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THE NEW FARM® Research Findings from our on-farm experiments here at The Rodale Institute®

Choosing cover crops for no-till organic soybeans

The more biomass the better for weed suppression—but you do have to be able to plant through the stuff

By Dave Wilson
October 13, 2005

In the no-till system the majority of the weeds are found in between the rows (above). This is in contrast to traditional-till organic soybeans, where most of the weeds are found in the rows (see below).

Weed management research at The Rodale Institute:

In the fall of 2004, The Rodale Institute entered into a research partnership with the USDA Beltsville Area Research Center's Sustainable Agricultural Systems Lab and Pennsylvania State University's Weed and Agroecology Lab to investigate integrated weed management for organic and sustainable farming systems.

As part of this collaboration, The New Farm has launched an Integrated Weed Management page, where we'll be collecting

Cover crops have multiple benefits for sustainable farming systems. They can be used to manage nutrient cycling, add organic matter, reduce leaching, prevent soil erosion, break up pest cycles, attract beneficial insects and promote biodiversity.

They can also be used to manage weeds. Here at The Rodale Institute, we use a number of winter annual cover crops in our rotation, including hairy vetch, cereal rye, wheat and barley. All are planted in late summer or early fall, and all can suppress the germination and growth of weeds through competition and shading.

online resources related to ecological weed management, and a Weed Management discussion forum where our readers can share questions and answers about practical strategies for better weed control on their farms. We'll also be reporting on the latest developments in weed ecology at Beltsville, Penn State and elsewhere.

Finally, we've planned a series of articles written by members of our research and farm operations teams here at The Rodale Institute summarizing completed and ongoing work on weed management in organic systems.

Feel free to contact us with comments or questions about this section of NewFarm.org.

Enjoy! *--Eds.*

Read the rest of the weed research series:

Part 1: Can organic crops tolerate more weeds? By Matt Ryan & Paul Hepperly

Part 2: Identifying weed-tolerant corn and soybean varieties By Rita Seidel and Paul Hepperly

In no-till systems, cover crops can be used to create a vegetative mulch for weed suppression after the primary crop has been planted. Unlike conventional no-till systems, which use herbicides to kill standing cover crops and/or weeds, our organic no-till system uses a roller mounted to the front of the tractor to kill the cover crop mechanically. (Although herbicides are generally regarded as benign compared to insecticides, they remain the largest agricultural pesticide class, accounting for 60 percent of the total amount of pesticide used in 2001. Intensive herbicide use has been associated with a variety of human health risks, negative impacts on wildlife and the development of herbicide-resistant weeds.)

Soybeans are the most weed-sensitive crop we grow and the most difficult to keep weed-free. Data from our Farming Systems Trial show a strong negative linear relationship between soybean yields and weed biomass: for every kilogram (2.20 lb) of weeds, soybean yields drop by one-third to two-fifths kg (0.73 lb to 0.88 lb).

These factors have made soybeans a priority candidate for our organic no-till trials. Unlike our traditional-till, cultivated organic soybeans, where most of the weeds are found in the rows, in the no-till system the majority of the weeds are found in between the rows. If and when they break through the mat, they grow fast and big, creating the appearance of a very weedy field. Our measurements have shown that overall weed biomass in our no-till soybeans tends to be somewhat higher than in our traditional-till soybeans, but it seems likely that competition from the weeds is reduced because of their location.

What makes a good mulch

The half-meter-square quadrat shown above helps researchers calculate cover crop biomass per acre.

The two key factors related to the weed suppressive effect of rolled down cover crops are aboveground biomass and carbon to nitrogen ratio. We measure biomass by placing a half-meter-square quadrat in the field and then cutting, drying and weighing all the plant material within the square. From this we can calculate pounds of dry matter per acre in the field as a whole.

The carbon to nitrogen ratio (or C:N ratio) is the proportion of the two chemical elements carbon and nitrogen in the cover crop plant tissue. Carbon is stored in carbohydrates such as simple sugars (monosaccharides), complex sugars (polysaccharides), starch, cellulose, hemicellulose and lignin, as well as in plant oils, fats and waxes. Nitrogen is stored in amino acids, the protein compounds in the plants. Protein is about 16 percent nitrogen.

The microbes that decompose crop residues use carbon as an energy source and nitrogen to build tissue. If residues have a C:N ratio higher than 20:1, the microbes will need to gather N from the surrounding environment to do their work. Generally speaking, the higher the C:N ratio of the cover crop residue, the more slowly decomposition will occur and the longer the residue will serve as a weed-suppressing mat.

For our no-till soybeans we've trialed three small grains as cover crops: barley, wheat and rye. Our goal was to document not just how much biomass each cover crop produced, but how it responded to rolling and how well it suppressed weeds. We believed that rye would provide the most biomass, for instance, but we weren't sure the roller could handle all that growth and knock it down effectively.

Rolled down barley.

Rolled down wheat.

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Rolled down rye.

As many organic farmers know, rye has great advantages as a cover crop. It's the most winter hardy of the small grains, with the lowest germination temperature and thus the greatest flexibility within rotations. Rye is also allelopathic, producing chemicals that inhibit germination of other seeds. When the standing rye is knocked down with the roller, these chemicals slowly leach out of the dying plant tissue and help prevent germination of small seeded weeds. This effect has been shown to last 30-60 days depending on environmental conditions.

Cover crop biomass amounts will vary from year to year, of course, depending on rainfall and temperatures. Generally speaking, however, rye grows taller and, as a result, produces more biomass than wheat or barley, a total of about 6,000-8,000 lbs/ac dry weight. It also has the highest C:N ratio (about 40:1), making it the most resistant to decomposition. Barley produces the least biomass (4,000 to 5,000 lbs/ac) and has the lowest C:N ratio (about 20:1). Wheat is in between, producing 5,000-6,000 lbs/ac of biomass with a C:N ratio of about 35:1.

One potential disadvantage of rye is that it can dry out a field, making it unsuitable as cover crop in drier regions, especially before soybeans, which require more water for germination than do other grain crops. As the saying goes, “If it’s too dry, don’t try."

Rolling small grain covers

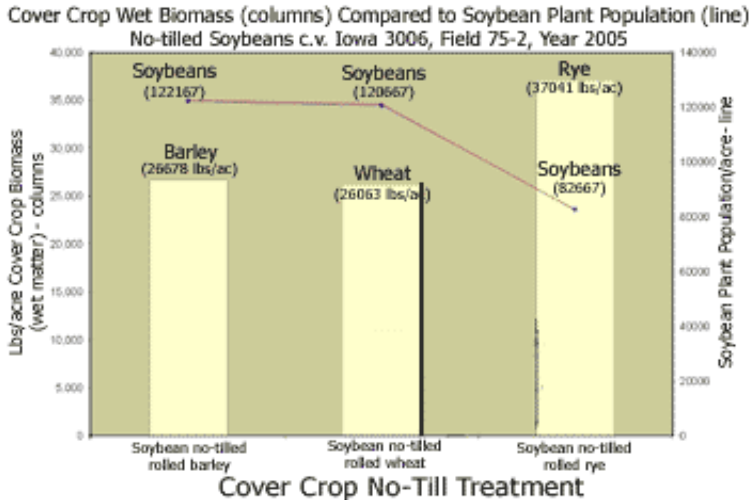
To kill standing small grain cover crops mechanically you have to wait at least until the plants are in the "boot" stage, with the head fully developed but still inside the rolled leaf sheath. For us the boot stage arrives in mid to late May, with heading and flowering in late May to early June. As a rule, the longer you wait past the boot stage, the more complete kill you get, provided you have enough weight to crimp the stems. We normally wait until the head has emerged and is flowering.

So far, we've been rolling our barley, wheat and rye all at the same time, in late May or early June. In the future we plan to adjust the time of rolling according to each crops' maturity. This could give us an earlier planting of beans in the barley, for instance, maximizing the effectiveness of the cover and giving us an earlier jump on the weeds.

Another consideration when rolling down small grain covers is the direction of rolling. We seed our small grains with a drill, so there are 7½-inch spaces between the rows. If the plants are rolled in the same direction as they were sown, gaps can appear along the inter-row spaces. Rolling perpendicularly or diagonally to the direction of drilling can avoid this, but may not be practical depending on the size and layout of the field.

Aiming for better seed-to-soil contact

The biggest challenge we're having now with our organic no-till system is not with killing the cover crop, however, but with getting a good stand planted through the knocked-down residue. Rye offers the best weed suppression, but the heavy mass of vegetation causes the planter's depth wheels to ride up and makes it difficult to get the seed placed well into the furrow.



The bar graph illustrates the pre-roll cover crop biomass (lbs/acre) wet matter on June 6, 2005; the line represents soybean plant population July 19, 2005.

Soybeans in particular require good seed-to-soil contact for germination. In conventional no-till it's recommended to increase seeding rates by 15 percent to compensate for loss in the residue, and it may be that a higher increase is needed for organic no-till. Our current planter set-up--a Monosem vacuum pickup mounted to a four-row Kinze planting unit--has a maximum seeding rate of 150,000-155,000 seeds/ac, so we're somewhat limited in how we address this.

The above graph shows how as cover crop biomass increases, soybean plant populations decrease. With a planting rate of 150,000 seeds/ac and a labeled germination rate of 88 percent (these were Iowa 3006 beans), ideally we would have had 132,000 plants/ac. Planting into the barley and wheat covers, with an average fresh-weight biomass of 26,370 lbs/ac, we obtained soybean populations of 121,417 plants/ac. But planting into the rye cover, with up to 37,041 lbs/ac biomass, soybean populations fell to 82,667 plants/ac. Soybeans are relatively “plastic,” so smaller plant populations have some ability to grow larger and produce similar yields to denser populations--but there are limits to that plasticity.

The biggest challenge we're having now is getting a good stand planted through the knocked-down residue.

Because of these challenges, yields in our organic no-till soybeans have been lower than our organic traditional-till beans—around 25 bu/ac in 2004 (compared to our typical 40 bu/ac). It's unclear whether the limiting factor in the no-till system at this point is seed placement and resulting crop plant populations, weed pressure, moisture or even fertility. In future seasons we'll continue to try to improve our planter setup, experiment with the timing of rolling and planting and begin to examine other questions like the role of cover crops in nutrient availability. NF

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