2014

Integrating Cover Crops in High Tunnel Crop Production

Ajay Nair
Iowa State University, nairajay@iastate.edu

Brandon H. Carpenter
Iowa State University, bracarp@iastate.edu

Jennifer L. Tillman
Iowa State University, jtillman@iastate.edu

Dana L. Jokela
Iowa State University, djokela@iastate.edu

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Abstract
High tunnels are plastic-covered, passively ventilated and heated structures where crops are grown directly in soil. They have become important tools for Iowa specialty crop producers to increase production of quality crops, extend the season, and increase profitability. The environment in a high tunnel, without rainfall, limited space, and potential climate control requires a unique set of crop management skills. High tunnel production is primarily dominated by tomatoes. Interest among growers focuses on year-round production in high tunnels. A cohesive and focused approach is needed to tackle issues that arise due to continuous production under these structures. One emerging issue is the intensive use of fertilizers to manage crop nutrient demand and the lack of crop rotation within high tunnels. This could lead to problems such as high salt build up, resurgence of soil-borne and foliar diseases, poor soil structure, lack of microbial diversity, and reduced crop yields.

Keywords
Horticulture

Disciplines
Agricultural Science | Agriculture | Horticulture

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RFR-A1355

Ajay Nair, assistant professor
Brandon Carpenter, graduate student
Jennifer Tillman, graduate student
Dana Jokela, graduate student
Kyle Tester, undergraduate student
Department of Horticulture

Introduction

High tunnels are plastic-covered, passively ventilated and heated structures where crops are grown directly in soil. They have become important tools for Iowa specialty crop producers to increase production of quality crops, extend the season, and increase profitability. The environment in a high tunnel, without rainfall, limited space, and potential climate control requires a unique set of crop management skills. High tunnel production is primarily dominated by tomatoes. Interest among growers focuses on year-round production in high tunnels. A cohesive and focused approach is needed to tackle issues that arise due to continuous production under these structures. One emerging issue is the intensive use of fertilizers to manage crop nutrient demand and the lack of crop rotation within high tunnels. This could lead to problems such as high salt build up, resurgence of soil-borne and foliar diseases, poor soil structure, lack of microbial diversity, and reduced crop yields.

One strategy to mitigate these issues would be to grow cover crops in high tunnels. Cover crops have the ability to build soil organic matter, increase soil structure, suppress weeds, and stimulate soil biology. The space under the high tunnel is of prime value so cover crops that are grown within high tunnels should be of short duration. This study investigated the use of two cover crops—oilseed radish and yellow mustard—in high tunnel tomato production. These cover crops belong to the Brassicaceae family, are short duration (mature 35-45 days after seeding), and are also known to produce a compound called Isothiocyanate (ITC), which acts as a biofumigant. The ITC is harmful to microorganisms and has been shown to suppress the growth of soil-borne pathogens.

Materials and Methods

The study was conducted at the ISU Horticulture Research Station, Ames, Iowa. The study comprised of three treatments—yellow mustard, oilseed radish, or no cover crop. The experimental design was a randomized complete block design with four replications. Each treatment plot was 15 ft × 20 ft with a 4-ft buffer between the blocks. Cover crops were seeded on March 6, 2012 and April 6, 2013. Cover crop seeding was delayed in 2013 as the high tunnel plastic was removed at the end of Fall 2012 to leach excess salts. This leads to excess soil moisture, which hindered tillage operation in Spring 2013. Cover crops were seeded at the rate of 10 lb/acre. Two cover crop biomass subsamples were collected from each treatment on May 7, 2012 and June 6, 2013 using 50 cm × 50 cm quadrats. Samples were oven-dried and weighed to collect cover crop biomass. In addition, in 2013 weed biomass samples were collected. Cover crops were later flail mowed and incorporated into the soil. Seven raised beds with plastic mulch and drip irrigation were created the same day, and tomato (cv. Mt. Spring) transplants were transplanted two days later. Out of the seven rows, three rows were data rows and the rest were guard rows. Each row consisted of 12 tomato plants with 10 data plants and 2 plants on each side as guard plants.

Plants were fertigated through drip irrigation using a combination of fertilizers (28% urea-ammonium nitrate, 20-20-20, or calcium nitrate). Tomato hornworms were managed using *Bacillus thurengiensis*. During the growing season data were collected on plant height and stem girth. Soil samples also were collected at the time transplanting, mid- and end of the season. Tomatoes were harvested and graded into marketable and non-marketable categories and data were collected on fruit number and weight.

Results and Discussion

Cover crop biomass ranged from 3,000 to 4,000 lb/acre. During and at the end of the growing season in 2012, soil pH ranged from 6.7 to 7.1 (Table 1). There were no statistically significant differences in soil pH at any of the sampling dates. Soil electrical conductivity showed significant differences at the start of the experiment but those differences gradually evened out (Table 2).

Plant height and width measured in July in both years did not show any difference either in 2012 and 2013 (data not shown). Cover crops significantly decreased weed biomass (Figure 1). Oilseed radish and yellow mustard treatments had less weed biomass than the control. In our study we did not find any statistically significant difference for marketable and non-marketable yields of tomatoes (Table 3). Overall, there was a decrease in yield in all treatments in 2013.

With cover crop research changes in soil, quality, plant growth, and yield characteristics take time to occur. Changes in soil properties are gradual and it takes continuous cover cropping and addition of soil amendments to bring significant changes in soil properties. Regardless, addition of cover crops builds soil organic matter and improves soil quality and health. Growers should strongly consider integrating cover crops or addition of organic amendments such as compost in their high tunnel systems to mitigate ongoing and future challenges associated with soil quality and health.

Table 1. Effect of cover crops in a high tunnel on soil pH in 2012.

Treatment	Soil pH		
	Before cover crop seeding[1]	Mid-season[1]	Harvest[1]
Control	7.1	7.1	6.9
Oilseed radish	6.6	7.1	6.7
Yellow mustard	6.7	6.8	6.8

[1]Non-significant. Mean separation within columns by Fisher's protected LSD ($P \leq 0.05$).

Table 2. Effect of cover crops in a high tunnel on soil electrical conductivity in 2012.

Treatment	Soil electrical conductivity (dS/m)		
	Before cover crop seeding[2]	Mid-season[1]	Harvest[1]
Control	0.2 b	0.2	0.2
Oilseed radish	0.3 b	0.3	0.4
Yellow mustard	0.6 a	0.2	0.3

[1]Non-significant.
[2]Mean separation within columns by Fisher's protected LSD ($P \leq 0.05$). Means followed by same letters are not statistically different.

Table 3. Effect of cover crop tomato yield characteristics (2012-2013). Data collected from 10 plants per treatment.

Treatment	Marketable number[1]	Marketable weight[1] (kg)
	2012	
Control	166	29
Oilseed radish	165	29
Yellow mustard	166	31
	2013	
Control	125	23
Oilseed radish	123	23
Yellow mustard	109	20

[1]Non-significant. Mean separation by Fisher's protected LSD (P≤0.05).

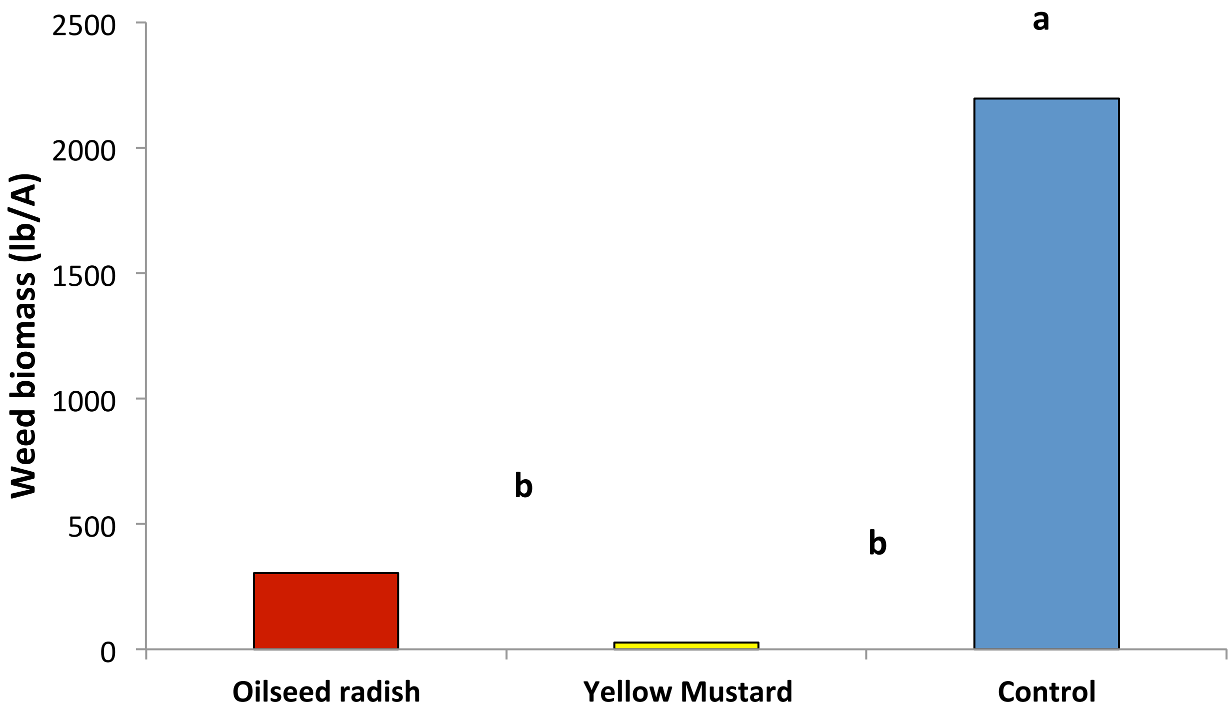

Figure 1. Effect of cover crop on weed biomass in 2012. Weed biomass was collected at the time of termination of cover crop. Columns with the same letters do not statistically differ (P≤0.05).