# High Tunnel Organic Vegetable Production at the University of Minnesota SWROC

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## INTRODUCTION

High tunnels are plastic covered, low-energy use structures that appear similar to greenhouses, but differ from conventional greenhouses in major ways, one being significantly lower construction and operating costs. High tunnels are capable of extending the growing season earlier in the spring and later in the fall, increasing the availability and amount of locally grown food. High tunnels are an intermediary between full environmental risk-taking of outdoor production, and the controlled conditions and relatively high energy use of a conventional greenhouse.

High tunnels can be successfully used in organic production by offering a more controlled environment offering protection from weather conditions such as heavy rain and wind; constant wet foliage which can lead to disease problems; may provide a safe haven for predatory insects; and generally provide plants with a less stressful growing environment.

Organic high tunnel research has been conducted at the University of Minnesota Southwest Research and Outreach Center (SWROC), located in Lamberton, MN since 2009. The SWROC has three 30' x 48' high tunnels, certified by the Midwest Organic Services Association (MOSA).

## OBJECTIVES

This research was conducted to investigate:
- the effects of beef manure compost and overwintering hairy vetch cover crop on crop yield (fertility);
- variety performance for cucumber, peppers, and tomatoes (variety);
- the interaction between fertility and variety and its effects on crop performance.

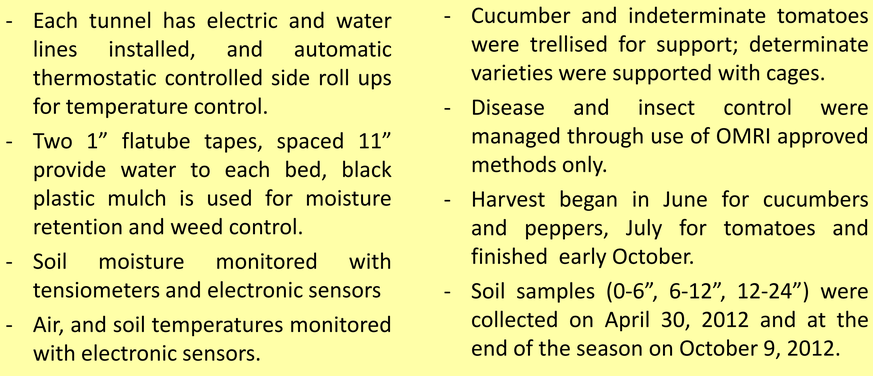
## MATERIALS AND METHOD

### Soil fertility treatments:

1. Beef manure compost applied at 100 lb available N/acre
2. Hairy vetch cover crop seeded at 35 lb seed/acre
3. Beef manure compost applied at 50 lb available N/acre + hairy vetch (35 lb seed/acre, fall of 2011)

### Vegetable crop varieties:

1. Indeterminate tomatoes – Cobra and Better Boy
2. Determinate tomatoes – BHN-589 and Scarlet Red
3. Cucumbers – Sweet Success and Socrates
4. Green Peppers – Ace and Carmen




### High tunnel setup:

- Three gothic style 30'x48' high tunnels oriented east-west for optimal solar radiation.
- Certified organic land, in close proximity to windbreaks for protection.
- Five 40'x2' raised beds (3") per tunnel, centered 63" apart, and divided into 3 soil fertility subplots.
- After construction each bed had an application of 28 lbs/ft$^2$ of sand.
- Each tunnel has electric and water lines installed, and automatic thermostatic controlled side roll ups for temperature control.
- Two 1" flatube tapes, spaced 11" provide water to each bed, black plastic mulch is used for moisture retention and weed control.
- Soil moisture monitored with tensiometers and electronic sensors
- Air, and soil temperatures monitored with electronic sensors.

### Procedures:

- Vegetable seedlings were started in greenhouse (tomatoes and peppers February 28, and cucumbers March 9).
- Hairy vetch (planted October 6, 2011), was mowed and incorporated into beds on March 28, 2012. Compost was applied and incorporated March 29, 2012.
- Vegetable seedlings were transplanted 22" apart into the high tunnels on April 23, 2012.
- Cucumber and indeterminate tomatoes were trellised for support; determinate varieties were supported with cages.
- Disease and insect control were managed through use of OMRI approved methods only.
- Harvest began in June for cucumbers and peppers, July for tomatoes and finished early October.
- Soil samples (0-6", 6-12", 12-24") were collected on April 30, 2012 and at the end of the season on October 9, 2012.


## RESULTS AND DISCUSSION

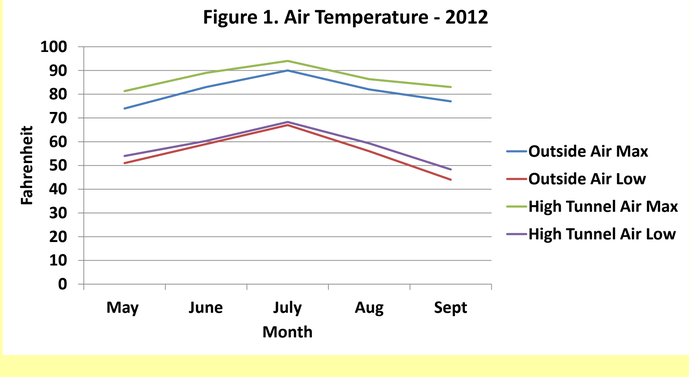



**Table 1. Growing Degree Days**

| | 2012 GDD | |
|---|---|---|
| Date | High Tunnel | Outdoor |
| May | 523 | 403 |
| June | 717 | 612 |
| July | 875 | 808 |
| August | 643 | 572 |
| September | 451 | 412 |
| Total | 3209 | 2807 |

+GDD = (Tmax +Tmin)/2 – Tbase. Where Tmax is maximum daily temperature and is set equal to 86°F when temperatures exceed 86°F,Tmin is the minimum daily temperature and is set equal to 50°F when temperatures fall below 50°F, Tbase is the base temperature.

**Table 2. 2012 Vegetable Yield – Total Season Weight (lbs) by Soil Fertility Treatment**

| | Cucumbers | | Green Peppers | | Indeterminate Tomato | | Determinate Tomato | |
|---|---|---|---|---|---|---|---|---|
| Soil Fertility Trt | Socrates | S. Success | Ace | Carmen | Cobra | B.Boy | BHN-589 | S. Red |
| Compost | 254 a | 259 b | 99 a | 108 a | 207 a | 202 a | 323 a | 240 a |
| Hairy Vetch | 225 b | 201 b | 118 a | 121 a | 186 a | 200 a | 339 a | 301 a |
| Compost + Hairy Vetch | 224 b | 326 a | 84 a | 101 a | 214 a | 176 a | 282 a | 174 a |

+Means followed by the same letter by column are not significantly different at the 0.05 probability level.

**Table 3. Cucumber Yield – Total fruit weight, number of fruit, and fruit size by date**

| | Total lbs/date | | Fruit harvested | | Mean lb/fruit | |
|---|---|---|---|---|---|---|
| Date | Socrates | S. Success | Socrates | S. Success | Socrates | S. Success |
| June | 218 b | 326 a | 585 a | 481 a | 0.37 a | 0.68 a |
| July | 320 a | 337 a | 823 a | 482 a | 0.39 a | 0.69 a |
| August | 165 b | 123 b | 483 a | 194 a | 0.31 a | 0.60 a |
| Total | 703 B | 786 A | 1891 A | 1157 A | 0.36 B | 0.66 A |

+Column values followed by the same lower-case letter are not significantly different at P = 0.05. Total values followed by the same capital letter are not significantly different at P = 0.05.

**Table 4. Pepper Yield – Total fruit weight, number of fruit, and fruit size by date**

| | Total lbs/date | | Fruit harvested | | Mean lb/fruit | |
|---|---|---|---|---|---|---|
| Date | Ace | Carmen | Ace | Carmen | Ace | Carmen |
| June | 24 c | | 109 b | | 0.22 b | |
| July | 51 b | 80 b | 161 b | 288 c | 0.32 a | 0.28 a |
| August | 98 a | 89 b | 349 a | 357 b | 0.28 a | 0.25 a |
| September | 39 b | 22 c | 169 b | 109 d | 0.25 b | 0.21 b |
| October | 89 a | 139 a | 390 a | 798 a | 0.23 b | 0.20 b |
| Total | 302 B | 330 A | 1178 B | 1552 A | 0.26 A | 0.24 B |

+Column values followed by the same lower case letter are not significantly different at P = 0.05. Total values followed by the same capital letter are not significantly different at P = 0.05.

**Table 5. Indeterminate Tomato Yield – Total fruit weight, number of fruit, and fruit size by date**

| | Total lbs/date | | Fruit harvested | | Mean lb/fruit | |
|---|---|---|---|---|---|---|
| Date | Better Boy | Cobra | Better Boy | Cobra | Better Boy | Cobra |
| July | 142 b | 151 b | 193 c | 235 c | 0.76 a | 0.56 a |
| August | 226 a | 190 a | 398 b | 466 b | 0.57 b | 0.43 b |
| September | 82 c | 80 c | 160 c | 218 c | 0.51 b | 0.32 c |
| October | 158 b | 158 b | 467 a | 562 a | 0.34 c | 0.29 d |
| Total | 607 A | 578 A | 1218 B | 1481 A | 0.54 A | 0.40 B |

+Column values followed by the same lower case letter are not significantly different at P = 0.05. Total values followed by the same capital letter are not significantly different at P = 0.05.

**Table 6. Determinate Tomato Yield – Total fruit weight, number of fruit, and fruit size by date**

| | Total lbs/date | | Fruit harvested | | Mean lb/fruit | |
|---|---|---|---|---|---|---|
| Date | BHN-589 | Scarlet Red | BHN-589 | Scarlet Red | BHN-589 | Scarlet Red |
| July | 143 c | 112 b | 277 c | 165 c | 0.53 a | 0.61 a |
| August | 317 b | 167 b | 630 b | 308 b | 0.51 ab | 0.54 b |
| September | 82 d | 139 b | 172 d | 283 b | 0.47 b | 0.48 c |
| October | 402 a | 297 a | 1287 a | 953 a | 0.31 c | 0.31 d |
| Total | 944 A | 715 B | 2366 A | 1709 B | 0.45 B | 0.52 A |

+Column values followed by the same lower case letter are not significantly different at P = 0.05. Total values followed by the same capital letter are not significantly different at P = 0.05.

## Discussion

- Maximum and minimum air temperatures are shown in Figure 1. During the 2012 growing season the maximum air temperature in the high tunnels averaged 5.5 ºF greater than the outside maximum temperature. In addition, High tunnel minimum air temperatures were 2.5 ºF warmer than the outside minimum temperatures.
- Growing degree days (GDD) are a method to evaluate the effect of temperatures on plant growth. Long-term GDD values for Lamberton average 2528. In 2012 (Table 1) outside GDD totals were 2807 compared to 3209 in the high tunnels.
- The different soil fertility treatments did not seem to be a significant factor controlling total yield for any of the vegetable crops or varieties studied except cucumbers (Table 2). Socrates yielded greatest with the compost only treatment, sweet success yielded greatest in compost plus cover treatment.
- Cucumber season totals are shown in Table 3. Yield weight totals were greatest in June and July for both varieties than in August. Due to the large variability, there was no significant difference in the number of fruit harvested or the size of the fruit. Overall, Sweet Success had a significantly greater total yield and fruit size, but Socrates produced more total fruit.
- Green pepper yields varied by variety (Table 4). Ace yield weight totals were significantly greater in August and October. Carmen total yield weight was significantly greatest in October. Fruit size was significantly greatest in July and August for both varieties. Carmen had significantly greater season yield totals and number of fruit harvested than Ace; however Ace had significantly greater fruit size.
- Indeterminate season totals are shown in Table 5. August was the most productive month in the season for both Better Boy and Cobra and October was the second highest in total yields. The greatest number of fruit were harvested in October for both varieties. Fruit size was largest in July for Better Boy and Cobra and decreased for both varieties as the season progressed. Overall, Better Boy had significantly greater total yield weight and fruit size, but had lower total fruit harvested.
- Determinate yields are shown in Table 6. BHN-589 and Scarlet Red had significantly greatest yield totals and number of fruit harvested in October. Fruit size was greatest early in season for both determinate tomato varieties, however, the fruit size decreased as the season progressed. The total yield weight and fruit harvested was significantly greater with BHN-589; in contrast Scarlet Red yielded significantly larger fruit size.

## CONCLUSIONS

- Air temperature and GDD results from this study showed that high tunnels can provide a positive impact for producers by providing higher GDD per season compared to outside conditions.
- All soil fertility treatments tested provided similar amounts of nutrients for optimum production. The choice for nutrient sources should be made after performing a detailed observation on the soil fertility status. This can help avoid potential drawbacks due to intense compost based agriculture.
- Crop variety was one of the most significant effect observed in this study. There was a trend in all varieties where the higher the fruit size the lower the total number of fruits produced.
- The results of this research showed that the best choice of variety for a farmer should be based on how the produce will be sold:
  - If produce is to be sold as unit, then varieties that produce the higher number of fruits should be selected;
  - if produce is to be sold by weight, then varieties that result in higher total yields should be selected.

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