Dig Deeper

Black plastic alternatives: Year 1

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The challenge

Is it possible to grow vegetables organically without black plastic, while controlling weeds and producing a decent yield? Can this system also benefit the soil and reduced costs?

These were the questions that the Rodale Institute research team set out to answer as they applied for a three-year Northeast SARE Research and Education Grant last winter. After announcement of the grant award in the spring, project work began this summer, with the goal of finding alternatives to using black plastic in vegetable production. Our objective was to compare different cover crop mixes and different methods of cover crop termination with black plastic to see how these variables impacted weed suppression, cover crop nitrogen concentration, soil moisture and yield in tomatoes and pole beans.

Granted, black plastic does have its benefits in that it provides easy weed control and an earlier start for vegetables. However, the costs impact both farm profitability and the environment. Ohio State University estimates that the cost of using black plastic is between $275-$300 an acre (including installation and removal costs), and the clean-up is messy and time-consuming (requiring about 8 hours per acre of mostly hand labor). Disposal also creates environmental problems because burning black plastic releases carcinogens and land-filling it creates long-term space and waste issues.

Tomatoes in cover crops and black plastic.

Our approach

We tested three different cover crop combinations with two methods of termination and compared their performances with a control treatment of black plastic. We planted rye and vetch in fall 2009 and let them over-winter, to be killed in the spring before planting tomatoes or green pole beans into them. Unfortunately, our nurse crop of oats did a poor job of mothering its vetch-babies over the snowy winter and instead smothered them. Thus, we reseeded the vetch in March in an attempt to achieve sufficient ground cover and nitrogen (N) inputs.

Our cover crop combinations were:

- Aroostook Rye (seeded at 3 bushels/acre),
- Hairy Vetch (seeded at 28 lbs/acre), and
- a rye-vetch mix (25 lbs/acre vetch and 75 lbs/acre rye).

In May we terminated the cover crops with three different methods:

- roller-crimper (mounted on the front of our 2950 John Deere tractor),
- flail mower (pulled by our Deutz 6260F), and
- moldboard plow (an International 145 pulled by our Ford 8240 tractor).

We laid black plastic by machine over the plowed portion, and then planted tomatoes and beans directly into the plastic and into the flattened cover crop mats. We planted three varieties of heirloom tomatoes in June: 1) Black Prince, a delicious dark slicer, 2) Bellstar, a hearty paste, and 3) Glacier, a cold-hearty early-producer of smaller fruit. Because hairy vetch naturally fixes soil nitrogen, we didn't fertilize the vetch plots. But the rye-vetch mix and rye plots both were watered with Fertrell 4-1-1 liquid fish fertilizer (rye-vetch mix rate: 0.9 gal/100 plants; rye rate: 1.8 gal/100 plants).

Our delicious Black Prince tomatoes were industrious producers.

We also planted Kentucky Wonder Pole Beans (planted late June) into a rye cover crop terminated four ways: by rolling, mowing, or plowing (topped with black plastic), like the tomatoes, and with an additional treatment of high-residue under-cutting (after rolling down). The under-cutter is designed to slice just below the soil surface to sever cover-crop roots from their crowns (thereby terminating the crop) without disturbing any of the aboveground mulch.

This is what rye looks like before being rolled or mowed. In the center is a black-plastic plot.

What we found

Cover crop biomass

Because more cover crop biomass means better weed suppression and potentially moister soil conditions, we wanted to know the amount of biomass produced per acre by our cover crops. Comparing vetch, rye-vetch mix, and rye in the rolled treatments we found that the rye and the rye-vetch mix produced almost twice as much biomass as did the vetch alone (about 4,600 lbs/acre for rye and rye-vetch mix, and just 2,200 lbs/acre for vetch), though the vetch-alone plots were handicapped by their winter die-off and replanting. While treatments with rye produced more biomass, treatments planted with vetch had a higher concentration of biomass nitrogen (108 lbs N/acre for the rye-vetch mix, versus just 47 lbs N/acre for rye). We found the rye-vetch mix to be a good compromise, with plenty of both biomass and nitrogen.

Percent moisture and temperature

We had a dry season this summer and gave our tomatoes 1-inch of water weekly through drip irrigation. We wanted to see if there were differences in soil moisture between cover crops

versus black plastic so we determined percent moisture gravimetrically (measuring soil weight after oven-drying) by taking samples both in-row and between-row. The treatment with the moistest soil was the mowed rye-vetch mix (29% soil moisture) and the driest soil was black plastic over vetch (22%). As expected, temperatures in the black plastic plots were higher than those in the cover crop plots (about 21.6 °C under black plastic, versus average of about 19.8 °C under cover crops).

Weeds

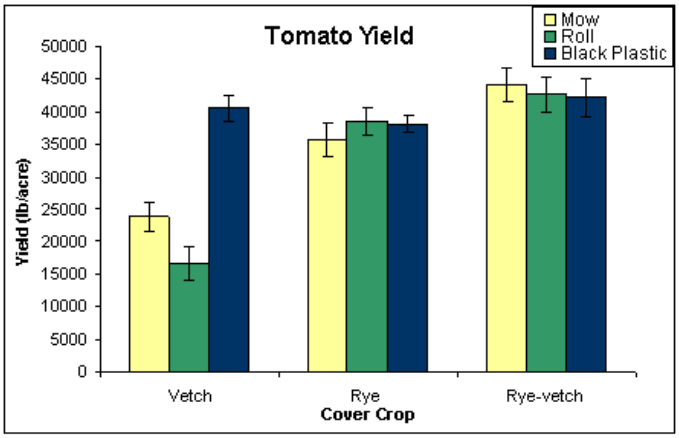
Our cover crop treatments had very different weed-suppression abilities. We set out half-meter square quadrats in the plots and counted and weighed every bit of weed biomass that stood within the quad. After four weeks, rolled rye treatments had the least amount of weed biomass (51 kg/ha) and rolled vetch treatments had the most weed biomass (2486 kg/ha). But after eight weeks after planting, the mowed rye-vetch mix had the least amount of weeds (407 kg/ha). Again, data for the vetch-alone treatment may have been negatively affected by the winter die-off and replanting of the crop, so we look forward to comparing these treatments again next year, hoping that cover crop growth will be more uniform.

A half square-meter of rolled vetch plot, photographed 4 weeks after planting tomatoes.
These plots had the most weed biomass four weeks after planting.
The main weed trouble-makers shown here are marsh yellow cress and ragweed.

A half square meter of rolled rye, photographed 4 weeks after planting tomatoes.
Rolled rye plots had the least amount of weed biomass after 4 weeks.
The rye provided a much thicker mat than did the vetch.

Tomato production

We were excited to find that tomato plants in rye and rye-vetch mulches produced just as much fruit as those in black plastic! We harvested tomatoes from early August until late September, picking twice each week. Yields ranged from 16,575 lbs/acre (in the rolled vetch treatment) up to 44,084 lbs/acre (in the mowed rye-vetch treatment). These values appear much larger than the Pennsylvania 10-year commercial average of 10,500 to 22,000 lbs/acre because we weighed all fruit (including unsellable fruit) because we wanted to know total plant production. Preliminary results from the tomato trial suggest that yields were highest in the mowed rye-vetch mix treatments and lowest in the rolled vetch treatment. The farmer across the road noticed Late Blight in his hoop houses, but the very dry weather, post-rain copper sprays, and limiting activities that might cause contamination kept our tomatoes blight-free.



Average tomato yield by treatment (termination method x cover crop) in lbs/acre. This yield appears unnaturally high because we picked and weighed all the fruit on the plants, including half-rotten and unsellable fruit. Additionally, our season extended until almost October. Error bars indicate standard error.

Economics

Treatments with vetch as a cover crop had the lowest production cost per acre, mainly because we used no fertilizer with vetch (see Table 1). The most expensive system was the rye system, due to the cost of fertilizer needed. Our analysis does not include costs associated with labor, irrigation, equipment depreciation, or black plastic disposal. Thus black plastic values are artificially low.

Production costs for each treatment
(in dollars per acre and dollars per lb of tomatoes produced)
Based on price of cover crop seed, black plastic, and fertilizer.

Treatment	Covering $/acre	Fert $/acre	Total $/acre	Tomatoes $/lb
Mowed rye-vetch	$48	$92	$820	$0.02
Rolled rye-vetch	$48	$92	$820	$0.02
Black plastic rye-vetch	$156	$92	$929	$0.02
Mowed vetch	$90	$0	$90	$0.004
Rolled vetch	$90	$0	$90	$0.01
Black plastic vetch	$198	$0	$199	$0.005
Mowed rye	$36	$179	$1,535	$0.04
Rolled rye	$36	$179	$1,535	$0.04
Black plastic rye	$145	$179	$1,644	$0.04

Bean production

Our trial of Kentucky Wonder Pole Beans served as an effective demonstration of rye as a cover crop, although bean yield data collection was time-consuming and production highly variable due to imperfect bean plant survival. Yields were greatest in plots terminated by high-residue undercutting and lowest in plots terminated by black plastic. Total weed biomass (assessed 4 and 8 weeks after planting) was greatest in plots terminated by moldboard plow and covered with black plastic (3256 kg/ha), and lowest in the mowed plots (906 kg/ha). We didn't do any between-row mowing, and our weed collection method incorporated between-row weeds, which is why the black plastic treatments appeared to have so many weeds.

Concerns and Challenges

Our vetch stubbornly refused to die after rolling in some plots and in these instances it climbed up around the tomato plants. Mowing did a better job of killing the vetch, and mixing it with rye also seemed to help prevent it from climbing the surrounding tomatoes. Growers have also voiced concerns about voles living in the shelter of a cover crop and harming the tomatoes. However, we didn't have that problem thanks to our farm's healthy population of cats.

Take-home message

Based on our first year of results, the rye-vetch mix seems to be the most effective, productive system.

Tomatoes planted into it produced as much as those planted in black plastic, and it did a good job suppressing weeds. It also helped keep the soil moist and provided plenty of biomass and nitrogen. We are excited by this year's results of successful cover-cropping and we look forward to next year's trial so we can learn more about year-to-year variability. We look forward to sharing these results with you when they come in, so stay tuned!

We had cats patrolling our tomato trial. This photo of Jolie in "action" was taken in one of the weedy vetch plots.

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