

PROJECT TITLE: Improving Organic No-Till Systems for Enhanced Soil Quality and Weed Management in Organic Grain/Forage Systems

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Introduction

The objectives of the experiment included a determination of the effect of field history related to crop rotation and tillage and how that affected crop germination, growth and productivity, along with soil quality. 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 (ISU) with a roller in 2005 for experimentation in Iowa.

The crop rotations at this certified organic site at the ISU Agronomy Farm, Boone, Iowa, had been either Rotation 1: spring wheat-winter rye cover crop (2008)-soybean (2009)-oat-hairy vetch cover crop (2010)-corn (2011)-oat/alfalfa (2012)-soybean (2013)-oat/alfalfa (2014)-soybean (2015)-oat/alfalfa (2016); or (Rotation 2) spring wheat-hairy vetch cover crop (2008)-corn (2009)-oat-rye cover crop (2010)-soybean (2011)-oat/alfalfa (2012)-corn (2013)-soybean (2014)-oat/alfalfa (2015)-soybean (2016). Rye was planted as a cover crop on all 2013 corn plots on October 21, 2013, to prepare for the no-tillage system for organic soybeans that would commence in 2014.

2014 Results

Rye was planted at 75 lb/acre to the eight plots going to organic soybeans in Spring 2014. Four of the plots had the rye cover crop mowed before planting, and four other plots had the rye cover rolled/crimped. Eight plots were planted to oats/alfalfa in order to continue a soil-building rotation for certified organic status. Rye was either mowed or rolled/crimped on June 13, 2014, with soybeans planted at 164,000 seeds/acre, immediately following mowing or rolling rye. The 2014 season had excessive rains in June, which limited soybean crop plant growth and encouraged weed growth. In July, a drought was experienced, which led to a reduction in oat and soybean growth. Oat yields were reduced in 2014 due to high rainfall during maturation and averaged 66 bu/acre, with no difference between rotational or tillage history. Oat straw yields averaged 1.3 tons/acre. Rye mulch coverage in soybean row middles was significantly greater in rolled no-till plots, averaging 44% coverage, compared to 27% in mowed rye plots. There were no differences based on rotational history. Soybean populations averaged 142,625 plants/acre, with no significant differences between rotational history or 2014 tillage (mowed vs. rolled). Soybean yields were exceptionally good, despite the weather, averaging 44 bu/acre, with a numerical trend of a 3-bushel/acre increase in the rolled vs. mowed rye plots. Rotation effects did not affect yields. In 2014, soybean cyst nematode populations averaged 975 eggs per 100 cc of soil, which was below economic threshold levels.

2015 Results

In 2015, the crop rotation at this site was flipped, and 2014 soybean plots were planted to oat/alfalfa, with 2014 oat/alfalfa plots planted to rye in the Fall and soybeans after mowing and rolling operations on June 19, with soybeans planted at 164,000 seeds/acre, immediately following mowing or rolling rye. Oats and alfalfa were drilled together on April 1, at a rate of 2 bu/acre (Badger oats, Albert Lea Seedhouse, MN) and 15 lb/acre alfalfa (Bluejay 3HR, Blue River Hybrids, Kelly, IA). Oats were chopped as baleage on June 19 and again on August 26. Oats were harvested as baleage as opposed to grain due to the excessive weed population that developed from drilling directly into the soybean stubble. It became apparent from this experiment that, in order to have the best oat stand and harvest, the ground should be tilled ahead of oat/alfalfa planting, which will take place in 2016, prior to oat planting. Soybeans were harvested on November 2, 2015. Soil samples to a 6-inch depth were taken on October 22 from three random areas in each soybean plot and delivered to the ISU Plant Pathology Lab (Ames, IA) for soybean cyst nematode analysis. A 200-g soybean sample was analyzed for grain quality at the ISU Grain Quality Lab. Soil samples to a 6-inch depth were also taken for soil quality analysis by the USDA-ARS lab, Ames, IA. Again in 2015, there were excessive spring/summer rains, and organic oats did not fill adequately, so the crop was cut for oatlage, an animal feed. Oatlage yields were similar between rotations and tillage systems, averaging 10,810 lb/acre at the first cutting, and 5,651 lb/acre at the second cutting, for a seasonal average of 16,461 lb/acre, which is considered a good yield. Soybean emergence was excellent in no-till plots, with stands averaging 118,195 plants/acre, and no differences between rotations or tillage system. Yield damage from native jackrabbits (a protected species) was extensive in 2015 in organic soybean plots (neighboring conventional soybean plots were not damaged). Soybean yields were good, however, in plots where the jackrabbits did not attack, averaging 31 bu/acre in mowed plots, with a significant increase in the no-till (rolled/crimped rye) plots, which averaged 42 bu/acre.

Soil quality differences were observed for soils sampled in the fall of 2015 after crop harvest but treatment differences were difficult to detect because of statistically significant field replicate effects. Despite the confounding replicate effects, the impact of no-tillage was strong enough such that stable macroaggregates (Agg%) comprised a greater proportion of the total soil mass in the rolled no-till soil compared with the mowed treatment, similar to results from fall 2014. Mehlich-extractable P was higher in the mowed treatment compared to the no-till for both rotation sequences, similar to 2014, but the effect was not statistically significant in 2015.

2016 Results

Rye was drilled at 130 lb/acre on September 28, 2015, in the eight oat/alfalfa plots going to organic soybeans in Spring 2016. Eight other plots were planted to oats/alfalfa at previous rates in Spring 2016 in order to continue a soil-building rotation for certified organic status. The rye was rolled/crimped on June 6. A new system of drilling soybeans into the stubble was attempted due to an Iowa farmer's success with this method in 2015. Soybeans (Viking 0.2399AT12N, Albert Lea Seed, MN) were drilled into the crushed mulch at a rate of 80 lb/acre, immediately following rolling the rye. Oats and alfalfa were drilled together on March 22, 2016, at a rate of 2 bu/acre (Saber oats, Albert Lea Seed, MN) and 15 lb/acre alfalfa (Viking 370HD, Albert Lea Seed, MN). Oat yields averaged 113 bu/acre in 2016, which was a higher yield than in recent years, suggesting the combination of an earlier planting date (March 22 vs. April 1 in 2015) and more supportive weather led to increased yields.

The farm experienced a severe drought and less than 10% of the soybeans emerged through the

thick rye mulch. Soybeans were re-drilled at the same rate on June 22, but the drought continued, and emergence was only slightly improved. On July 6, soybeans were re-planted using a 4-row 30-inch planter that opened a slot where soybeans could emerge. Emergence was good following the rains that finally came, but it was too late for a fully mature soybean crop to develop. Thus, soybeans were chopped for livestock feed on September 13, with soybean biomass weighed in a weigh wagon. Chopped soybean biomass yield at harvest was equivalent between treatments, averaging 10,803 lb/acre. Again there appeared to be greater yield in the Rotation 2 plots, averaging 11,778 lb/acre compared to 9,830 lb/acre in Rotation 1 plots. One of the differences between Rotation 1 and 2 was the addition of composted animal manure on the 2013 corn crop and a crop of oat/alfalfa the previous year (2015) in Rotation 2 plots, which could have led to greater soil fertility in those plots. Insect populations were low overall, with no differences among treatments. Bean leaf beetles averaged 4 beetles/plot; aphids and whiteflies averaged 1 insect/plot; corn rootworms averaged 4 beetles/plot; and thrips averaged 2 thrips/plot. Beneficial insects were equivalent among treatments with nabids, spiders, and minute pirate bugs averaging 1 insect/plot.

Discussion

Because continuous organic no-till was not supported by this experiment, nor by previous data in Iowa, due to ‘volunteer’ winter rye and hairy vetch, along with perennial weed populations, which impacted yields, it was determined that periodic tillage may be necessary to obtain optimal oat/alfalfa and soybean yields. Thus, tillage before planting the rye cover crop in the fall and before oat/alfalfa planting in the spring is recommended to ensure the greatest seed-to-soil contact for optimal crop emergence, and for destruction of perennial weeds in the system. The amount of reduced tillage will still be increased in this system compared to a typical tilled system, in that a fall cover crop of rye will be covering the soil for 6 to 7 months. This experiment was heavily impacted by extreme weather events, with excess rains in 2014 and 2015, and drought in 2016. These events are representative of the global climate challenges organic farmers may face with higher occurrence in future years. The greatest benefits of organic no-till lie in the soil quality component, with increases in soil macroaggregation evident in no-till plots. Macroaggregation is an integral indicator of soil dynamic change, where enhancement is also related to changes in soil structural stability, water infiltration and storage, and carbon storage. Increasing carbon storage in soils can help mitigate negative impacts from global climate change (Singerman et al., 2011).

Reference

- Singerman, A., K. Delate, C. Chase, C. Greene, M. Livingston, S. Lence and C. Hart. 2011. Profitability of organic and conventional soybean production under ‘green payments’ in carbon offset programs. *Renewable Agriculture and Food Systems* doi:10/1017/S1742170511000408.

