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Robust Results From Long-Term Research on Organic Cover Cropping

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Meeting all USDA organic certification standards, lettuce harvested from the Salinas test site is packaged in the field and delivered table ready to the store.

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"We can obtain important results from short-term field studies, but they don't always capture year-to-year variability. Long-term research often provides more reliable results that farmers need," says Agricultural Research Service horticulturist Eric Brennan.

Brennan speaks from personal experience. In 2003, he and a team of University of California-Davis collaborators began a 2-year field study that evolved into a unique long-term investigation of high-value organic cropping. The project, the Salinas Organic Cropping Systems trial, is being conducted on an ARS research farm and is now in its 10th year of certified organic production. Brennan, who works in the ARS Crop Improvement and Protection Research Unit in Salinas, California, is analyzing a huge collection of data to pinpoint findings that can benefit commercial producers of organic crops.

Production expenses for high-value organic crops like lettuce and broccoli can exceed $7,000 per acre. Producers who pay high land rent need to maximize profits with an annual two- to three-crop rotation that also includes either keeping fields fallow in the winter or planting winter cover crops.

Many farmers keep winter fields bare because of the extra work and expense of tilling cover crop residues into the soil. Planting a cover crop also requires allowing enough time for its residue to decompose before planting cash crops—and production schedules can become very tight if prolonged spring rains keep farmers from plowing under the winter cover crops.

Brennan designed a long-term investigation of several different cover cropping strategies for an annual lettuce-broccoli production system. Six of the strategies involved cover cropping every winter, and the other two involved cover cropping every fourth winter.

Brennan selected three winter cover crops often grown in the area—rye, mustard, and a legume-rye mix—and planted each at either a typical seeding rate or a rate three times higher. Seeding rates can affect a cover crop's ability to smother weeds.

All systems received the same fertilizer and irrigation inputs and pest management. Harvest and sale of the lettuce and broccoli crops—which met all U.S. Department of Agriculture organic standards—were conducted by a commercial harvester.

Only Time Will Tell

Brennan's results indicated that all three cover crops yielded more dry matter than the 2 tons of crop residue per acre often recommended for maintaining soil organic matter. The legume-rye and rye cover crops produced about 25 percent more dry matter biomass than the mustard crops. But effectively suppressing weeds with the legume-rye crops required seeding at three times the typical rate, while rye and mustard crops appeared to suppress weeds adequately with typical seeding rates.

"In earlier short-term studies, we didn't observe any difference in dry matter production among the three types of cover crops. We also thought that higher seeding rates were always needed," Brennan says. "But in the 8-year study, we clearly saw that mustard did not produce as much biomass as the other two crops and that the legume-rye mix required seeding at the higher rate for effective weed suppression."

The long-term study also provided Brennan with more data about year-to-year yield

variations in the legume-rye mix, including why legumes, which make up most of the seed costs, are not consistently abundant. "We think cooler early-season weather helps legumes compete with the rye," Brennan says. "So if farmers are expecting a hot and dry fall, they might not want to spend the money for a legume cover crop; they might decide to just use rye instead."

Notes on Nitrogen

One benefit of many cover crops is that they take up nitrogen from the soil, which helps reduce nitrate losses into ground water and nearby streams and waterways. When farmers prepare fields for planting by disking cover crop residues into the soil, the nitrogen accumulated by the cover crop gets recycled back into the soil and can be taken up by cash crops that follow.

Brennan's data revealed that the long-term average nitrogen uptake by rye and mustard did not differ significantly (98 and 102 pounds of nitrogen per acre, respectively). But the legume-rye mix accumulated 135 pounds of nitrogen per acre, possibly due to nitrogen fixing by the legumes.

Farmers often rate the quality of cover crop residue by its carbon/nitrogen ratio. "High-quality" residues have lower carbon/nitrogen ratios, so the residue decomposes more quickly and may provide nitrogen to the cash crops that follow. But during wet spring periods, nitrogen that has been rapidly released by these residues may also leach below the root zone more easily. On the other hand, "low-quality" residues with high carbon/nitrogen ratios may temporarily deplete soil nitrogen, as organisms use it to break down the residue.

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In a field planted with a cover crop mixture, horticulturalist Eric Brennan counts the number of plants of each species in the mixture to determine plant density. This field contains a mix of rye, vetch, peas, and faba bean.

Brennan determined that cover crop carbon/nitrogen ratios increased through the winter and were always higher in rye than in the other two cover crops. Slower decomposition of low-quality rye residues could use more soil nitrogen than the decomposition of the other two cover crops and might reduce the amount of nitrogen available to the cash crops.

The scientist also used his data on carbon/nitrogen crop ratios and cover crop dry matter production to calculate that cover crop contributions to soil carbon levels would be around 30 percent greater for rye and the legume-rye mixture—1.4 tons per acre—than for mustard, which only added 1.1 ton of carbon per acre.

The Price To Pay

Brennan concluded that rye and mustard planted at typical seeding rates were the most cost-effective cover crops for maximizing dry matter production and weed control. Planting 80 pounds of rye seed would cost $28 per acre, while planting 10 pounds of mustard seed would cost $30 per acre. Seed costs for planting a legume-rye mix at the three times the typical rate—125 pounds per acre, the level needed for good winter weed suppression—was nearly10 times more, at $275 per acre.

But on the plus side, the legumes can help fix nitrogen in the soil. "Farmers have to decide if it's worth the extra cost to plant a legume-rye cover crop, which might contribute more nitrogen for the next crop, or if it makes sense to use more pelleted organic fertilizer made from chicken litter and protein meals instead," Brennan explains.

"These findings can help farmers in high-value vegetable production systems figure out where to spend their money," he concludes. "And as in conventional cropping systems, cover crops can help organic producers improve their environmental footprint with sustainable practices that help reduce soil nitrogen losses—an issue that is becoming increasingly important for agricultural producers."

Some of these findings have appeared in *Agronomy Journal* and *Applied Soil Ecology*.—By **Ann Perry,** ARS.

This research is part of Agricultural System Competitiveness and Sustainability (#216) and Climate Change, Soils, and Emissions (#212), two ARS national programs described at www.nps.ars.usda.gov.

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A field test site in Salinas, California, showing a checkerboard of different cover crop treatments being tested, including mustard (yellow flowers), rye, and fallow.

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