# Impacts of biochar on plant growth in an agrivoltaics setting

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## Introduction

- Utilizing marginal lands may help resolve the conflict between using land for food or increased biofuel production for climate change mitigation.
- Poor soil quality in the Southwest can make it challenging to convert marginal lands for cultivation, but when used as a soil amendment, biochar can improve soil health and water retention.
- Because solar power is a natural solution for green energy production in these arid, sunny climates, we hypothesized that the combination of biochar and shading provided by solar panels might be especially beneficial for plant growth and yield in the Southwest.

## Methods

To test biochar's effect on plant performance in an agrivoltaics setting, tomato plants were grown with and without biochar, and under or away from solar panels on an existing solar panel field on an old stream bed with highly packed silty loam soil in El Rito, NM (Fig. 1). From 6/27/22 to 10/17/22, 5 tomato plants grew in each plot after being started from seed in a greenhouse. In addition to natural rainfall, plants were watered 3 times a week with 26 gallons per plot. In 2023, 5 tomato plants, collard greens, and chili peppers were planted in each plot, but prairie dogs ate the plants within two weeks. The plots were not irrigated after the plant destruction, so the soil temperature and moisture results reflect natural precipitation received from 6/29/23 to 11/3/23. Table 1 shows the amounts of biochar and compost used in each plot, and Table 2 shows the measurements collected.

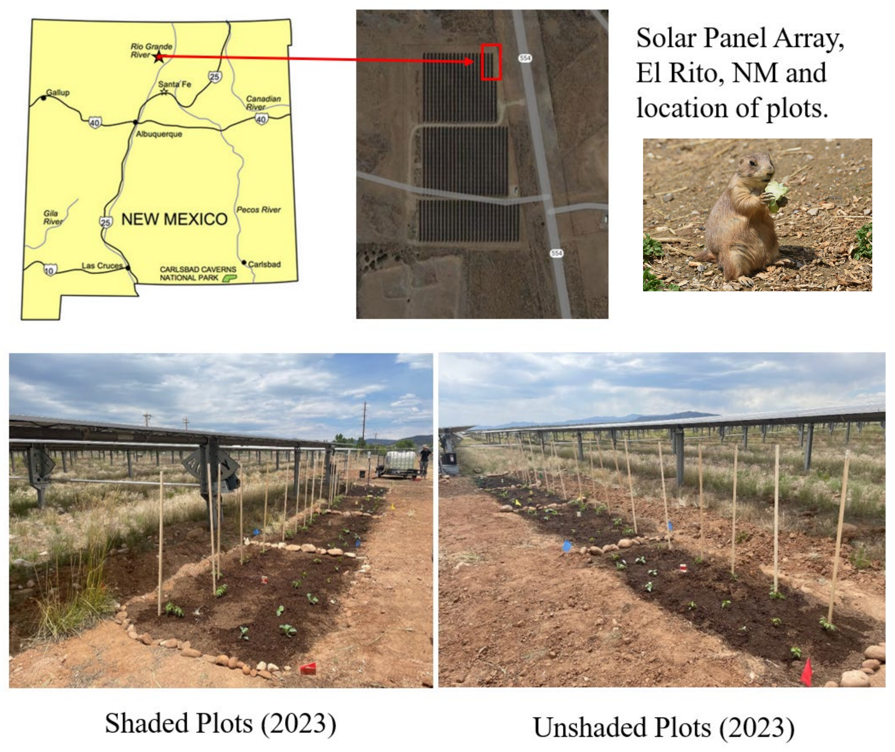


**Figure 1.** Location of solar panel array and photos of the plots in 2023.

**Table 1.** Percentages of compost and biochar used in each plot.

| Plot | Year | 0" – 4" bgs | 4" – 10" bgs |
|---|---|---|---|
| Control | 2022 & 2023 | 100 % compost | 50% native soil, 50% compost |
| 95% - 5% | 2023 | 95% compost, 5% biochar | 47.5% native soil, 47.5% compost, 5% biochar |
| 90% - 10% | 2022 & 2023 | 90 % compost, 10% biochar | 45% native soil, 45% compost, 10% biochar |
| 50% - 50% | 2023 | 50% compost, 50% biochar | 40% native soil, 40% compost, 20% biochar |

**Table 2.** Measurements collected in 2022 and 2023.

| Measurement | Year | Method | Quantify impacts of: |
|---|---|---|---|
| Photosynthesis & stomatal conductance | 2022 | Licor LI-6400 Portable Photosynthesis System | Biochar on plant performance |
| Plant height & number of fruits | 2022 | Yard stick & counting | Biochar on plant performance |
| Soil temperature | 2022 & 2023 | Type-t thermocouples + Campbell CR1000 datalogger (CR1000) | Biochar on soil |
| Soil volumetric water content | 2022 & 2023 | Campbell CS616 water content reflectometers + CR1000 | Biochar on soil |
| Solar Radiation | 2022 & 2023 | Licor LI200X-LC pyranometer + CR1000 | Solar panels on plots |

## Results

### Solar panels shade plots in the afternoon

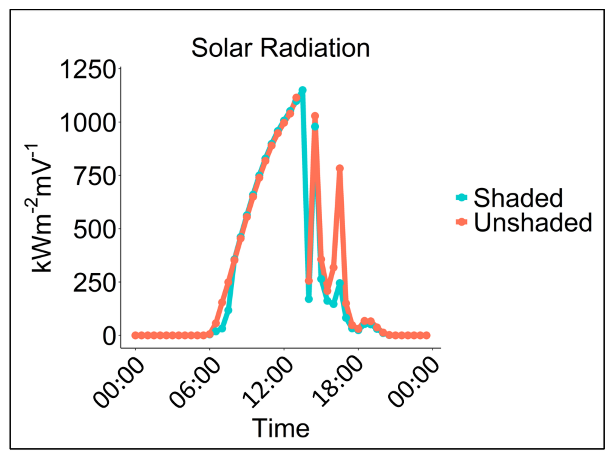


**Figure 2.** Solar radiation in the shaded and unshaded plots over a 24-hour period during the 2022 experiment.

### Biochar increases water retention in shaded plots

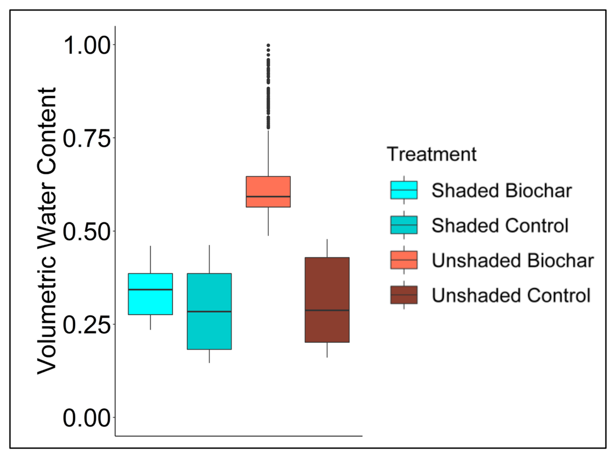


**Figure 3.** VWC in each treatment over the duration of the 2022 experiment.

### Biochar cools soil temperatures at all depths in shaded plots, but not in unshaded plots

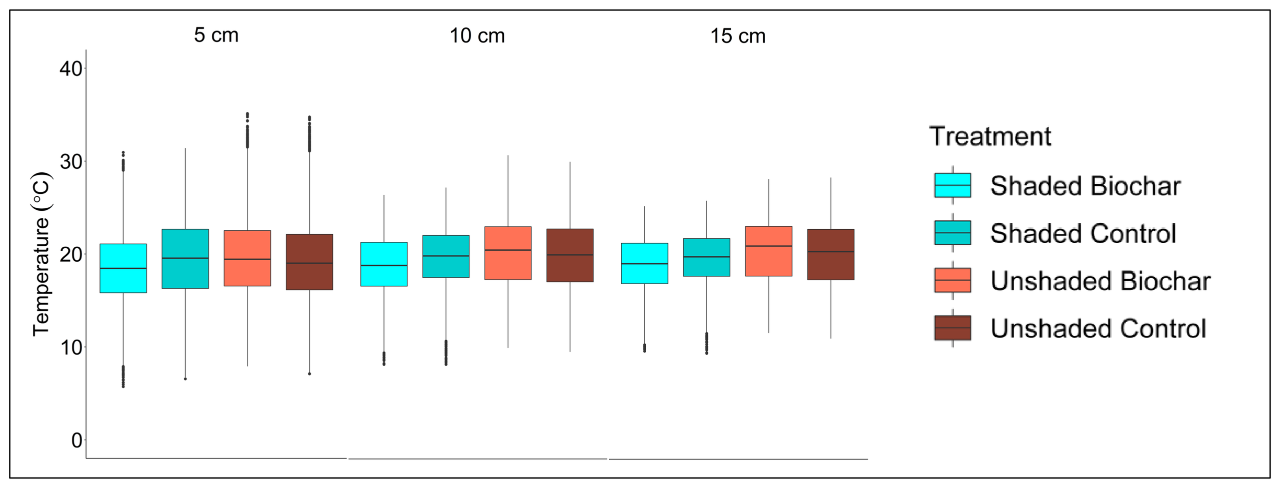


**Figure 4.** Soil temperatures at 5, 10, and 15 cm over the duration of the 2022 experiment.

- Photosynthesis was highest in the shaded control plot
- Stomatal conductance was lower in the biochar plots relative to the control plots (meaning plants retain more water)
- Water use efficiency improved slightly in the biochar plots relative to the controls
- Plants in the shaded biochar plots were the tallest and had the most tomatoes

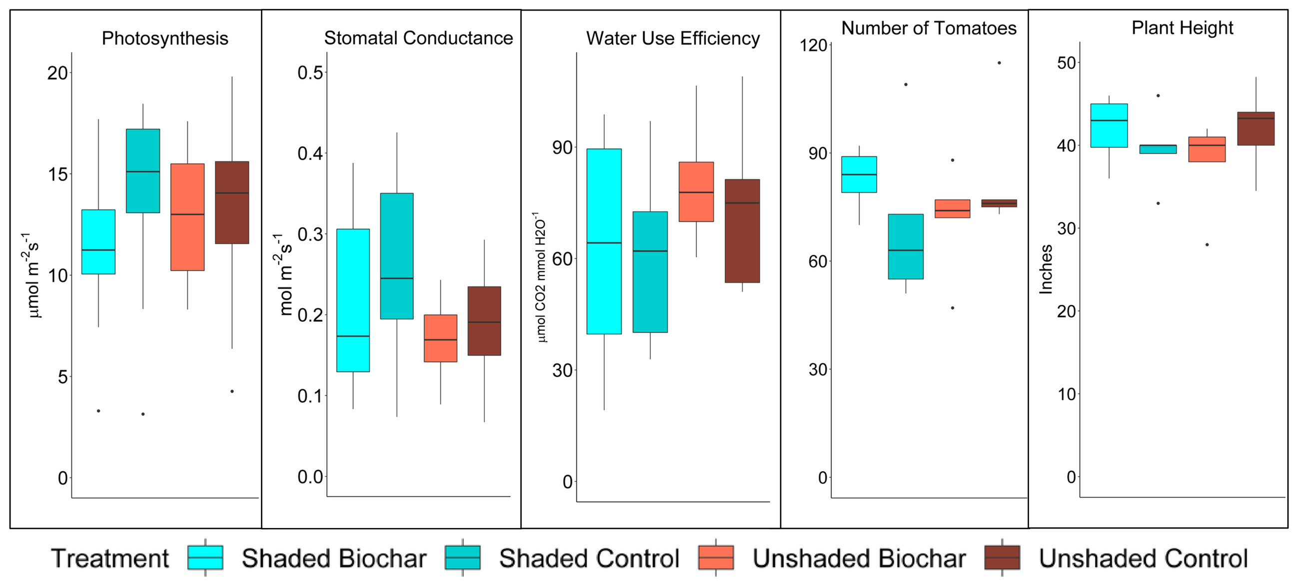


**Figure 5.** Photosynthesis, stomatal conductance, water use efficiency, number of tomatoes, and plant height in each treatment at the end of the 2022 experiment.

### Soil temperatures in 2023 were higher relative to 2022, with no cooling benefits from biochar

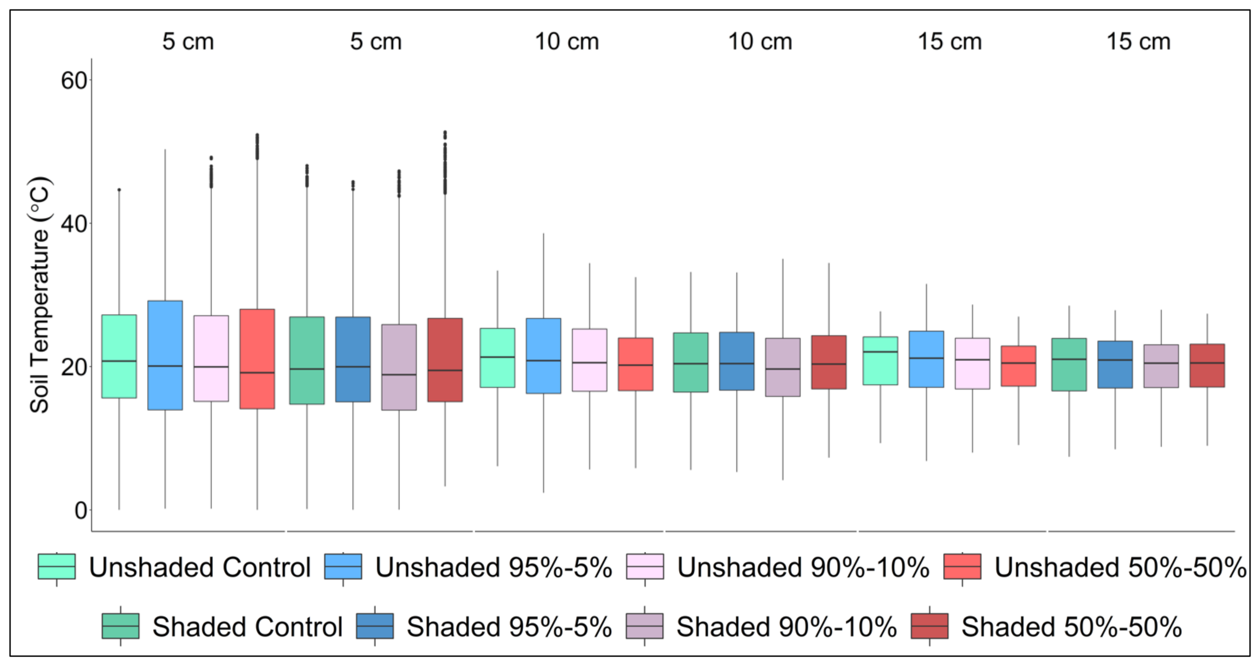


**Figure 6.** Soil temperatures at 5, 10, and 15 cm over the duration of the 2023 experiment.

### In 2023, maximum soil temperature at 5 cm increased with higher biochar content

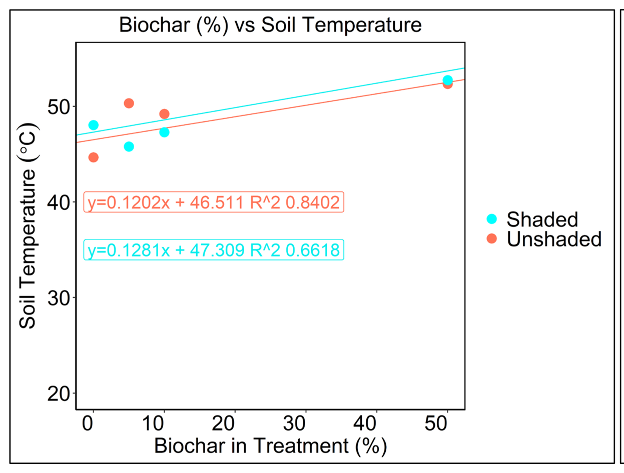


**Figure 7.** Biochar percentage vs. maximum soil temperature at 5 cm in 2023.

### VWC in 2023 was lower relative to 2022, and decreased with increasing biochar content

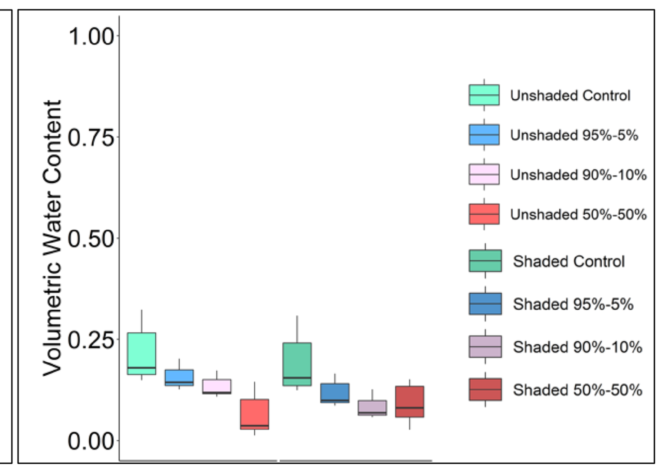


**Figure 8.** VWC in each treatment over the duration of the 2023 experiment.

## Conclusions

- In 2022, biochar addition to the plots resulted in higher water retention and cooler soil temperatures in the shaded plots, resulting in improved tomato plant growth, fruit production, water use efficiency, and stomatal conductance.
- In 2023, when soil temperatures were higher and soil moisture was lower, biochar increased the maximum soil temperatures and decreased water retention.
- Comparing the results of 2022 and 2023 suggests that the effects of biochar on soil may depend on the baseline of soil moisture, temperature, and biochar dose.

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