Liz Perkus
APS Seminar Abstract
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The Soil at the End of the Tunnel: Soil health and cover cropping in high tunnels

Introduction:

High tunnels (sometimes called hoop houses or poly tunnels) are semi-permanent, plastic-film covered, protected field environments with a unique microclimate: hot, dry summer conditions and warmer spring and fall conditions (Lamont, 2005). In high tunnels, most producers plant crops directly into the ground and irrigate through a dripline. Growers in the Midwest use high tunnels mainly for warm season vegetables (tomato, cucumber, and pepper) in summer, and cool season greens (lettuce, spinach, mustard) in early spring and late fall (Knewston et al., 2010a). High tunnels increase marketable crop quality and yield, while also allowing growers to claim a price premium for off-season, local produce. The yield increase is so dependable that high tunnels are as effective as crop insurance in managing income risk (Belasco et al., 2013).

Access to local produce markets in combination with recent cost-share incentives through the USDA NRCS Environmental Quality Incentive Program have stimulated a rapid expansion in high tunnel construction. While there is a body of evidence demonstrating the effect of high tunnels on crop yields, there is little known about the effect of high tunnels on soil health. Survey data suggests growers in the Midwest are facing soil problems such as salinity and loss of organic matter (Knewston et al., 2010b), and common management practices exacerbate these problems (Montri and Biernbaum, 2009). Research has documented an increase in salinity in high tunnels compared to open fields whether growers are using conventional or organic fertilizers, though not to levels toxic to plants (Knewston et al., 2012). It has also been shown that adding organic matter to high tunnel soils can improve soil health parameters (Bonamoni et al., 2014, Rudisil et al., 2015).

Legume cover crops are a potential management tool to add organic matter to high tunnel systems while decreasing the need for nitrogen fertilizers. Legume cover crops could be grown in the off season winter months (Knewston et al., 2010a). My master's project evaluates legume cover crops as a tool to fertilize cash crops while increasing soil health parameters through organic matter additions.

Project 1:

This research project was designed to evaluate the effect of cover crop treatments for cover crop growth, soil health parameters, and cash crop production. Cover crop treatments included 1) Red clover monoculture, 2) Austrian winter pea/winter rye 1:1 mix, and 3) Hairy vetch/winter rye/tillage radish 4:15:1 mix and 4) Bare soil control. The treatments were planted in a randomized complete block design in 2014 in existing high tunnels in Grand Rapids, MN (zone 3b), Morris, MN (zone 4a), and Rosemount, MN (zone 4b), with 3 blocks in each tunnel. In 2015 and 2016 a split plot design was overlaid to include a planting date treatment.

In 2014, cover crops were broadcast seeded in late September. All cover crops died in the first year, so cover crops were re-seeded in mid-April 2015. In 2015 and 2016, cover crops were seeded at two planting dates, once in late August in between rows of bell peppers and once in mid-September after bell peppers were removed. Cover crops were sampled, mowed, and rototilled in May 2015 and 2016. Bell pepper transplants were planted a week later. Bell peppers received no additional fertilizer, and were harvested from mid-August to mid-September. Soil was sampled just before cover crops were tilled in, 2 weeks after tillage, 5 weeks after tillage, and at final pepper harvest. Data collected includes cover crop biomass dry weight, cover crop percent carbon and nitrogen, potentially mineralizable nitrogen, microbial biomass, permanganate oxidizable carbon, particulate organic matter, total soil carbon and nitrogen, and pH and EC of soil.

Project 2:

After all cover crops died in winter 2014-15, a project was developed to evaluate cover crop freezing tolerance after growth in high tunnels. Freezing tolerance is improved after a period of cold acclimation (Xin and Browse, 2000), but fall high tunnel conditions do not provide this acclimation period. A freezing study, based on similar work by Hulke et al. (2008) will evaluate freezing tolerance of red clover (*Trifolium pratense*) and hairy vetch (*Vicia villosa*) for gradient of freezing temperatures: -6°C, -10°C, -14°C, -18°C, -22°C. Plants will germinate in a 24°C greenhouse for 3 weeks, then grow for 2 weeks in typical late fall high tunnel conditions, 20°C day/-2°C night. The plants will then be exposed to one of five freezing temperatures, and then returned to late fall high tunnel conditions for 3 weeks. After 3 weeks post-freezing, plants will be assessed for survival. Living plants will be harvested dried, and weighed for dry biomass. Dry biomass will be ground to 1 mm, then analyzed on a C/N combustion analyzer for %C, %N, and C:N ratio.

Summary and Impact:

High tunnels are favored by growers in Minnesota for the extended growing season and improved produce yield and quality. Many new high tunnels are being built on the landscape, and there is published and anecdotal data recording soil health decreases in high tunnels. Legume cover crops are a potential management tool to include in high tunnel crop rotations to maintain soil health while also providing nitrogen for cash crops. Preliminary results show that legume cover crop mixtures add between 12.6-44.5 kg N ha^{-1}. There is no measureable effect on soil health measures. Use of a cover crop in this experiment does not decrease pepper yield. Freezing study research will help develop guidelines for cover crop winter survival in high tunnel conditions. The combined results of both projects will be useful for all growers concerned with soil health and reducing fertilizer inputs, and they will be especially useful for organic growers who are directed by the National Organic Program to use cover crops in their crop rotations.

References:

Belasco, E., Galinato, S., Marsh, T., Miles, C., & Wallace, R. (2013). High tunnels are my crop insurance: An assessment of risk management tools for small-scale specialty crop producers. Agricultural and Resource Economics Review, 42(2), 403–418.

Bonanomi, G., D'Ascoli, R., Scotti, R., Gaglione, S. A., Caceres, M. G., Sultana, S., Zoina, A. (2014). Soil quality recovery and crop yield enhancement by combined application of compost and wood to vegetables grown under plastic tunnels. Agriculture, Ecosystems and Environment, 192, 1–7.

Hulke, B. S., Watkins, E., Wyse, D. L., & Ehlke, N. J. (2008). Freezing tolerance of selected perennial ryegrass (Lolium perenne L.) accessions and its association with field winterhardiness and turf traits. Euphytica, 163, 131–141.

Knewtson, S. J. B., Carey, E. E., & Kirkham, M. B. (2010). Management practices of growers using high tunnels in the central great plains of the United States. HortTechnology, 20(3), 639-645.

Knewtson, S. J. B., Janke, R., Kirkham, M. B., Williams, K. A., & Carey, E. E. (2010). Trends in soil quality under high tunnels. HortScience, 45(10), 1534–1538.

Knewtson, S. J. B., Kirkham, M. B., Janke, R. R., Murray, L. W., & Carey, E. E. (2012). Soil quality after eight years under high tunnels. HortScience, 47(11), 1630–1633.

Lamont, W. J. (2005). Plastics: Modifying the microclimate for the production of vegetable crops. HortTechnology, 15(3), 477–481.

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Montri, A., & Biernbaum, J. A. (2009). Management of the Soil Environment in High Tunnels. HortTechnology, 19(March), 34–36.

Rudisill, M. A., Bordelon, B. P., Turco, R. F., & Hoagland, L. A. (2015). Sustaining Soil Quality in Intensively Managed High Tunnel Vegetable Production Systems: A Role for Green Manures and Chicken Litter - Twin Cities Campus. HortScience, 50(3), 461-468.

Xin, Z., & Browse, J. (2000). Cold comfort farm: The acclimation of plants to freezing temperatures. Plant, Cell and Environment, 23(9), 893–902.