Fall-sown cover crops and weed suppression in organic small-scale vegetable production

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Researchers testing cover crop treatments on three organic vegetable crops found that cover crop mulch was effective for early season weed control, but less so later in the season.

In terms of vegetable yields and quality, some vegetables may be better suited to the studied cover crop technique than others.

Weed management is a significant challenge for organic crop and vegetable growers of all scales. Cover crops can be a good option for weed control because they suppress weeds by competing for light, water and nutrients. While contributing to successful weed management, cover crops provide other benefits by reducing erosion, building soil organic matter, and, depending on the cover crop, retaining or providing soil nutrients.

A technique to control weeds with cover crops called Cover crop-based reduced tillage (CCBRT) is gaining traction on organic row crop farms. Could this technique work on small, organic diversified vegetable farms? A team of UW-Madison researchers undertook a two-year study to evaluate weed suppression, manual labor requirements and crop yield and quality under a CCBRT system in organic vegetable plantings. They found that cover crop mulch was effective in early season weed control but less so later in the season, and manual weeding time required in the cover crop treatment was not less than in the cultivated plots. Vegetable yields and quality varied by treatment, crop and year.

About the study

UW-Madison researchers Eric Bietila, Anne Pfeiffer and Erin Silva from Plant Pathology and Jed Colquhoun from Horticulture received funding from the Ceres Trust and the USDA North Central Region Sustainable Agriculture Research and Education program to implement this study. The trials were conducted from October 2012 to October 2014 at the UW-Madison West Madison Agricultural Research Station using two adjacent areas of certified organic land. These plots had been previously planted to diverse vegetable crops and managed organically.

The researchers planned to compare four cover crop treatments: cereal rye, hairy vetch, winter wheat, and a cultivated control plot with no cover crop. Because the hairy vetch completely winterkilled both years, an additional treatment of oat straw mulch was substituted. Within each cover crop plot, they compared three crops: bell peppers, snap beans and potatoes. All field work was carried out with equipment and protocols that would be easily replicated by a typical small-scale grower.

Terminated rye covers the ground between rows of vegetables.

Planting and harvesting

Two weeks prior to planting fall cover crops, residue from the previous vegetable crop was tilled into the soil, with additional tillage for seedbed preparation just prior to planting. Cover crops were seeded into 15-foot wide and 20-foot long plots in October 2012 and September 2013, within the standard planting date recommendations for southern Wisconsin. The cover crop seed was broadcast by hand and lightly hand raked.

The following spring, six nine-inch wide bands were strip tilled at a 30-inch between row spacing into each treatment replication with a small tiller. Strips were tilled every three weeks from mid-April to planting time to maintain a cover crop-free zone for planting vegetables. In late spring, the researchers measured the biomass of each cover crop at flowering, prior to mowing. After cereal grains flowered, the cover crops were mowed with a walk-behind sickle bar mower.

Once the cover crops were terminated, the researchers planted snap bean seeds, seed potato pieces, and eight-week-old bell pepper transplants in the 30-inch tilled strips. They counted, identified and harvested weeds by clipping in two areas in each plot at cover crop termination and at four and six-and-a-half weeks after termination. Weeding was done by hand in each plot to minimize mulch disturbance, both in and between rows. Total hours (standardized for a single person) required for weed management were recorded.

Vegetable plants were side-dressed with composted chicken manure at approximately 18 days after transplanting or after the first true leaves developed. Potato plants were treated with organic-approved substances to combat potato blight and potato leafhoppers in both years.

The researchers harvested all ripe and damaged bell peppers at the green-ripe stage on three dates each year. Snap beans and potatoes were each harvested once per year. For each vegetable, the researchers collected data on a subset of the harvests and sorted the crop into marketable and unmarketable produce, and recorded numbers, weights and other characteristics of each group.

Results

Results differed in 2013 and 2014 because of weather variation. The winter of 2012-13 was colder than average with good snow cover, followed by a wet spring. The summer of 2013 was drier than average, followed by a colder, slightly drier winter than the previous year. Spring 2014 precipitation was normal until June, which was wetter than average. The summer of 2014 saw average temperatures and slightly less-than-average rainfall.

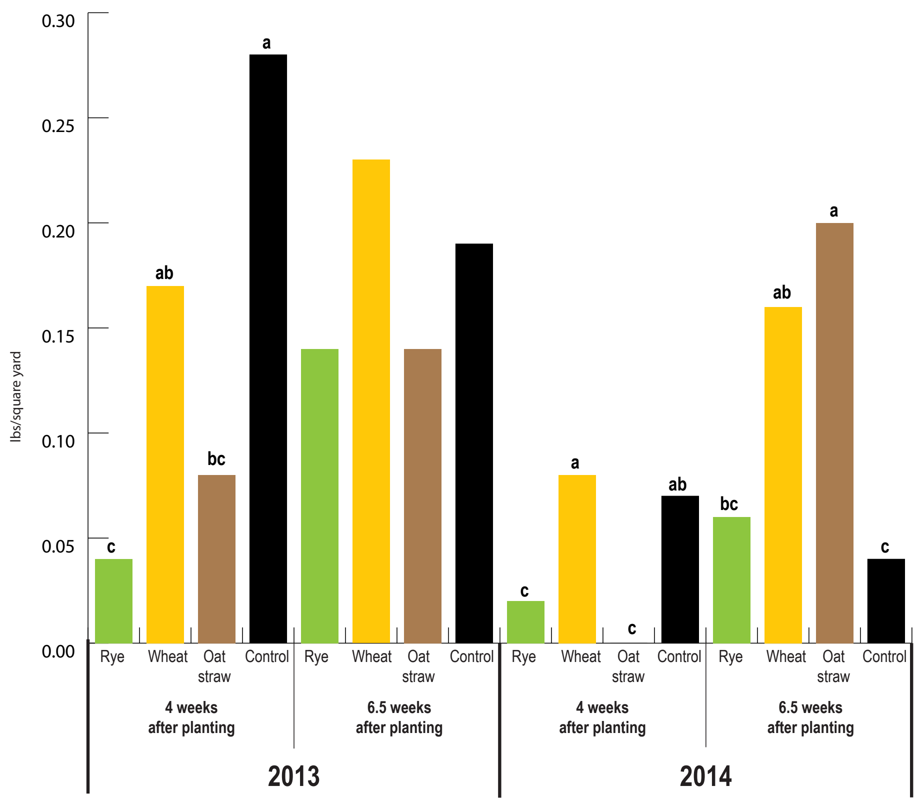
Above-ground biomass production for the wheat and rye cover crops fell near the optimal ranges reported for successful CCRBT techniques in both years of the study. No significant differences in cover crop biomass in wheat and rye were found either year.

Researchers assessed yields and percent marketable crop. Here, a researcher harvests potatoes.

Weed biomass varied by year and by treatment (see Figure 1 on page 3). In both 2013 and 2014, researchers collected less weed biomass from the rye cover crop and oat straw mulch plots as compared to the cultivated control and wheat cover crop plots at four weeks after planting. In 2013, no significant weed pressure differences between treatments were observed at six-and-a-half weeks after planting. However, in 2014, greater weed pressure was noted in the oat straw mulch compared to the other treatments at six-and-a-half weeks after planting due to volunteer oats sprouting from the oat seed in the mulch.

The researchers have several explanations for differences in weed densities among the treatments. First, cereal rye has been reported to

Figure 1. Weed biomass (pounds per square yard) across cover crop treatments and cultivated bare ground control during 2013 and 2014 vegetable production seasons



Column means with the same letter were not significantly different across treatments, within the same year and crop, at $P<0.05$. Columns with no letters contain no values that were significantly different from each other.

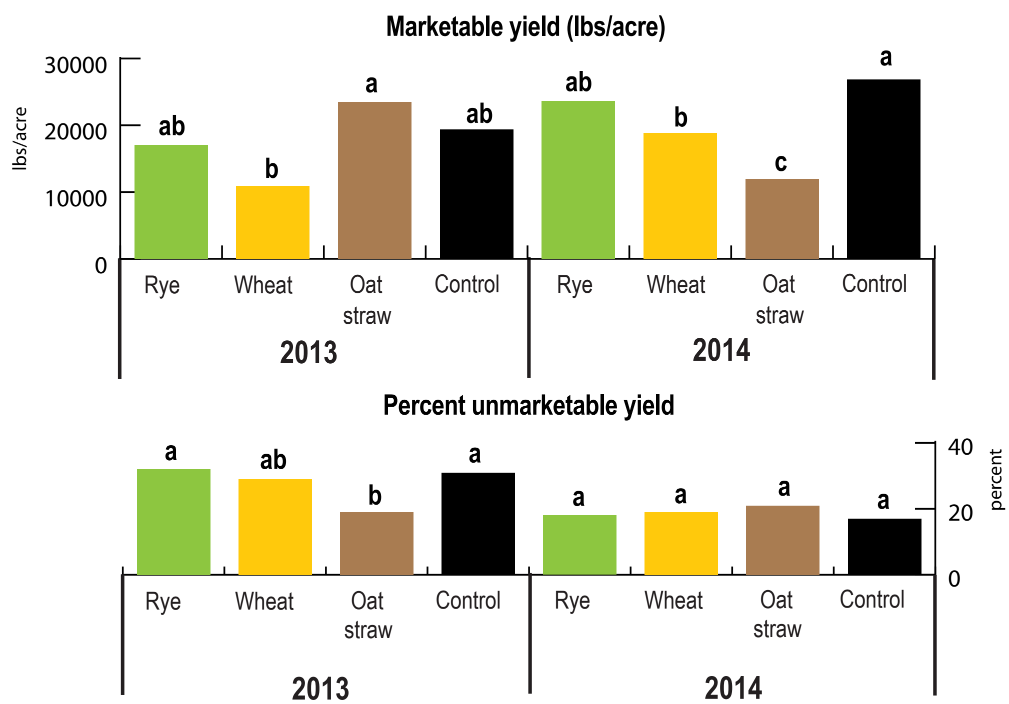
have allelopathic effects, and excellent weed suppression has been demonstrated in other CCBRT systems. Also, termination of the cover crops with mowing resulted in cover crop residues that were not evenly distributed on the soil surface, leaving gaps throughout the row. Weeds could become established in the places where the ground was bare. The oat straw mulch was spread on the ground by hand, which prevented bare spots and provided more consistent suppression of weeds.

The hand-weeding time required for the vegetable plantings was not decreased in the CCBRT treatments compared with the control plots. Because the hand-weeding crews were required to remove weeds through the cover crop residue, the time for manual weeding in the wheat cover crop plots exceeded that of the control plots despite similar weed pressures. Weeds that came up through gaps in the cover crop residue required hand removal throughout the growing season in all of the treatments.

Vegetable yields and quality

In 2013, bell pepper yields were similar in plots with oat straw mulch, rye, and the cultivated control, while those in the wheat treatment had lower yields than the oat straw mulch plots (see Figure 2 on page 4). In 2014, peppers in the rye plots had similar yields to the cultivated control, and those in the wheat plots had lower yields. The oat straw mulch treatment had the lowest pepper yields in 2014, likely due to competition from volunteer oat plants. In 2013, fewer unmarketable peppers were harvested from the straw mulch treatment (19 percent) as compared with rye (32 percent), wheat (29 percent) and control (31 percent) treatments. There were no significant differences in the percent of unmarketable peppers between treatments in 2014. The peppers from rye plots had the largest average fruit diameter and thickest wall width in both years; otherwise, there were no differences observed in fruit quality, shape or symmetry between treatments. Both years, and in all treatments pepper quality was negatively affected by blossom end rot, bacterial soft rot or fungal disease.

Figure 2. Bell peppers under four weed control treatments, 2013 and 2014

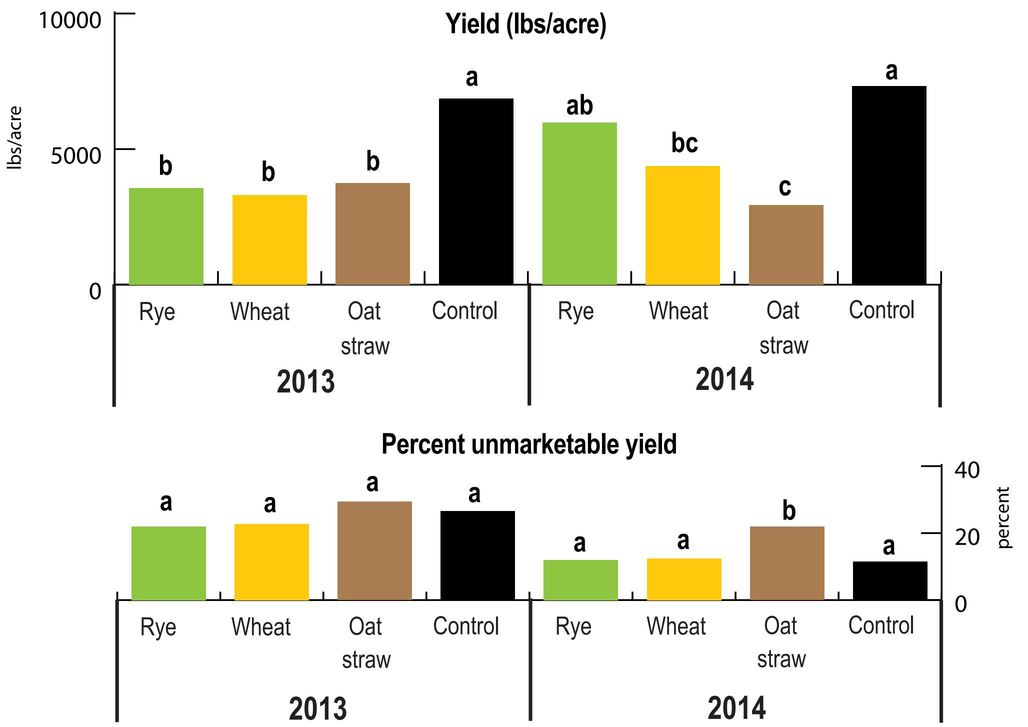


Column means with the same letter were not significantly different across treatments, within the same year and crop, at P<0.05.

In 2013, snap bean yields were highest in the control plots (see Figure 3 on page 5). In 2014, however, bean yields were similar in the rye and control treatments. Similar to peppers, snap bean yields in the 2014 oat straw treatments were lower than the control plots, due to competition from volunteer oat plants. In 2013, no differences were observed in the number of marketable beans from the various treatments. In contrast, the straw mulch plots had significantly more unmarketable beans than all the other treatments in 2014. Unmarketable beans were small, withered, or had insect and disease damage. The average length of the harvested beans was greater in the control plots than in wheat in 2013, and in oat straw mulch in 2014.

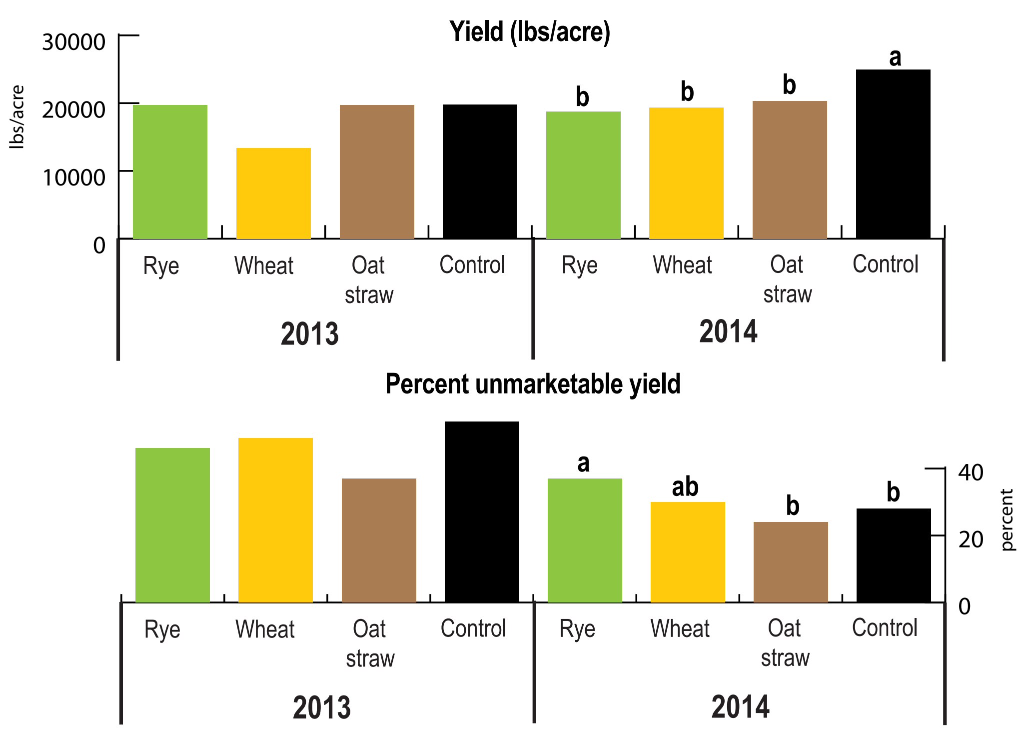
Harvested yields of potato tubers did not vary between treatments in 2013, but in 2014 greater yields were harvested from the control plots compared to all of the other treatments (see Figure 4 on page 5). In 2013, plants in the rye and oat straw mulch treatments yielded the most Grade A size tubers, with over 30 percent weighing more than a quarter pound. In the wheat treatment, only 16 percent of tubers reached this size, and 24 percent did so in the control plots. In 2014, the oat straw mulch treatment resulted in the greatest percentage of Grade A tubers (45 percent), with all other treatments being similar (37 percent). There were no significant differences in unmarketable potatoes between

Figure 3. Snap bean under four weed control treatments, 2013 and 2014



Column means with the same letter were not significantly different across treatments, within the same year and crop, at P<0.05.

Figure 4. Potato under four weed control treatments, 2013 and 2014



Column means with the same letter were not significantly different across treatments, within the same year and crop, at P<0.05. Columns with no letters contain no values that were significantly different from each other.

treatments in 2013. A lower percentage of the oat straw mulch tubers were unmarketable than in the rye plots in 2014. Common reasons for potatoes being unmarketable were small size, greening on the surface and pest damage. In 2014, tubers from the rye plots showed significantly greater pest damage (20 percent) than other treatments, which ranged from four percent in the control plots to seven percent in wheat and 11 percent in oat straw mulch.

Conclusions

"While our results demonstrate that no-till vegetable production using fall-planted cover crops has potential, they also illustrate that challenges remain that need to be recognized when adopting this technique," says Silva. First, the yield impacts differ on any given crop, and certain vegetable crops may be more suited to the system than others. While this data shows that of the vegetables trialed (snap beans, bell peppers, and potatoes), those managed using typical organic production methods had the highest yields, in some cases, the yields using CCBRT techniques were statistically equivalent. In a system where yields and labor are similar for standard cultivation methods and cover crops for weed control, a grower may choose cover crops because of their nutrient cycling and soil building advantages. Further work should be conducted that addresses yield gaps through minimization of cover crop competition for nutrients and water.

Management of the cover crop at termination also remains a key factor determining the success of the system. "Although the CCBRT system provided adequate weed suppression in other row crop trials using a roller-crimper for cover crop termination, this level of weed control did not occur in this study using mowing for termination," Silva says. A smaller version of the roller-crimper adaptable to small-scale vegetable farms could result in more consistent success of CCBRT due to the even distribution of cover crop residue. While the roller-crimper may positively contribute to weed management, vegetable growers need to pay close attention to other management decisions related to cash crop production, including transplanting practices and providing adequate fertility and irrigation to the cash crop. Future research may lead to a set of best management practices for consistent and reliable implementation of CCBRT on organic, diversified vegetable farms.

For more information, contact Erin Silva at emsilva@wisc.edu.

Authors: Erin Silva, Eric Bietila, Jed Colquhoun, Anne Pfeiffer, Ruth McNair

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