results were similar to previous no-till experiments in Iowa. The largest impediment in an organic no-till system for organic corn utilizing hairy vetch as a cover crop appears to be thoroughly killing the cover crop with the roller-crimper. The rolled hairy vetch, which continued to grow, drastically reduced corn yields and provide did not provide adequate control of the weeds compared to the tilled control plots. Rolling the vetch at later dates in June has been shown to potentially alleviate both problems by allowing for larger biomass growth and better control of the hairy vetch, thus providing higher yields (Mischler et al., 2010). This aspect will be taken into consideration for the 2011 crop year. Although the organic no-till system has shown success, it needs additional modification before recommending the technique for organic growers in all regions.

Literature Cited

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Table 1. Pre-planting soil quality in organic no-till experiment, Agronomy Farm, Boone, Iowa, September 17, 2008.

Crop	Treatment	Bray phosphorus (ppm)	Potassium (ppm)	Calcium (ppm)	Magnesium (ppm)	Total nitrogen (%)	Ammonium nitrogen (ppm)	Nitrate nitrogen (ppm)
Soybean	No Cover	14.14	145	5126	513	2.42	0.607	0.433
	Rye Cover	19.3	144	4342	511	2.43	0.337	0.533
	LSD 0.05	NS	NS	NS	NS	NS	NS	NS
Corn	No Cover	19.95	133	4084	547	2.26	0.255	0.315
	Hairy Vetch Cover	9.08	133	5317	466	2.55	0.570	0.353
	LSD 0.05	NS	NS	NS	NS	NS	NS	NS

Table 2. Soybean and corn parameters in organic no-till experiment, ISU Agronomy Farm, Boone, Iowa, 2009.

Crop	Treatment	Stand (plants/acre)	Stalk nitrate (ppm)	Yield (bu/acre)	Weed populations (weeds/m^2)					
					June 22		July 2		August 4	
		8/4/09	10/12/09		Broadleaves	Grasses	Broadleaves	Grasses	Broadleaves	Grasses
Soybean	No Cover	133,750a	N/A	42.60	3.92a	17.08	2.25	1.58	1.58	5.33a
	Rye Cover	149,083b	N/A	36.575	1.50b	17.33	1.19	0.00	3.167	51.250b
	LSD 0.05	14,950	N/A	NS	2.23	NS	NS	NS	NS	25.77
Corn	No Cover	29,250a	32.63a	99.39a	2.17a	16.67	1.58a	6.00	1.25a	5.50
	Hairy Vetch Cover	19,917b	20.00b	29.94b	7.17b	9.33	7.08b	10.08	8.75b	9.17
	LSD 0.05	5,229	9.63	27.49	2.390	NS	3.136	NS	4.532	NS

Table 3. Hairy vetch and winter rye cover crop parameters in organic no-till experiment, ISU Agronomy Farm, Boone, Iowa, 2009.

Treatment	Stand (plants/acre)	Plant height (cm)	Biomass (lbs/acre)
	May 12	**June 4**	**September 14**
Rye Cover	2,408,868	57.40	13,794a
Hairy Vetch Cover	135,036b	22.00	5,298b

Table 4. Corn grain quality in organic no-till experiment, Agronomy Farm, Boone, Iowa, 2009.

Crop	Treatment	Moisture (%)	Protein (%)	Oil (%)	Starch (%)
Corn	No Cover	40.23	6.82	4.33	62.63
	Hairy Vetch Cover	40.40	7.00	4.25	62.15
	LSD 0.05	NS	NS	NS	NS