Assessing the Impacts of Organic Farming Practices on Soil Health and Weed Management

Andrei Bucaloiu, Bitseat Getaneh, and Dr. Mark Spiro

Biology Department, Summer 2019

Objective

Using organic farming practices can help ensure the long-term viability of a plot of land by sustaining the macroscopic and microscopic ecosystems that contribute to healthy soil and therefore, healthy crop growth. This research aims to test the effectiveness of four different organic agricultural practices for converting previously fallow land at the Bucknell University Farm to functional small-scale agriculture while suppressing perennial weed growth, maintaining soil health, and maximizing food output and nutritional value. The overarching goal of the experiment is to test organic farming techniques that can feasibly be used by everyday gardeners and small-scale farmers.

Methods

We randomized 12 plots (11 x 45 ft.) to four organic farming practices and assessed their effectiveness in weed suppression and maintaining soil health.

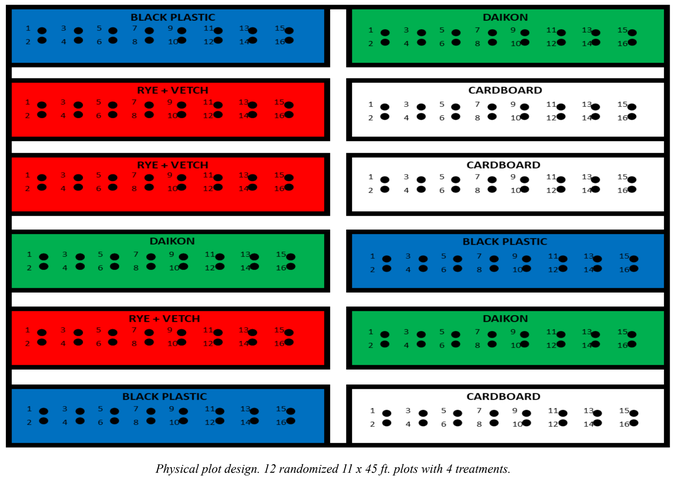
1) Cardboard sheet mulching with oat straw and compost layering above
2) Long-term smothering with black plastic sheeting
3) Shallow rototilling followed by a cereal rye and hairy vetch over-winter cover crop combination
4) Shallow rototilling with an oilseed radish (daikon) winter-kill cover crop

Weed inventories were counted manually. Functional assemblages of microorganisms were assessed using a *BIOLOG EcoPlate*™ assay. Soil temperature was measured with a compost thermometer and soil hardness readings with a soil penetrometer. Soil samples were prepared in May 2019 and sent off to Cornell Soil Health Testing Laboratory to assess basic chemical, physical, and biological factors. See figures and tables.

Butternut squash

Sweet potatoes and Sweet Corn

Potatoes



Physical plot design. 12 randomized 11 x 45 ft. plots with 4 treatments.

Results

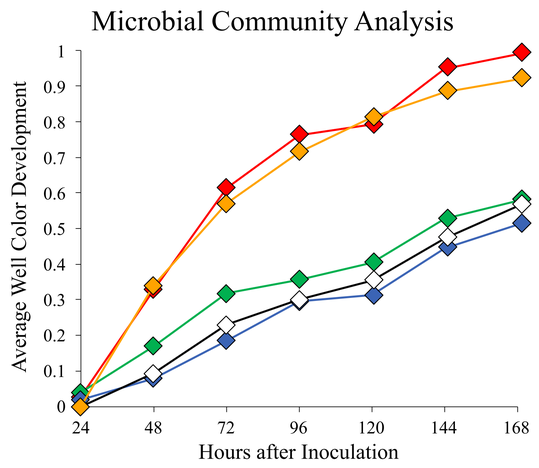


Figure 1 Average Well Color Development at 24 hour intervals for rye and vetch (◆), daikon (◆), black plastic (◆), cardboard (◇), and the control plot (◆)

Table 1 Mean soil respiration for all experimental plots

Treatment	Mean Soil Respiration (mg of CO_2) ± SE
Black Plastic	0.546 ± 0.072
Cardboard	0.609 ± 0.034
Rye and Vetch	0.803 ± 0.045
Daikon	0.692 ± 0.014
Control	0.851 ± 0.053

Table 2 Mean soil temperature for all experimental plots

Treatment	Mean Temp °C ± SE
Black Plastic	15.3 ± 0.1
Cardboard	11.4 ± 0.1
Rye and Vetch	12.8 ± 0.2
Daikon	13.3 ± 0.1
Control	13.7 ± 0.1

Table 3 Mean penetrometer readings for all experimental plots

Treatment	Mean Penetrometer Reading (psi) ± SE
Black Plastic	258.3 ± 21.6
Cardboard	208.3 ± 17.2
Rye and Vetch	195.8 ±16.8
Daikon	154.2 ± 9.6
Control	212.5 ± 12.1

BIOLOG EcoPlate™

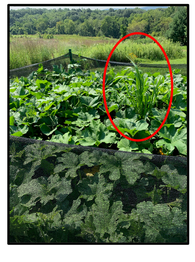
BIOLOG EcoPlate™

A small soil sample is collected using sterile equipment and diluted with saline solution to extract bacteria and minimize particulate matter. A BIOLOG™ EcoPlate contains 31 different carbon substrates that can provide energy to certain functional groups of bacteria. Each plate contains three replicates of the 31 carbon sources and water as a control. As the bacteria start growing they metabolize the substrate which leads to a color change. Higher total average well color development across all substrates means there is a higher total diversity of bacteria; a diverse microbial community in the soil indicates good soil health.

Weed Inventory

Table 4 Mean number of weeds per m^2 found growing in each experimental plot

Treatment	Potato	Sweet Potato	Corn	Squash
Black Plastic	21	14	14	3
Cardboard	46	4	106	9
Rye and Vetch	39	22	7	13



Cardboard treatment (Butternut Squash)

Black Plastic (Butternut Squash)

Rye and Vetch (Butternut Squash)

Discussion

- We observed a significant difference in the soil microbial diversity results between the rye and vetch and the control plots, and the other 3 interventions, which appeared to diminish soil microbial diversity (Figure 1).
- Mean soil respiration was higher in the plots that showed the greatest microbial diversity – control and rye and vetch (Table 1).
- Mean soil temperature was similar between the plots (Table 2).
- Penetrometer reading ranges were all under 300 psi which means none of the 4 treatments greatly inhibit root growth (Table 3).
- Weed pressure varied widely between the plots, and across crops. For cardboard, weed pressure was lowest for both sweet potato and squash, whereas in the rye/vetch and black plastic plots weed pressure was lowest for corn and squash respectively (See Table 4 and the images below).

Going Forward

Professor Spiro Mowing 7/24/19

Building the deer fence 7/24/219

- This is an interim report of data collected in 2019 in a multi-year study.
- More data on perennial weed growth, soil health, and the nutritional content of the crops will be collected and assessed for years to come in the context of a multi-year experiment.
- There will be lots of hard physical work to maintain the plots.

References

Filion, E. (2018) "Assessing the Impacts of Organic Farming Practices on Soil Health and Weed Management." Undergraduate Research Project.

Govaerts, B., Mezzalama, M., Unno, Y., Sayre, K., Luna-Guido, M., Vanherck, K., . . . Deckers, J. (2008). Influence of tillage, residue management, and crop rotation on soil microbial biomass and catabolic diversity. Applied Soil Ecology : A Section of Agriculture, Ecosystems & Environment,37(1), 18.

Pankhurst, C., Hawke, B., McDonald, H., Kirkby, C., Buckerfield, J., Michelsen, P., . . . Doube, B. (1995). Evaluation of soil biological properties as potential bioindicators of soil health. Australian Journal of Experimental Agriculture, 35(7), 1015-1015. doi:10.1071/EA9951015

Acknowledgements

- The Manning Intern for Botanical Science Fund & David Burpee Plant Research Fellowship funded our research.
- Jen Schneidman Partica taught us how to do organic farm work and helped us daily with any and all of our farm/garden work.