Novel Cover Crops for High Tunnels Outreach and Research Internship

Alexandra Tracy[1], Krista Jacobsen[1], Erin Haramoto [2], Timothy Phillips [2], Annette Wszelaki[3], and Julia Gaskin[4]

[1] Department of Horticulture, University of Kentucky; [2]Department of Plant and Soil Sciences, University of Kentucky;
[3] Department of Plant Sciences, University of Tennessee; [4] Department of Crop and Soil Sciences, University of Georgia

Introduction

Cover crops have been extensively studied in open-field systems, and are generally considered to enhance environmental sustainability and may be of relatively minimal economic cost, as they typically are grown during a time when crops cannot be grown. The primary reason cover crops are not widely used in high tunnels is due to the growing time required, which encroaches upon cash crop production in year-round systems (Montri & Biernbaum, 2009). If cover crop use is to be expanded in the region, we must identify new cover crops that are particularly well-suited to the unique temporal windows and microclimates of high tunnels. Specifically, ideal cover crops for high tunnels should exhibit traits such as:

- Mature rapidly to minimize the time sacrificed from cash crop production,
- Tolerance to rapid temperature fluxes, including rapid warming in the morning and rapid cooling at night that characterize high tunnels,
- Tolerance to drought and high evapotranspiration rates in summer high tunnel conditions,
- Have sufficient biomass to suppress weeds but be of a manageable quantity that residue can be can be managed with smaller scale equipment,
- Decompose relatively rapidly to minimize nitrogen immobilization that will rob N from the succeeding crop, and/or
- Have other management benefits such as pathogen or pest suppression, or discernable effects on soil health indicators.

As a Southern SARE Young Scholar Enhancement (YSE) Grant recipient, I joined Dr. Krista Jacobsen's lab for a Summer 2018 research and outreach internship associated with the SSARE Research and Education Project "Cover Crops Under Cover" (SSARE award #LS16-272). As a SSARE YSE Scholar, my project assisted with the research and outreach aspects of evaluating novel cover crops for high tunnels in the Southern region, and developing outreach materials that will be useful for high tunnel producers and Extension educators.

Figure 1. Southern SARE YSE Scholar Alexandra Tracy, with novel summer cover crop trial (Objective 2) at the University of Kentucky Horticulture Research Farm, Summer 2018.

Objectives

Objective 1. Develop Cover Crops for High Tunnels Outreach Materials.

The purpose of this objective was to develop a guide to cover crops for high tunnels for the Southeast that bring together our research results from the novel cover crops work, profiles of the successful novel cover crop species and provides basic guidance on high tunnel cover crop selection and management.

Objective 2. Participate in Field Research in Novel Cover Crops for High Tunnels. I participated in every aspect of the second year of the warm season novel cover crop trial at the University of Kentucky Horticulture Research Farm in Lexington, KY. I worked with a team of UK faculty and students who are involved in the project, including the Dr. Erin Haramoto's weed science group, and Dr. Tim Phillips on the species selection and installing the experiment.

Objective 3. Cover Crop Physiological Model Screening. One goal of the funded R&E project is to screen the cover crop accessions for traits that may predict cover crop growth and performance across the Southeast Region. For example, a cover crop with growth that may be predicted by accumulation of growing degree days would mature much more rapidly in the southern portion of the region as compared to the northern portion. I worked with the 2017-2018 data to organize the weather and biomass data to visualize and screen the data for linearity and fit to simple regression models.

Materials & Methods

Objective 1. Outreach documents were drafted to outline promising warm and cool season cover crop candidates identified in the University of Kentucky trials. Research results were combined with a brief literature review, including SARE Resources like "Managing Cover Crops Profitably", the Midwest Cover Crops Council website, and the new Southern Cover Crops Council, to help frame the materials. Draft materials were shared with co-PI's on the project, Dr. Annette Wszelaki (UT) and Julia Gaskin (UGA).

In addition to the Kentucky work, we took a study tour to Georgia (July 20 – July 23, 2018) to meet the participating growers and tour the UGA Plant Science Farm. These sites were growing some of the summer cover crops being trialed at the UK Horticulture Research Farm.

Objective 2. The warm season novel cover crop trial was planted June 15, 2018. A list of accessions and seeding rates are listed in Table 1. Each accession had three replicates, one in each of the three 30' x 72' high tunnels used in the study. Plots were 5' wide by 10' long. The cover crops were broadcast seeded, lightly raked in to ensure good soil contact, and irrigated using drip irrigation. Plots were subdivided into two halves, length-wise. One half was maintained as weed-free, to assess cover crop growth and establishment with minimal presence of weed competition. In the other subplot weeds were allowed to grow with the cover crop to assess weed competitiveness. Biomass samples were taken monthly from each subplot, with weeds in the weed-free subplot sorted by species. Biomass samples were dried at 50C until a constant mass was achieved and then weighed.

Table 1. Seeding rates and selection rationale for the accessions used in the 2018 warm season novel high tunnel cover crop trials at the University of Kentucky Horticulture Research Farm, Lexington, KY.

Accession Name	Seeding Rate (lb/ac)	Selection Traits
Sunn hemp (*Crotalaria juncea*)	35	Soil builder, N scavenger, great weed competitor, excellent nematode suppression, heat tolerant.
Tropic sun sunn hemp (*Crotalaria juncea*)	35	Soil builder, N scavenger, great weed competitor, excellent nematode suppression, heat tolerant.
Sod buster radish (*Raphanus sativus L.)*	12	Large taproot, nutrient scavenger, nematode resistant.
Chinese red cowpea *(Vigna sinensis)*	100	Grows in thick stands to suppress weeds, tolerant to heat, drought, and low soil fertility, resistant to rodent damage.
Teosinte *(Zea luxurians)*	25	Heat tolerant, great weed fighter, soil builder.
Red hemp (*Crotalaria juncea*)	25	Excellent nematode suppression, N scavenger.
Japanese millet *(Echinochloa esculenta)*	28	Fast growing, great weed competitor.
German millet *(Setaria italica)*	28	Fast growing, great weed competitor, low water requirement.
Iron clay pea *(Vigna unguiculata)*	100	Weed suppressor, tolerant to heat, drought and low soil fertility, resistant to root knot nematodes.
Sesame (*Sesamum indicum*)	6	Heat and drought tolerant, resistant to many insect pests, nematode suppressor, soil builder.
Florida broadleaf mustard (*Brassica juncea*)	15	Adapted to grow in hot climates, N scavenger, great nematode suppressor, drought tolerant.
Unplanted check	NA	To verify the weeds that are present.

Objective 3. Temperature and relative humidity data were collected at 15 min intervals on Watchdog button loggers (Spectrum Technologies, Aurora IL) since the start of the novel tunnel crop experiment in June, 2017. Growing degree days were calculated from these data for each replicated tunnel, using a 50°F base temperature and 86°F maximum, where:

$$GDD = (Daily\max(°F) + Daily\min(°F))/2 - 50$$

Cumulative GDD were plotted against cover crop biomass at each collection date from the weeded cover crop subplot for the 2017 warm season and cool season novel cover crop field trails at the Horticulture Research Farm. Data were visualized using pivot tables in Microsoft Excel.

Results

Objectives 1&2. Outreach materials were drafted based on the observations and data from our field study (Objective 2), discussion with the project leads at UT-Knoxville and UGA, and from talking with the participating Georgia farmers. Based on these experiences, we identified some key outreach needs and outlets, and developed our overall outreach plan for the project. From talking with farmers and the researchers, we determined that we needed outreach information that included information on cover crops for high tunnels more generally, as well as information on specific cover crops we have been evaluating.

Figure 2. Photos of participating farmer's in Georgia. Above: Celia Barss of Woodland Gardens with her sunn hemp cover crop and the Kentucky study tour team. Below: Nicolas Donck of Crystal Organic Farm with his sunn hemp and Iron Clay cowpea cover crops. Both producers indicated preference for cover crops with manageable biomass and nematode suppression traits.

As an outcome of this Southern SARE YSE project, we were also able to connect this work with the Southern Cover Crops Council. This was an exciting development from the study tour and provides an ongoing outreach home for materials developed from this project.

The following materials were drafted, and will be edited and refined by the researchers as the project draws to a close:

- University of Kentucky Extension fact sheet on managing cover crops in high tunnels, focused on general with general information on cover crop selection, planting and establishment considerations, and some of the unique challenges to cover crop production in high tunnels and how to manage for them.
- Cover crop profiles for high tunnels, based on the novel cover crops evaluated in Objective 2, as well as more common cover crops successfully used in high tunnels. These will be formatted for use for the Southern Cover Crops Council website.

An example of some of the summary tables guiding cover crop selection, are shown in Table 2, below.

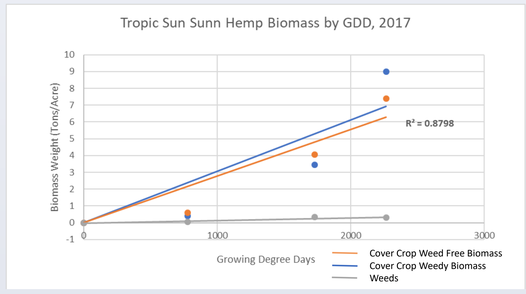
Table 2. Cover crop rankings for promising warm season cover crops for high tunnels evaluated in Objective 2. Rankings were developed from experimental data and observations, and complemented with literature review findings when available.

Cover Crop	Traits						Tolerance			Comments
	N Fixing	N Scavenging	Soil Builder	Weed Suppression	Nematode Suppression	Quick Growth	Heat	Draught	Low Fertility	
Millet, German	No	Good	Fair	Good	Poor	Excellent	Very Good	Good	Poor	Matures a few weeks later than Japanese millet.
Millet, Japanese	No	Good	Good	Good	Poor	Excellent	Very Good	Good	Poor	Rapidly maturing after initial establishment.
Teosinte	No	Good	Excellent	Excellent	Unknown	Good	Excellent	Very Good	Unknown	Less biomass than a sorghum-sudan crop. Excellent weed suppression.
Cowpea, Chinese Red	Yes	Fair	Fair	Fair	Poor	Good	Very Good	Very Good	Very Good	More vining habit and later to mature than Iron Clay varieties.
Cowpea, Iron Clay	Yes	Fair	Good	Fair	Good	Good	Very Good	Very Good	Very Good	Rapidly maturing. Heat and drought tolerant once germinated.
Sesame	No	Unknown	Excellent	Very Good	Very Good	Fair	Excellent	Excellent	Unknown	Tolerates high heat, breaks down quickly.
Sunn Hemp, AU Golden	Yes	Very Good	Very Good	Good	Excellent	Fair	Excellent	Very Good	Very Good	Prone to rodent and rabbit damage, can be difficult to establish. Very drought tolerant and rapid growth.
Sunn Hemp, Tropical	Yes	Very Good	Very Good	Very Good	Very Good	Fair	Excellent	Very Good	Very Good	Prone to rodent and rabbit damage, can be difficult to establish. Very drought tolerant and rapid growth.
Mustard, Florida Broadleaf	No	Good	Poor	Poor	Very Good	Fair	Good	Very Good	Fair	Not heat tolerant. Rapidly maturing.

Results (Continued)

Objective 3. Much of the summer efforts on this objective involved organizing plant biomass data and working with large data logger sets to calculate growing degree days and format master data sheets. Pivot tables were used to do the preliminary data visualization, and determine if simple regression models using the basic GDD base 50 calculation could potentially fit. Promising summer cover crop candidates, pending additional analyses, include 'Tropic Sun' sunn hemp (Figure 3), Japanese millet, and Chinese red cowpea. The researchers will continue to refine this data and include the data from the 2017 warm season trial, and the upcoming 2017-2018 cool season trial.

Figure 3. Example of regression of plant biomass on growing degree days, used to assess potential for simply Base 50 GDD models. R^2 values reflect crop weed-free biomass.



Conclusions

The body of work performed through this YSE grant made strides on a number of project objectives. The energy put into the development of outreach materials will greatly increase the overall impact of the project, and helped the researchers determine an outlet for the materials that will build on the cover crop movement in the region. The data organization and preliminary analysis go a long way in helping the researchers move toward final analysis and publication. And finally, we all greatly enjoyed working and learning together, and are grateful for the opportunity this funding afforded.

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