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New Tools for Organic No-Till

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By Laura Sayre

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Rest assured, however--there were no chemicals involved. Instead, Moyer used a new, front-mounted cover-crop roller designed and built at The Rodale Institute® as part of a continuing effort to develop practical methods for reduced tillage organic production. The Rodale Institute Farm team has experimented with no-till corn into mixed legume covers as well as no-till soybeans into small grain covers, and is greatly excited about the results. "We're moving toward a situation in which we do our primary tillage to get our cover crop established, so that [the cover crop] almost becomes your primary crop, even though it's not for sale," Moyer explains. "It changes the way you think about the whole system."

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Modified stalk-choppers like the one Moyer was using before have gained some popularity as cover-crop rollers, but they do have a couple of significant shortcomings. First, any rear-mounted roller is liable to perform unevenly because the plant material won't receive the full impact of the roller where it falls into the depressions created by the tractor tires. Second, steering the planter accurately across the knocked-down residue can be a challenge because the planter's row-markers can't make a good line in the thick residue. To get around that problem, the team even tried planting first and then rolling, but before long they realized that a front-mounted roller would resolve both issues--and have the additional advantage of saving another trip across the field.

To design the new roller, Brubaker explains, they began "by looking at what worked and what didn't work with the stalk chopper." The stalk chopper's eight rolling drums arranged in two parallel rows, for instance, meant sixteen sets of bearings to maintain and as many snag spots for the cover-crop material to get bound up on. The new implement's single cylinder has just two bearings, and these are inset three inches on either side and fronted with a smooth shield to reduce catching. The stalk chopper has blades running parallel along the drums, but Brubaker's familiarity with steel wheels led him to suggest curving the roller's blades around the cylinder in a chevron pattern, which prevents bouncing and helps guide the tractor in a straight line (whereas curving the blades in a screw pattern would tend to auger the tractor to one side). Brubaker also knew that the blades should be angled back from the direction of motion, because if they were mounted at a 90º angle to the drum they would kick up soil as they left the ground.

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With these features in place, the team strove to make the roller as adjustable as possible. Since they were starting with a hollow pipe, they sealed it tight and inserted a removable plug so that the drum could be filled with water to vary its weight for different field conditions. All of the blunt, square-ended blades are bolted in place instead of being welded so that they can be removed or replaced as needed. And when choosing the degree of twisting of the blades around the drum, Moyer and Brubaker made it so that if every other blade were removed there would still be continuous ground contact from one blade to the next.

Field testing, and looking to the future

But the proof, of course, is in the field performance. Although the 2003 crop yield and weed biomass data have yet to be analyzed (at this writing the soybeans are still in the field), Matt Ryan reports that "everyone was really, really impressed with how well this [system] worked." Part of this year's improvement was due to the new Monosem planter, which makes a narrower planting strip in the cover-crop residue and thus minimizes the potential weed zone. But the roller was the star of the show. Moyer estimates that they got "at least a 90% knockdown" with the new setup; and the roller easily handled tough cover crop combinations, like hairy vetch and rye, which caused lots of problems with the stalk chopper. "The only change we might make is to add some tractor weights to the frame" of the roller, says Brubaker, since they found that in the toughest field conditions for knockdown--a very dense stand of cover, on a dry soil--the implement wasn't quite heavy enough even when filled with water.

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After planting, a few weeds did eventually get through the mulch, but for the most part these were delayed enough in their growth that they posed no competitive threat to the crop. "It's important to remember that beyond a certain point, weed control becomes strictly a beautification process," Moyer emphasizes. "Small weeds are not going to affect your crop yields." To handle the occasional aggressive interloper in the no-till field, Moyer and his crew did a quick and dirty trial of vinegar as an herbicide, tacking some shields onto a two-row sprayer and running through a few rows of the soybeans. "It would have worked better if we'd sprayed the vinegar earlier," says Moyer, "but you can see it did have an effect." (USDA researchers John Teasdale and others have published initial experimental results of using vinegar as an organic herbicide www.barc.usda.gov/anri/sasl/vinegar.html.)

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Researchers roll out the details of 2006 no-till organic corn numbers

In this above-average rainfall year, using a rolled-down cover crop worked better than tilling organic plots or non-organic comparison fields.

By Dave Wilson and Christine Ziegler Ulsh

March 15, 2007: We've had time to compile the numbers behind Paul Hepperly's report in January on organic no-till corn yields from our fields in 2006. Readers sent in several queries, so we want to share those along with the details of the growing conditions and practices that generated those yields (so you can adapt what we learned to your own fields).

No-till organic corn growing through hairy vetch mat killed by roller-crimper.

The organic no-till corn yield of 160 bu/ac cited by Dr. Hepperly was an average harvested from two of our production fields. Because these fields were planted solely for production, we did not measure their hairy vetch seeding rates, cover crop biomass, corn plant populations or weed biomass. They were harvested with a standard combine, and the grain collected from three measured field passes was commingled then weighed.

The standard-till organic corn yield of 143 bu/ac was taken from a single production field using the same method, while the non-organic chisel-plow yield of 113 bu/ac was harvested with a research combine from our Farming Systems Trial (FST) conventional system (a yield average from eight plots that total about 1.1 acres).

We also planted 1 acre of organic no-till research corn that generated an average of 146 bu/ac from 24 plots of 20x50 feet. In this research field, we gathered a lot of the specific information you requested concerning:

- Field history prior to the no-till corn
- The type of cover crop used
- How the cover crop was established (when, with what equipment, at what rate)
- How the cover crop was killed and incorporated
- How N was made available to the crop
- What corn variety was planted
- How the corn was planted
- Growing conditions for the season
- Comparative yields for the region
- Input costs

It's important to note that the topography and soil types on our research farm vary considerably from one field to another, and sometimes even from one end of a field to the other. Consequently, the yields from these fields will vary as well (even if all other treatments and practices are the same). For example, the no-till production yields were taken from fields that lie low on our farm and have excellent, deep top soil, while the no-till research yields were harvested from a hill-top field that has a thinner layer of top soil and faster drainage. These differences in soil quality and water retention likely caused some part of the yield difference between the production and research organic no-till yields.

Field history

In the two organic no-till corn production fields, hairy vetch was planted in September 2005 following small grain harvest and an August application of compost. (The compost was applied onto stubble at 8 to 10 tons/ac [wet weight] and moldboard plowed for incorporation.) In one field, oats had been preceded by a crop of soybeans, which had been relay cropped into winter wheat in 2004. In the other field, winter wheat had been preceded by oats in 2004 and compost was also applied in August 2004 following the oat harvest.

In the standard-tilled organic field, corn was planted in May 2006 after plowdown of poultry manure and a 2-year-old alfalfa hay field, which had been frost seeded into wheat in March 2004.

In the research no-till corn field, winter wheat was planted in early October 2004 and harvested in July of 2005, followed by the incorporation of compost in August and drilling of hairy vetch in September. Click here for a diagram of different field histories.

Cover crop variety and planting particulars

We used hairy vetch as our cover crop in all our no-till and standard-till organic corn. The vetch was planted with a grain drill in late August or early September (depending when the previous crop was removed and compost applied). Hairy vetch needs to be sowed 40 to 60 days before the first killing frost in order to form N-fixing root nodules, produce enough biomass and store enough carbohydrates to survive the winter. (Hairy vetch cultivar choice and individual plant genetics also influence winter survivability. For example, planting hairy vetch seed from north of our latitude reduces winter kill.)

Checking seed placement and soil cover in freshly rolled hairy vetch.

If you are planting hairy vetch for the first time in your field's history, you'll need to inoculate your vetch seed with a pea-vetch inoculum before planting (*Rhizobium leguminosarum*, type C [pea]). We recommend inoculating your vetch seed every time you plant in order to support optimal growth and N fixation (an inoculum packet is often included with vetch seed purchases), but for a first-time planting, inoculation is vital.

In the research field plots, the vetch was planted at a rate of 25 lbs/ac and produced an average total biomass of 6,146 lbs/ac by the time it was rolled down for corn planting on June 9. The average N content of this biomass was 3.31 percent, or about 203 lbs/ac. (Biomass and N content data were not collected from the production fields.)

Cover crop incorporation and corn planting

In early June, the hairy vetch in both the research and production no-till fields was rolled down with a front-mounted Rodale Institute-designed roller/crimper. In the same field pass we planted Blue River 68F32 corn with a rear-mounted four-row Monosem no-till planter.

The planter is a hybrid composed of a Monosem vacuum seed pickup attached to a Kinze toolbar planter, equipped with 15-inch fluted disk blades to cut through the rolled vetch mat, followed by a 15-inch double-disk opener and then a pair of 12-inch cast-iron closing disks and a plastic Keeton seed firmer. Extra weight is added to this planter to help it cut through the thick hairy vetch mat into the soil surface for effective corn establishment.

There was no further incorporation of the hairy vetch; the rolled vetch mat was left on the soil surface to decompose naturally and suppress weeds.

The research corn plots were planted at a density of 32,000 seeds per acre, and the pre-harvest population count averaged 24,533 plants/acre. A large portion of this population reduction was due to cutworm damage. In coming years, we are planning to address this issue either by delaying the planting date and/or applying Bt and diatomaceous earth as we plant.

Growing conditions in 2006

Blue River 68F32 is a full-season corn with a relative maturity rating of 113 days. During the 2006 growing season, we accumulated 2,140 growing degree units between June 9 (the research plot planting date) and the end of September, when the corn reached full maturity. Rainfall for this period was 26.5 inches, 10.44 inches above average for that time period, based on 30-year records.

Comparative yields around the region

As reported, the average corn yield of the two organic no-till production fields was 160 bu/ac, while the no-till research field plots averaged 146 bu/ac over 24 plots. The standard-till organic production field yielded 143 bu/ac, while the Farming Systems Trial's (FST's) standard-till organic plots yielded 139 bu/ac in the manure system (which received compost but no vetch N inputs) and 132 bu/ac in the legume system (which received vetch but no compost). At the same time, the FST's non-organic standard-till field yielded 113 bu/ac.

To compare, the Berks County average non-organic corn yield for 2006 was 130 bu/ac, and the average yield for Southeastern Pennsylvania was 147 bu/ac (Click here to see chart).

Cost analyses

Hairy vetch seed costs $50 to $75 per acre. Given the estimated N output of the hairy vetch biomass in the research field, the cost of the hairy vetch N averaged 25 cents to 37 cents per pound. In comparison, our conventional N fertilizer cost approximately 50 cents per pound in 2006.

It is important to note that not all the N generated by the hairy vetch biomass is available for plant use. Some is lost to volatilization and some is retained in the soil organic matter. However, vetch is not the only N source available to our corn crops. After years of organic production, our farm's soils have received many cover crops, crop residue and compost inputs that have increased the soils' organic matter and microbial activity.

The N in these soils becomes more available as the soil warms in the spring and feeds plant growth steadily over the growing season. Thus, the hairy vetch provides N for the season's crop and also acts as a soil conditioner to improve the long-term nutrient availability and performance of our soils. These factors make N cost analysis more complex, but the long-term benefits showcase the system's advantages.

At the same time, the rolled mat of hairy vetch limited weed biomass to an average 1,170 lbs/ac in the organic no-till research plots, with particularly excellent control during the critical third- through eighth-leaf growth stage. Weeds do eventually break through the hairy vetch mat, but at a later point in the season when they do not pose a competitive threat to the corn. Therefore, weed management benefits must also be calculated as part of the vetch seed expense, including the elimination of five to seven field preparation and cultivation passes (reducing tractor wear, diesel use and labor).

Final thoughts

Keep in mind that The Rodale Institute's organic no-till rotation is not designed as a continuous no-till system. Tillage is used to incorporate residues or inputs and to prepare seed beds at different points in the rotation. For example, after the no-till research corn was harvested, the field was disked and a winter rye cover crop was planted into the corn stubble and vetch residue. And so the cycle continues.

Any reduction or elimination of tillage can improve soil quality and nutrient retention, but our research shows that judicious tillage, when coupled with organic soil improvement, can create soil benefits that surpass those of continuous conventional no-till systems. Thus, we will continue to develop our organic no-till rotation in combination with other proven organic practices to strike a successful balance of soil improvement, weed control, yield and economic viability. NF

No-tilled corn into rolled vetch at harvest.

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