# Exploring Winter Legume Cover Crops in Organically Managed High Tunnels


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## INTRODUCTION

### BACKGROUND:

- High tunnels (HT) are semi-permanent structures used in temperate climates to increase vegetable production
- HTs leverage shoulder seasons when open fields may be inaccessible (cold weather or spring flooding)
- NRCS have increased their popularity through cost-share programs

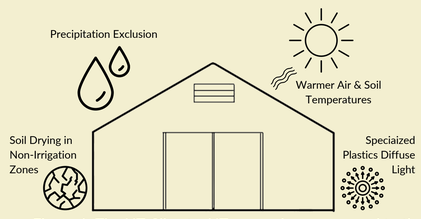



Figure 1: The HT Climate. HTs are unique compared to the open field

### SOIL HEALTH TRADEOFFS:

- HTs are associated with soil degradation via nutrient buildup, compaction, and yield losses
- Caused by the unique HT climate (Fig. 1) and intensified management

**Image 1: Salt accumulation is a particular threat to the productivity of HTs**

### RESEARCH OBJECTIVE:

- Determine planting and termination times for winter legume cover crops to optimize cover crop biomass production, soil health metrics, and cash crop yield

### JUSTIFICATION:

- **There is limited knowledge of how winter cover crops' planting and termination time impact soil health and cash crop yield**

**Image 2: Legume cover crops are valued in organic agriculture for their ability to biologically fix nitrogen from the atmosphere**

### HYPOTHESES:

- Cover crop plots with the longest growth time may have lower cash crop productivity
- Cover crop plots with the shortest growth time may have lower soil health and nutrient cycling metrics
- Control plots without cover crops (continuous cash crops) will have lower soil health metrics since all crop residue is removed

## METHODS

### FIELD / TREATMENT DESIGN

#### SITE CHARACTERISTICS:

- Randomized complete block design (Image 3)
- All site management practices follow USDA Organic standards
- No compost or fertilizer used to best capture cover crop contributions
- St. Paul, MN (1 HT, 96'x30')
- Lamberton, MN (2 HTs, 48'x30')*


#### CROPS IMPLEMENTED

WINTER COVER CROP

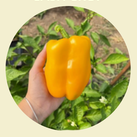
Organic Hairy Vetch [*Vicia villosa*]

Organic Austrian Winter Pea [*Pisum sativum*]

WINTER CASH CROP

Organic "Corvair" Spinach [*Spinacia oleracea*]

SUMMER CASH CROP



Organic "Sweet Sunrise" Bell Pepper [*Capsicum annuum*]

#### COVER CROP PLANTING TIMES:

- mid-September planted (early)
- mid-October planted (late)

#### COVER CROP TERMINATION TIMES:

- mid-April terminated (early)
- mid-May terminated (late)

#### TREATMENTS TESTED:

**2 Cover Crops × 2 Planting Times × 2 Termination Times**

| | | |
|---|---|---|
| PEA | SEPTEMBER | APRIL |
| PEA | SEPTEMBER | MAY |
| PEA | OCTOBER | APRIL |
| PEA | OCTOBER | MAY |
| VETCH | SEPTEMBER | APRIL |
| VETCH | SEPTEMBER | MAY |
| VETCH | OCTOBER | APRIL |
| VETCH | OCTOBER | MAY |

**SHORTHAND KEY:**

**PSA = Pea/September Planted/April Terminated**

*DATA NOT REPORTED

**Image 3: Block design with different cover crop treatments**

### MEASUREMENTS

#### SOIL HEALTH METRICS:

- Permanganate Oxidizable Carbon (POX-C)
- Microbial Biomass (MB)**
- Potentially Mineralizable Nitrogen (PMN)**

#### COVER CROP PRODUCTIVITY:

- At spring termination ~2 sq. ft. of cover crop biomass was collected from each plot and weighed
- Biomass was dried and combusted for carbon (C) and nitrogen (N) content**

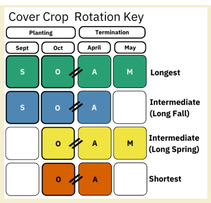
#### CASH CROP PRODUCTIVITY:

- Bell pepper harvest began once peppers reached marketable quality or if damage/disease was present
- Yield weight per plant/week was recorded

**ANALYSES UNDERWAY

## RESULTS

### TREATMENT/ROTATION KEY

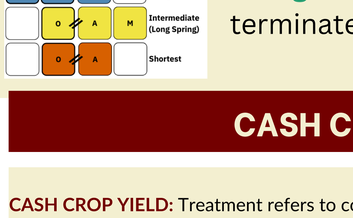



**RESULTS** are color-coded according to **COVER CROP** rotation length (e.g. "**Longest**" = September planted, May terminated)

### CASH CROP YIELD

**CASH CROP YIELD:** Treatment refers to cover crop species and rotation. Long cash crop season did not significantly increase yield. Data reported includes St. Paul, MN 2023 seasonal data only



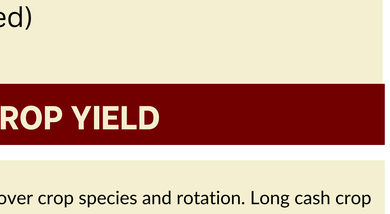




**IMAGE 5: Pepper criteria for Marketable and Culled peppers. Cash crop figures reflect marketable peppers only.**

### COVER CROP BIOMASS

Table 1: Total legume cover crop biomass in lb · acre-1 (dead and alive), analyzed by year. Data reported by cover crop treatment for St. Paul site only. Letters represent significant differences (alpha = 0.05) between values for a single biomass type within a single year column. Mean separation was performed using Tukey's HSD test

| | | Fall Termination | Spring Planting | Y1 2021-22 | Y2 2022-23 |
|---|---|---|---|---|---|
| Legume biomass (lb · acre-1) | Pea | September | April | 5782 b | 1118 ab |
| | | | May | 5326 b | 1853 b |
| | | October | April | 3510 ab | 117 a |
| | | | May | 6030 b | 242 a |
| | Vetch | September | April | 2418 ab | 138 a |
| | | | May | 4072 ab | 280 a |
| | | October | April | 596 a | 21 a |
| | | | May | 3931 ab | 165 a |

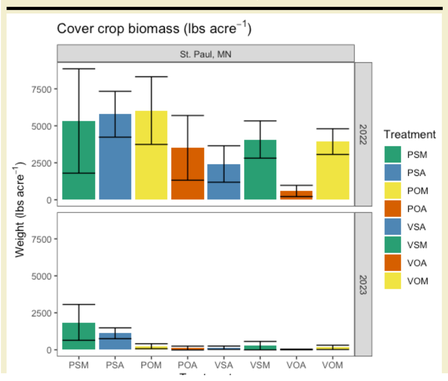
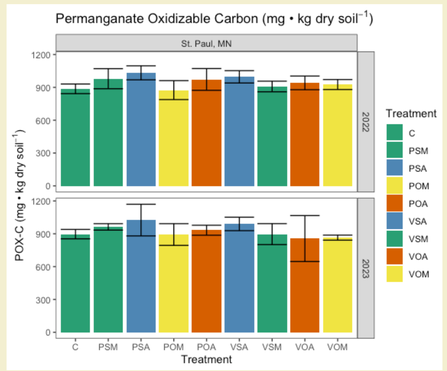
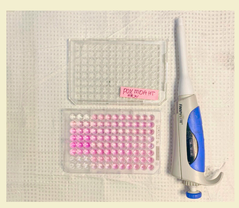



**IMAGE 4: Y1 PSM (longest) cover crop plots.**

### LABILE CARBON (POX-C)

**POX-C:** No treatment differences; cover crops did not increase readily available carbon pools compared to no cover crop plots



## CONCLUSIONS

### CASH CROP

- Early planted peppers (i.e. VOA, VSA, POA, PSA) saw significant spikes in yield in mid-August, while others did not
- Growing peppers later into the fall did NOT increase overall yield

### COVER CROP:

- Longest cover crop treatments accumulated the most biomass (September planted, May terminated)
  - Most cover crop treatments did NOT have any differences

### SOIL:

- POX-C was not affected by cover crop treatments

## DISCUSSION & FUTURE WORK

- HTs offer high-value, season extension to organic vegetable farmers' rotations.
  - Soil degradation has the potential to offset economic gains
- Producers can monitor cash crop yield to determine the optimal cut-off time and reduce strain on the soil
- Cover crops have the potential to increase soil health, however, long-term studies are needed as effects can take years to translate into tangible results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