Overcoming tunnel vision:

Incorporating cover crops into high tunnel rotations to improve soil health

eaperkus@umn.edu

Liz Perkus[1], Julie Grossman[1], Mary Rogers[1], and Steve Poppe[2]

University of Minnesota Twin Cities - Department of Horticultural Sciences[1], University of Minnesota Morris - West Central Research and Outreach Center[2]

Introduction

High tunnels are increasingly used for season extension in the Upper Midwest for small scale vegetable producers to grow good quality, high value crops. High tunnels extend the growing season earlier in the spring and later in the fall, in many cases allowing year-round crop production with little to no additional heat. High tunnels also create hotter summer conditions needed to produce high quality tomatoes and peppers in Minnesota.

However, intensive high tunnel planting, irrigation, and fertilization to optimize high-value growing space can lead to soil health problems, such as phosphorus build-up, increased salinity and potential loss of organic matter. **This project evaluated the use of cover crops as a management tool for high tunnel soil health improvement and nitrogen fertilization.**

Objectives:

Determine the effect of winter annual legume cover crop mixtures on:

1. Soil health parameters
2. Nitrogen (N) credit
3. Cash crop (pepper) production

Hypotheses:

Legume cover crop mixes will improve soil health parameters relative to a bare control, provide an adequate N credit, and produce an equal or higher yield as the bare control.

Materials and Methods

Four cover crop treatments were broadcast seeded from fall 2015 to spring 2016 in high tunnels at Grand Rapids, MN (21x50 ft), Morris, MN (30x48 ft), and Rosemount, MN (30x48 ft), then terminated with a mower and incorporated with a rototiller. Treatments were replicated three times in one tunnel at each site in a randomized complete block design. Sweet Sunrise yellow bell peppers were planted in spring 2016 and harvested when peppers reached maturity.

1. Red clover
13.5 kg/ha

2. Pea/rye 50-50 mix
84.1 kg/ha

3. Vetch/radish/rye 20-5-75 mix
84.1 kg/ha

4. No cover crop - bare control
Weeded weekly

Site	Hardiness zone	Cover crop plant date	Cover crop termination date	Pepper harvest dates
Grand Rapids	3b	Aug 28, 2015	May 17, 2016	Aug 25 – Sept 16, 2016
Morris	4a	Aug 24, 2015	May 6, 2016	Aug 11 – Sept 13, 2016
Rosemount	4b	Sept 2, 2015	May 4, 2016	Aug 5 – Sept 12, 2016

Sample Collection and Analysis:

1. Cover crop biomass
   Two random 0.1m^2 quadrats per plot were collected and pooled. Samples were dried at 60°C, ground to 1mm, and run on a combustion analyzer for C and N content.
2. Soil samples
   Eight random soil cores were taken to 20cm deep and pooled. Fresh soil was sieved to 2mm, then analyzed with a 28 day aerobic PMN assay and a chloroform fumigation MB assay. Dry soil was dried at 35°C, ground to 2mm and analyzed with a POX-C assay.
3. Pepper harvest
   Peppers were harvested when more than 90% yellow.

Results

Cover crop biomass & C:N ratio:

- Total biomass was similar for treatments across sites
- Legumes and radishes produced more biomass at warmer sites
- Treatments with more legume biomass had a lower C:N ratio

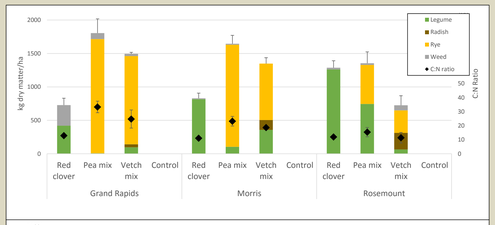

Fig 1. Bars represent cover crop biomass by cover crop type, error bars represent 1 SE, n=3. Black points represent the C:N ratio (right-hand axis) for total biomass, error bars represent 1 SE, n=3.

Permanganate Oxidizable Carbon (POX-C):

- POX-C shows an increasing trend after the addition of cover crop biomass
- Site differences drove observed differences in POX-C concentrations
- Cover crop treatments did not affect POX-C

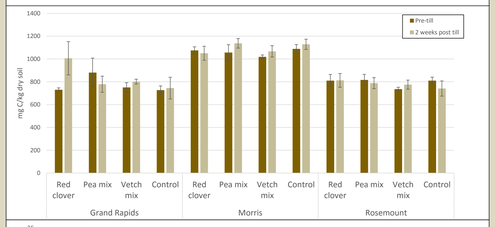

Fig 2. Bars represent permanganate oxidizable carbon (POX-C), error bars represent 1 SE, n=3.

Potentially Mineralizable N (PMN) and Microbial Biomass (MB):

- Cover crops did not noticeably affect PMN or MB, though bare controls generally had lower or midrange values
- Interestingly, Grand Rapids MB in bare controls trended towards higher ranges than cover crop treatment plots

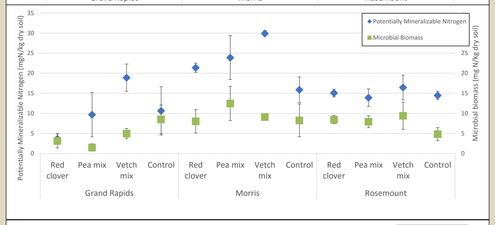

Fig 3. Blue points represent PMN (left-hand axis) with error bars representing 1 SE, n=3. Green points represent MB nitrogen (right-hand axis) with error bars representing 1 SE, n=3.

Pepper Yield and Nitrogen Credit:

- Pepper yield was achieved with no fertilizer additions besides cover crop contributions
- Pepper yield was correlated with cover crop N contributions
- Lower yields at Grand Rapids likely due to cooler growing season

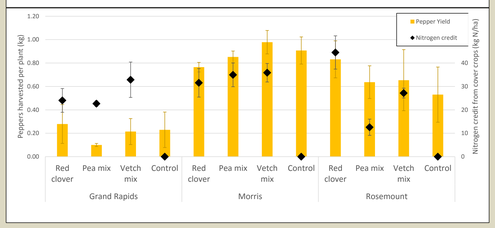

Fig 4. Bars represent total pepper yield (kg) per plant for the whole season. Error bars represent 1 SE, n=3. Black points represent total nitrogen (right-hand axis) added to soil through cover crop biomass. Error bars represent 1 SE, n=3.

Conclusions

- Soil health parameters (POX-C, PMN, MB) may be influenced to a larger degree by site than by cover crop treatment.
- However, cover crops appear to impact a range of soil health parameters when compared to plots where no cover crops are planted.
- Nitrogen delivered through cover crops was correlated with positive changes in yield, PMN, and MB.
- **Cover crop mixes produced a satisfactory yield of peppers with no additional fertilizer.**

Acknowledgments

This project was funded through a USDA NRCS Conservation Innovation Grant (number 69-3A75-14-249).

Endless thanks to the Grossman lab, RROC, NCROC, and WCROC staff for lab, field and technical support, especially Peyton Ginakes, Anne Pfeiffer, Alex Liebman, Sharon Perrone, JiJY Sooksan-Nguan, Vick Hoffman, Kalei Holt, Siwook Hwang, and Yordanose Solomone.