Biochar to Enhance Tomato and Melon Productivity and Protect Against Phytophthora Root Rot

Marion Murray and Diane Alston, Dept. of Biology, Utah State University, Logan, UT; Britney Hunter, AquaYield, Taylorsville, UT; Darren McAvoy, Dept. of Natural Resources, USU; Grant Cardon, Dept. of Plant, Soils, and Climate, USU; Shawn Olsen, Davis County Extension, USU

Summary

Utah's commercial vegetable industry (valued at $16 million) expressed the need to increase crop yields and prevent losses due to diseases, in particular by soil-borne pathogens. This project investigated the use of biochar as a soil amendment to address these concerns.

Biochar is a carbon-rich material similar to charcoal, produced by heating plant biomass in a closed system with limited supply of oxygen, in a process called pyrolysis. Biochar is soil-applied and must be "charged" with a fertilizer.

For this study, tomato and melon crops were planted on four cooperator farms, with and without biochar (each treatment with an organic fertilizer), and biomass and harvest weights were compared between treatments. We also conducted greenhouse trials to evaluate the effect of biochar on susceptibility of tomato and melon to Phytophthora crown rot.

In the field trials, the use of biochar only slightly increased biomass and yield over fertilizer alone, and both were more effective than the control. In the Phytophthora crown rot greenhouse trials, the addition of biochar to the planting medium had no effect on plant susceptibility to the disease.

Methods

CROP YIELD

For the biochar production, we had envisioned using orchard wood prunings from cooperating producers. Unfortunately, due to the wetness of the fruit wood and subsequent equipment malfunction, the chosen manufacturer was unable to produce the biochar. Biochar was instead purchased from Confluence Energy in Colorado that was made from beetle-killed pine (pyrolized at 375°C). The per-acre field rate of biochar for this study was determined by conducting a lettuce pot study, and was found to be 2% (by volume).

For the cooperating producer sites, we set up three treatments in plots using a randomized block design:

- 10 tons biochar plus 60 lb fertilizer per acre rate (biochar was applied once, in 2015; fertilizer applied in 2015, 2016, and 2017)
- 60 lb fertilizer per acre rate (applied in 2015, 2016, and 2017)
- untreated

The plots were planted with melons and tomatoes in May of each year, and fruit weights and dry plant weights were collected at the end of each season.

ROOT ROT RESISTANCE

We planted 40 melon and 40 tomato transplants in 3-gallon pots with either plain potting soil (20 of each) or soil amended with 2% biochar (by volume; 20 of each). The plants were then grown with normal watering and fertilization.

After 8 weeks, we inoculated 10 melon and 10 tomato plants from each treatment by inserting 20 grains of rice that had been grown in *Phytophthora nicotianae, P. megasperma*, or *P. capsici*, 1-inch below the soil surface. Plain rice was applied in the soil of the remaining plants. After 8 weeks, the top and roots of the plants were rated 1-4 for symptomology, and dried for weight. This process was repeated three times.

Results

CROP YIELD

The one-time application of biochar occurred on four producer sites in 2015. By the following year, however, we lost three of the sites. One lost irrigation and became fallow; one was plowed and converted to wheat; and the third was sold to a developer. Therefore, all final data is presented from the fourth site–Kaysville, UT–that remained intact.

Plant Dry Weight

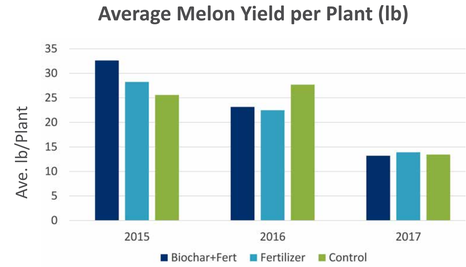
There were no statistically significant differences in average per-plant dry weight within-years, or overall. In the first year after biochar application (2015), the melon plants' average dry weight across all sites was slightly greater in the biochar+fert treatment, while there was no difference among tomato treatments. In year 2 (Kaysville site only), there were no differences in dry weights of the melon treatments, while the dry weights of the tomatoes were highest in the biochar+fert (but not significantly so). In year 3, there were no significant differences in dry weights of either melon or tomato plants across all treatments.

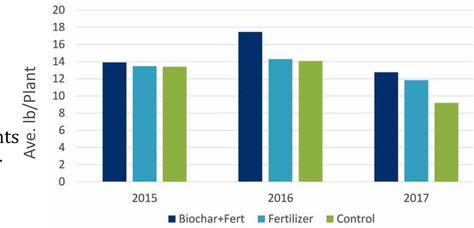
Fruit Weight (see graphs at right)

There were no statistically significant differences in average per-plant yields between treatments either within-years, or overall. Across all sites in 2015, melon yield was highest in the fertilizer treatment, while tomato yield was highest in the untreated. In year 2 (Kaysville site only), melon yield was highest in the untreated, and tomato yield was highest in the biochar+fert treatment. In year 3, melon yield was highest in the fertilizer, and tomato yield was highest in the biochar+fert.

In general:

- For the tomatoes in all three years, yield was highest in the biochar+fert plots, with the greatest increase in year two.
- The melons in the biochar+fert plots had the highest yield in the first year, but that improvement was not seen again in years two or three.





Average yield for melon and tomato plants grown for three years in soil amended with biochar plus fertilizer, fertilizer alone, or with no amendment in Kaysville, UT. Although the biochar treatment did not significantly increase yield, we found that tomato yield responded best to biochar.

ROOT ROT RESISTANCE

For all three trials, there were no significant differences in the development of root rot between the biochar- and non-biochar-grown plants.

Producers assisted with planting and harvesting the plots (near right). Example planting of tomatoes and melons (far right).

Outreach

Although we lost producer sites, we kept cooperators engaged through participation in project plantings / harvesting, and 3 field days.

Other outreach included presentations at regional and national meetings, fact sheets, webinars, radio shows, newsletters, and more, impacting over 500 producers in Utah.

Conclusions

There are still challenges that remain to be solved before biochar can be adopted on a wide-scale basis, such as:

Soil health: In some cases, plants growing in soils that are already healthy may not benefit from a biochar application.

Biochar source and production method: Properties of biochar vary with both the feedstock from which it is produced and the method of production, outlining the need to classify biochar types.

Soil application rate: Research studies of biochar in agriculture have used one-time rates ranging from 2 to 22 tons per acre, and there is a need to clarify the optimal rates and timing for various crops and soil types.

Cost: Today, purchasing commercially-prepared biochar for agriculture is not economically feasible, with costs ranging from $400 to $2,000 per ton. As an alternative, some commercial growers are investigating on-site production of their own biochar.

Funding: This project was funded through a WSARE Professional + Producer Grant.

We are grateful to the producers in Utah for allowing us to use their cropland, and for participating in this project.