

# Biochar as a Soil Amendment in a High Tunnel, Polybag Growth System

**Dr. Ron Goldy and Virginia Wendzel**  
**Southwest Michigan Research and Extension Center**  
**Benton Harbor, Michigan**

## Objectives

The purpose of this trial is to determine if biochar has an effect on yield and quality of cucumber (*Cucumis sativus*, cv. USAC 8834), tomato (*Solanum lycopersicum*, cv. Conan), spinach (*Spinacia oleracea*, cv. Bloomsdale), basil (*Ocimum basilicum*, cv. Italian Large Leaf), Swiss chard (*Beta vulgaris* subsp. *cicla*, cv. Technicolor), snap dragon (*Antirrhinum majus*, cv. Rocket Mix), and lettuce (*Lactuca sativa*, cv. Tropicana) in a high tunnel production, polybag system.

## Summary

Addition of biochar at volumes of 0.5%, 1%, 2%, 4%, and 8% to Morgan's 301 soil mix did not increase yield or quality of cucumber, tomato, spinach, basil, Swiss chard, lettuce, or snap dragon. Lack of significant effect could be due to the high organic and nutrient content already present in the 301 mix. Biochar also has proven to have a greater effect the second year after application.

## Methods

### Soil Mix

Biochar was combined with Morgan's 301 Mix at a volume ratio of 0, 0.5%, 1%, 2%, 4%, and 8% and placed into five-gallon polybags. Biochar was supplied by Biogenic Reagents and met the following standards:

|                  |                             |
|------------------|-----------------------------|
| Surface area:    | 400 m <sup>2</sup> /g (min) |
| Ash:             | 5% (max)                    |
| Volatile matter: | 5% (max)                    |
| Carbon:          | 90% (min)                   |
| pH:              | 7-9                         |

Biochar was combined with Morgan's 301 by placing the appropriate ratios into a cement mixer and tumbling until they were well mixed. The mix was then placed into the bags. The mix was moistened and allowed to sit a minimum of two weeks before planting.

### Fertilizer

No fertilizer was applied other than what was present in the Morgan's 301.

### Weed Control

Weeds were controlled by covering the ground in the tunnel with black ground cloth.

### Planting

Seven crop species were evaluated: cucumber (*Cucumis sativus*, cv. USAC 8834), tomato (*Solanum lycopersicum*, cv. Conan), spinach (*Spinacia oleracea*, cv. Bloomsdale), basil (*Ocimum basilicum*, cv. Italian Large Leaf), Swiss chard (*Beta vulgaris* subsp. *cicla*, cv. Technicolor), snap dragon (*Antirrhinum majus*, cv. Rocket Mix), and lettuce (*Lactuca sativa*, cv.

Tropicana). The tomato was set as a transplant on May 23, one plant per bag. The cucumber was direct seeded on May 23, one plant per bag. Snap dragons were planted as transplants, three per bag on May 15. Spinach, basil, and lettuce were set as transplants, three plants per bag on May 23. The cucumber, lettuce, and basil were planted a second time in a similar manner. There were four bags per plot, with four reps per biochar treatment.

### **Plant Care**

Plots were irrigated as needed; no insect and disease controls were needed in 2014.

### **Harvest and Data Collection**

Plots were harvested at the suitable stage for that species and graded according to commercial standards (tomato and cucumber), weighed (lettuce, spinach, Swiss chard, basil), or number of marketable flowers counted (snap dragons). The second cucumber planting did not produce any harvestable fruit. Data from the two basil and lettuce plantings were combined. Plots were standardized to one or three plants per bag and the data subjected to statistical analysis.

## **Results**

Biochar treatments generally had no effect on the species evaluated (Table 1). Significant differences were not found in total weight for cucumber, spinach, lettuce, Swiss chard, and total number of marketable flowers for snap dragons. Differences were noted in tomato and basil total yields (Table 1) but the noted biochar differences were not statistically different than the no biochar treatment. Some quality differences were noted in tomato fruit numbers and grades (Table 2). However, the differences could not be attributed to the biochar. In cucumber, differences were noted only in the weight of number 2 fruit (Table 3).

Reasons for lack of separation are unclear. Previous biochar studies (Major, et al. 2010) have found no differences the first year but significant differences in subsequent years. Biochar also has a greater effect on low organic matter and low nutrition soils. Morgan's 301 is a high organic soil and contains a significant amount of nutrients since one of the components is cow manure. High nutrient and organic matter levels could explain the lack of separation. Treatment differences may occur if the soil mix is used a second year after readily available nutrients are utilized or leached from the soil mix not having biochar.

The cucumber and tomato, and to some extent the basil and Swiss chard, continued to show poor growth later in the season. That has become typical of many tunnel-grown crops at SWMREC. The crops look good shortly after planting (Figures 1 and 2) but by late July and into August they look poor (Figures 2 and 3). It was hoped that the addition of biochar would relieve this condition without the addition of fertilizer.

### **Literature Cited**

- Major, J, Rondon, MA, Molina Lopez, DL, Riha, SJ, and Lehmann, J. 2010. Maize yield and nutrition during 4 years after biochar application to a Colombian savanna oxisol. *Plant and Soil* 33:117–128. Available online [www.css.cornell.edu/faculty/lehmann/publ/PlantSoil%20333,%20117-128,%202010%20Major.pdf](http://www.css.cornell.edu/faculty/lehmann/publ/PlantSoil%20333,%20117-128,%202010%20Major.pdf).

**Table 1.** Total yield of seven crop species grown in polybag culture in a high tunnel system at the Southwest Michigan Research and Extension Center, Benton Harbor, Michigan, in 2014. Treatments were 0 to 8% by volume of biochar. Numbers in bold are not significantly different than the top performing treatment.

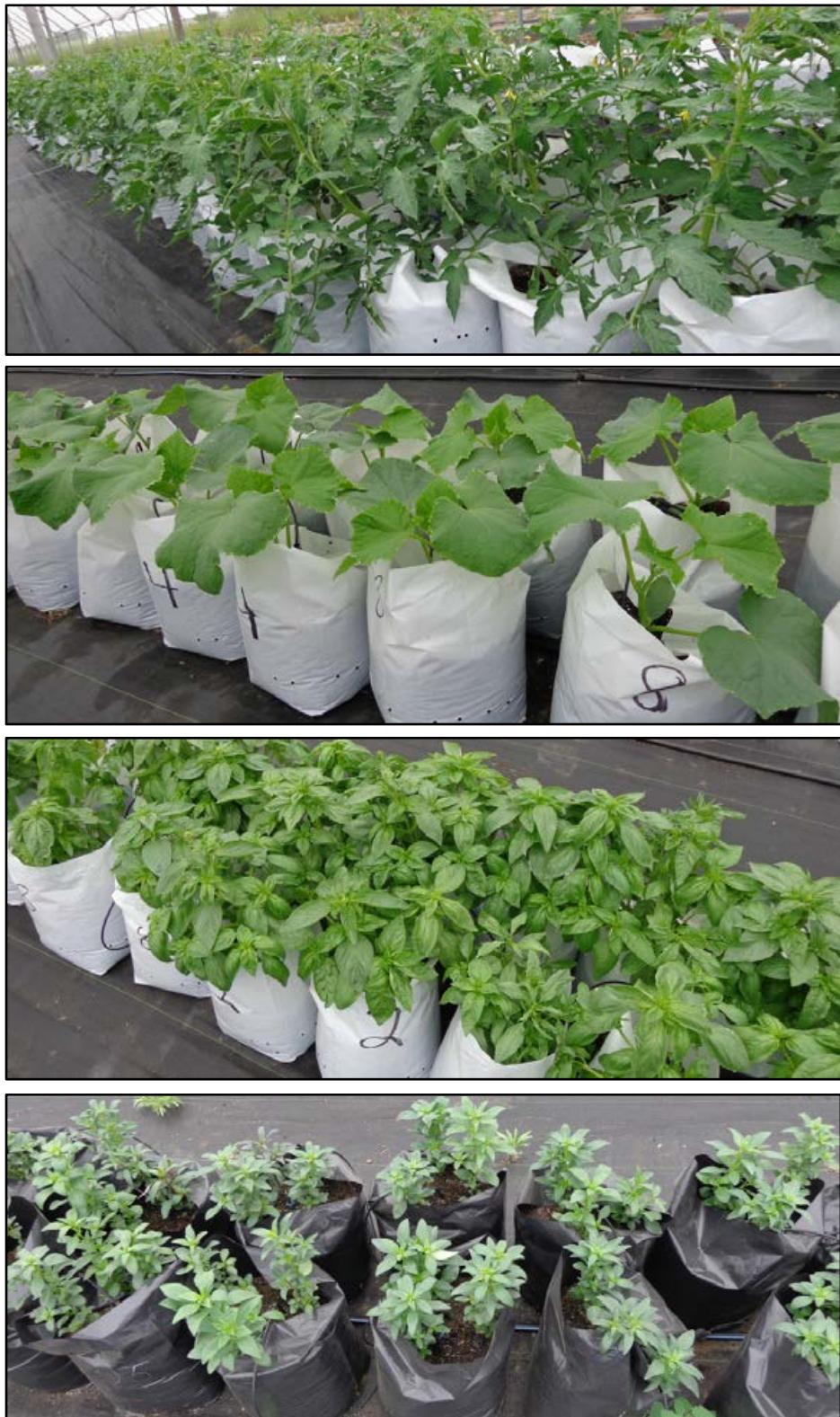
| Treatment<br>(% by vol.) | Tomato<br>(grams/bag) | Cucumber<br>(grams/bag) | Spinach<br>(grams/bag) | Lettuce<br>(grams/bag) | Basil<br>(grams/bag) | Swiss Chard<br>(grams/bag) | Snap dragons<br>(stems/bag) |
|--------------------------|-----------------------|-------------------------|------------------------|------------------------|----------------------|----------------------------|-----------------------------|
| <b>0</b>                 | <b>2,872</b>          | <b>1,444</b>            | 69                     | 352                    | <b>365</b>           | 352                        | 46                          |
| <b>0.5</b>               | <b>2,809</b>          | <b>1,427</b>            | 77                     | 262                    | 322                  | 262                        | 46                          |
| <b>1</b>                 | 2,254                 | <b>1,156</b>            | 70                     | 299                    | <b>415</b>           | 299                        | 41                          |
| <b>2</b>                 | 2,201                 | 1,287                   | 56                     | 272                    | <b>382</b>           | 272                        | 45                          |
| <b>4</b>                 | <b>3,327</b>          | 1,128                   | 80                     | 340                    | 318                  | 340                        | 40                          |
| <b>8</b>                 | 2,042                 | 1,033                   | 71                     | 321                    | 308                  | 321                        | 40                          |
| <b>Lsd 0.05</b>          | <b>968</b>            | <b>ns</b>               | <b>ns</b>              | <b>ns</b>              | <b>65</b>            | <b>ns</b>                  | <b>ns</b>                   |

**Table 2.** Total yield and quality of ‘Conan’ tomato grown in polybag culture in a high tunnel system at the Southwest Michigan Research and Extension Center, Benton Harbor, Michigan, in 2014. Treatments were 0 to 8% by volume of biochar. Numbers in bold are not significantly different than the top performing treatment.

| Treatment<br>(% by vol.) | Total Yield<br>(grams/bag) | Yield No. 1<br>(grams/bag) | Count No.<br>1/Bag | Average No. 1<br>Weight (grams) | Yield No. 2<br>(grams/bag) | Yield Cull<br>(grams/bag) |
|--------------------------|----------------------------|----------------------------|--------------------|---------------------------------|----------------------------|---------------------------|
| <b>0</b>                 | <b>2,872</b>               | <b>2,142</b>               | <b>15</b>          | <b>145</b>                      | <b>199</b>                 | <b>531</b>                |
| <b>0.5</b>               | <b>2,809</b>               | <b>2,154</b>               | <b>14</b>          | <b>149</b>                      | <b>118</b>                 | <b>537</b>                |
| <b>1</b>                 | 2,254                      | <b>1,638</b>               | <b>12</b>          | <b>136</b>                      | 52                         | <b>564</b>                |
| <b>2</b>                 | 2,201                      | 1,420                      | 10                 | <b>147</b>                      | <b>86</b>                  | <b>695</b>                |
| <b>4</b>                 | <b>3,327</b>               | <b>2,116</b>               | <b>15</b>          | <b>144</b>                      | <b>649</b>                 | <b>562</b>                |
| <b>8</b>                 | 2,042                      | 1,379                      | 10                 | 127                             | <b>208</b>                 | 455                       |
| <b>Lsd 0.05</b>          | <b>968</b>                 | <b>640</b>                 | 4                  | <b>16</b>                       | <b>567</b>                 | <b>191</b>                |

**Table 3.** Total yield and quality of ‘USAC 8834’ cucumber grown in polybag culture in a high tunnel system at the Southwest Michigan Research and Extension Center, Benton Harbor, Michigan, in 2014. Treatments were 0 to 8% by volume of biochar. Numbers in bold are not significantly different than the top performing treatment.

| Treatment<br>(% by vol.) | Total Yield<br>(grams/bag) | Yield No. 1<br>(grams/bag) | Count of No. 1<br>Fruit/Bag | Average No. 1<br>Weight (grams) | Yield No. 2<br>(grams/bag) | Yield Cull<br>(grams/bag) |
|--------------------------|----------------------------|----------------------------|-----------------------------|---------------------------------|----------------------------|---------------------------|
| <b>0</b>                 | 1,444                      | 810                        | 6                           | 124                             | <b>130</b>                 | 504                       |
| <b>0.5</b>               | 1,427                      | 774                        | 6                           | 121                             | <b>201</b>                 | 452                       |
| <b>1</b>                 | 1,156                      | 656                        | 5                           | 122                             | <b>127</b>                 | 373                       |
| <b>2</b>                 | 1,287                      | 677                        | 6                           | 118                             | 84                         | 526                       |
| <b>4</b>                 | 1,128                      | 649                        | 6                           | 116                             | 88                         | 391                       |
| <b>8</b>                 | 1,033                      | 579                        | 5                           | 121                             | <b>138</b>                 | 316                       |
| Lsd 0.05                 | ns                         | ns                         | ns                          | ns                              | 110                        | ns                        |



**Figure 1.** Growth of four crops in a high-tunnel system at the Southwest Michigan Research and Extension Center, Benton Harbor, Michigan, in 2014. Tomato, cucumber, basil, and snap dragon (top to bottom). Picture taken 6/12/14.



**Figure 2.** Growth of four crops in a high-tunnel system at the Southwest Michigan Research and Extension Center, Benton Harbor, Michigan, in 2014. Tomato, cucumber, basil, and snap dragon (top to bottom). Picture taken 7/25/14.



**Figure 3.** Growth of three crops in a high-tunnel system at the Southwest Michigan Research and Extension Center, Benton Harbor, Michigan, in 2014. Tomato, basil, and snap dragon (top to bottom). Pictures taken 7/31/14 (basil) and 8/18 (tomato and snap dragon).