TESTING HIGH RESIDUE CULTIVATION FOR NO-TILL SNAP BEAN PRODUCTION

2018 Final Report for the Pennsylvania Vegetable Marketing & Research Program

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Introduction

Conservation tillage practices and the use of cover crops promote soil quality in reduced tillage vegetable cropping systems. However, vegetable growers are facing challenges with weed control during the growing season. In no-till vegetable systems, surface residues of cover crops that were either killed with herbicide or mechanical methods provide weed suppression for about four to five weeks. After this time, there are few chemical options and mechanical cultivation is difficult if cover crop residues are left on the soil surface. Therefore, the growth and yield of vegetable crops such as snap beans and winter squash may be impacted by spring weeds that grow at a faster rate than the cash crop or summer weeds that emerge after planting.

The high residue cultivator (HRC) (Figure 1) has been developed to mechanically control weeds in no-till grain systems that include cover crops terminated with herbicides or the roller-crimper tool (Figure 2). The cover crop residue makes normal cultivation difficult or impossible but the HRC has sweeps that pass under the residue and undercut weeds in the first inch of soil. It has been a successful tool in corn (*Zea* mays) and soybean (*Glycine max*) grain production but is rarely used for vegetables.

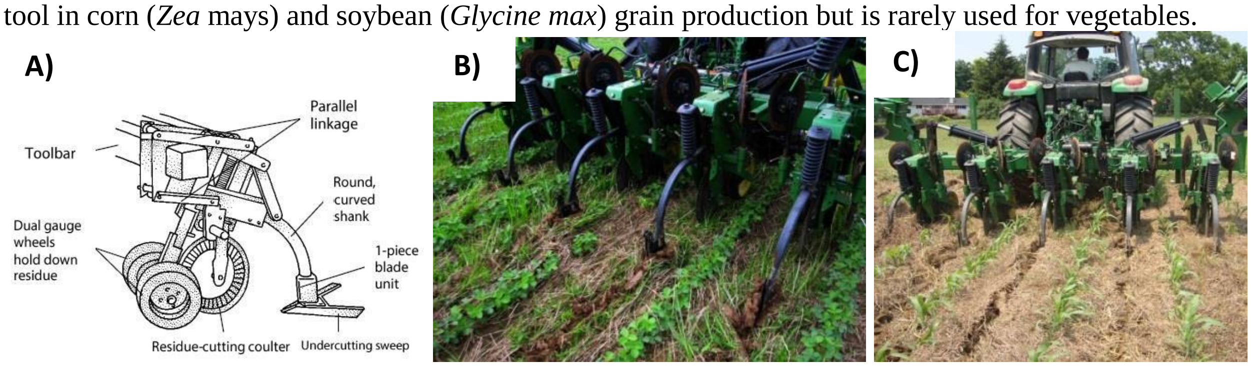

Figure 1. High Residue Cultivators. A) High residue cultivator schematic (from North Carolina State University), B) in organic soybean production, and C) in conventional no-till corn production

In 2018, a field trial was conducted within the Rodale Institute Vegetable Systems Trial (VST) that compared weed control in organic and conventional no-till snap bean (*Phaseolus vulgaris*) production. The VST, which began in 2017, is a long-term, side-by-side comparison of different vegetable management systems that include reduced till and plasticulture systems under organic and conventional management. Weed populations will be continuously monitored within these systems over time. Funding by the Pennsylvania Vegetable Growers Association and Pennsylvania Vegetable Marketing board were used to take weed and yield measurements in 2018.

The specific objective of this project was to measure differences in weed densities, weed communities, and yield of snap beans grown in a no-till system under organic or conventional management.

Materials and Methods

The field layout was a randomized complete block design with 4 replicates of organic no-till snap beans and 4 replicates of conventional no-till snap beans.

***Cover crop establishment*:** Snap beans follow butternut squash (*Curcubita moschata*) in a rotation and cover crops were established on September 12th, 2017 following squash harvest. The organic plots were tilled with a chisel plow, disked and packed, and planted with cereal rye (*Secale cereale*) (VNS) at a rate of 3 bushels (168 lbs.) per acre. Conventional plots were sprayed with 685 ml (24 oz.) Bullzeye®

(Glyphosate) per acre using with a field sprayer and 1.78 bushels (100 lbs.) of cereal rye was planted one week later using a no-till grain drill.

Figure 2. Roller-Crimper. A) Roller-crimper front mounted with a Monosem NG+ no-till planter mounted behind the tractor. B) Rolling down cereal rye and planting snap bean in one pass. The dust cloud just above the roller-crimper is rye pollen. C) Close-up view of roller-crimper and chevron pattern that allows the roller-crimper to maintain contact with cover crop residue at all times and not bounce or skip. D) Field after one-pass roll-crimp and planting. (photos: Rodale Institute)

Cover crop biomass measurements: One day prior to cover crop termination, all aboveground plant biomass is removed from a 1-m^2 quadrat and weighed wet and dry.

Cover crop termination: On May 14th, conventional plots were sprayed with 395 ml (13.4 oz.) Bullzeye® (Glyphosate) tank mixed with 354 ml (12 oz.) Dual II Magnum (S-Metolacholor) and 842 g (1.86 lbs.) ammonium sulfate per acre. On June 6th snap beans (Provider) were planted with a Monosem NG+ no-till field planter in 30-inch rows. An IJ Manufacturing (Gap, PA) 10-foot roller-crimper was front mounted to the tractor to roll and crimp the rye cover crop while planting. In the organic system it is required that the cereal rye reach pollen shed (anthesis) prior to rolling-crimping in order to achieve effective cover crop kill and residue to provide a weed barrier. Two days after planting on June 8th, an additional application of 685 ml (24 oz.) Bullzeye® (Glyphosate) per acre was applied to the conventional plots.

High residue cultivation: The high residue cultivator was used in the organic plots only approximately thirty days after planting on July 2nd.

Weed measurements*:* Weed measurements were taken on July 12th when plants began flowering. Weed measurements within a 1-m^2 quadrat were taken in three random locations in each research plot. All weeds within the quadrat were removed, counted, identified, and total weights measured wet and dry.

Yield measurements*:* Once pods reached marketable size beans were harvested two times per week for five harvest dates. All potentially marketable beans were harvested from two twenty-foot row sections in the middle two rows (8 rows total). Yields were also taken in 10-foot row weed-free plots in each plot. These plots were hand weeded weekly starting 14 days after planting and prior to first harvest. All beans were brought back to the lab and sorted into marketable and cull beans. Culls were mainly those that were misshapen or had spots indicating disease.

Results

Cover crop biomass: The rye cover crop biomass was 2,850 kg per hectare and 4,300 kg per hectare in the conventional and organic plots, respectively. The difference between the management systems was not unexpected since the conventional plots were sprayed with herbicides three weeks prior to cover crop termination with the roller-crimper in the organic plots. Cover crop biomass in the organic treatment is sufficient for adequate weed control but studies with soybeans indicate that as cover crop biomass increases, weed control and yields are improved with a target minimum biomass of 5,000 kg per hectare. The conventional system is relying on herbicides and not cover crop biomass for weed control.

***Weed measurements*:** Weed biomass (grams dry weight per 1-m^2) was higher in the organic treatment but weed density (Number of weeds per 1-m^2) was higher in the conventional treatment (Figure 3). Weeds in the conventional plots emerged later in the growing season due to herbicide applications that included a contact (Glypohosate) and a pre-emergence (Dual II Magnum) herbicide and therefore there were more weeds that were smaller. The weeds in the organic treatment likely emerged early and those that were able to break through the cover crop barrier were larger by time of weed measurement. The weed communities were different between the treatments with ragweed, hairy galinsoga, foxtail and pigweed higher in conventional plots and thistle, dock, nightshade, and bindweed higher in organic plots. Future management strategies may include a targeted approach for problem weeds. Weed management needs to be improved in both systems. In the organic system, strategies should include methods to increase cover crop biomass. In the conventional system, increasing herbicide rates may be necessary for improved weed management. Future research trials will explore these possibilities.

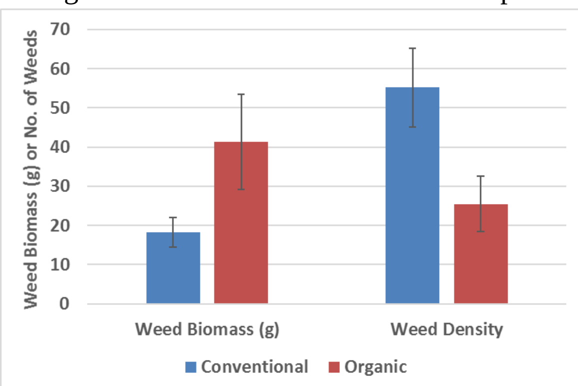

Figure 3. Weed measurements in snap bean production in the Vegetable Systems Trial, Kutztown, PA – 2018. Columns (±SEM) are average dry weed biomass or total number of weeds counted in three 1-m^2 quadrats (4 replicates) in snap bean plots under conventional or organic management.

Yield: Yields were higher in the conventional management system (Figure 4). In the conventional system, yields in the weed free sub-plots were 20% higher than the sub-plots under standard management. In the organic system, yields in the weed free sub-plots were 111% higher than the sub-plots under standard management. It therefore appears that weeds limited yields in the organic system to a greater extent than in the conventional system. However, in the absence of weeds it would be expected that yields between the conventional and organic systems would be comparable. Cereal rye is known to have allelopathic or growth limiting effects on plants grown near rye. This has not been observed for soybean (*Glycine max*) but we suspect it could be what is causing the severe difference in yields between conventional and organic snap beans in this trial. Investigations will be conducted in 2019 to compare snap bean production in rye, triticale, and bare ground to determine if allolopathy may be stunting snap bean growth and production. Previous studies have also found a benefit of heavy rye residue during periods of drought but 2018 was an extremely wet year and soil moisture was not a limiting factor on plant growth.

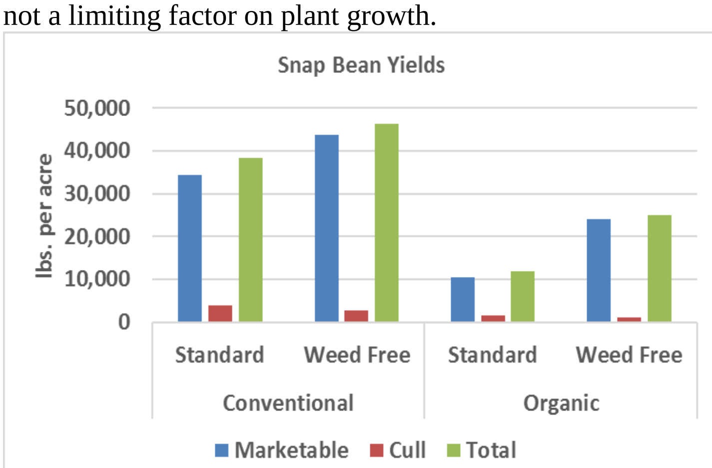

Figure 4. Snap bean yields organic and conventional no-till production systems, Vegetable Systems Trial, Kutztown, PA – 2018. Columns are the sum weights of marketable, cull, and total snap beans harvest five times over three weeks.

The relationship between weed biomass or weed density and yields was modeled and show that incremental increases in weed pressure in the conventional system results in reduced yields while yields are not substantially reduced as weed pressure increases in the organic system. This is consistent with previous work conducted on corn and soybeans [1, 2] and suggests that factors other than weeds may be more limiting to snap bean yields in organic systems. This model will be improved by adding yield and weed free data from 2017 and future years in to a hyperbolic model that has been used previously by weed scientists [1, 2] to determine yield-weed relationships. Also, weed seed bank measurements are taken every three years and will also be used to determine yield limitations due to weeds in organic and conventional vegetable systems [3, 4].

Outreach

This project was showcased during the Rodale Institute's field day in July 2018. Over 400 visitors attended the field day and the VST station included citizen science soil measurements in the organic and conventional snap bean fields. Comprehensive soil health measurements are taken annually in all VST plots that include chemical, physical, and biological measurements. For the field day demonstration penetrometer readings were taken in ten in-row locations in an organic and conventional plot. This was repeated four times with different groups of visitors and each time the depth to sub-surface compaction was shallower in the conventional plot meaning more compaction and a restricted plant rooting depth. The conventional plot had not been tilled for more than 2 years while the organic plot was tilled twice over that time period to establish cover crops. While this was a non-scientific study it suggests that tillage may play a beneficial role of breaking up compaction and that multiple soil health indicators are needed to determine overall soil health. The results of this report will be posted as a fact sheet on the Rodale Institute website. This will be made available as a link from the Pennsylvania Vegetable Grower Associate website or as print article in the Pennsylvania Vegetable Growers Quarterly Newsletter.

Discussion

Weed management is a major concern for vegetable producers. Control of weeds can be a limiting factor in growers deciding to adopt no-till or organic practices. Crop residue left on the soil surface makes it difficult to control weeds during the season without cultivating and organic growers do not have herbicides as tool for weed management. The high residue cultivator could be a viable tool for conventional and organic growers to have additional weed control mid-season in snap beans and other vegetable crops. This study was part of a systems trial that compares differences between organic and conventional management and therefore the high residue cultivator was not tested in the conventional system. Future studies will test the high residue cultivator in organic and conventional plots and take weed measurements before and after cultivation and yield measurements with and without cultivation. The growth of the organic snap beans appeared stunted in 2017 and 2018. Both years were atypically cool, wet years and the heavy rye cover crop residue in the organic system may have kept soils cool and restricted plant growth. However, in both years, there were small, round blemishes on the first and second true leaves that appeared like the symptoms of rust. However, these symptoms were never noticed on the conventional plants and future growth did not show these symptoms. Also, the leaves in the organic plots were a pale green suggesting nitrogen deficiency, yet the seeds were inoculated with *Rhizobium* spp. for nitrogen fixation. For these reasons, we suspect that rye may be stunting the growth of the snap bean plants in the organic system. Future investigations will be conducted to determine if cereal rye is in fact reducing snap bean growth and yield.

Literature Cited

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