SP 823

Row crop production in sandy soil: Can biochar help?

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Introduction

In recent years, summer rainfall patterns have become more variable with some increased flooding along creeks and rivers as well as prolonged dry spells during the growing season. Flood water can deposit sands in the lower parts of a field (Figure 1), which during subsequent dry spells can result in water limited conditions that can negatively impact crop yields. Sand deposits may be several feet deep and can greatly reduce the water and nutrient holding capacity of the soil, resulting in poor crop stands and significantly lower crop yields due to water deficit stress during the growing season.

Physically removing sand deposits following flooding can be an expensive, time-consuming undertaking and may not be cost-effective. Remediation of the sand-deposits with a soil amendment such as biochar can increase the soil's water-holding capacity and potentially improve the soil's productivity. Biochar amendments, in combination with other soil management conservation practices such as no-till and cover crops are potential alternatives to physically removing sand deposits.

Figure 1. Milan Tennessee, Milan AgResearch and Education Center, a field location after spring flooding in 2019 left the area inundated with sand. Photo credit: Forbes Walker

Why biochar and what to expect when using biochar?

Biochar is composed of very resistant carbon that can persist in the soil for a very long time, so annual applications of biochar to agricultural fields are not recommended (aces.nmsu.edu/pubs/_circulars/CR690/welcome.html). Biochar has been used as an effective soil amendment for the improvement of soil nutrient and water management. Biochar is a carbon-rich, charcoal-like byproduct after biomass (wood, corn husks, poultry manure, etc.) is heated at high temperatures in the absence of oxygen (Figure 2). Biochar has lots of tiny spaces, or pores, that cause it to act like a “hard sponge” when it is in the soil. These characteristics contribute to its potential to improve soil water availability by absorbing and retaining water.

Figure 2. Biomass (left) and biochar (right) from big saltbush (top) and pecan shells (bottom). Photo credits: Catherine Brewer (top left), Kwabena Sarpong (top right), Jere Freeh (bottom left), and Jose Rodriguez (bottom right). aces.nmsu.edu/pubs/_circulars/CR690/welcome.html

The optimal rate and frequency of biochar applications depends on many factors, including the soil texture and rainfall frequency and intensity, and based on limited research not all soils respond to biochar applications. Well-drained sandy soils tend to benefit more from biochar amendments due to increased soil moisture retention. In contrast, moderately well-drained and/or clayey soils in Michigan did not always respond as positively (canr.msu.edu/news/biochar-an-emerging-soil-amendment). In a New Mexico study (aces.nmsu.edu/pubs/_circulars/CR690/welcome.html), biochar made from hardwood, peanut shells, pecan shells, poultry litter and switchgrass improved moisture retention in a sandy loam and silt loam soil. The switchgrass biochar produced at more than 900 F (500 C) and added at 2 percent by soil weight gave the best moisture retention in the soils, which was about 10 percent more than soils without biochar.

Field activities and findings

In 2018 and 2019, a biochar study was conducted at the UT West Tennessee AgResearch and Education Center in Jackson, Tennessee, to measure biochar’s effect on wilting, the soil water holding capacity and ultimately crop productivity. Table 1 presents the rainfall amounts and distribution by month for both 2018 and 2019 growing seasons at the center.

Table 1. Rainfall amounts and distribution by month for both 2018 and 2019.

	West Tennessee AgResearch and Education Center	
	2018	2019
May	4.5	3.2
June	7.1	4.5
July	8.7	11.3
August	3.0	5.2
September	13.9	1.4
October	3.0	5.5

In the field, soybeans (Becks 424L4 in 2018 and TN16-520R1 in 2019) were grown in a Mantachie fine sandy loam soil in a previously flooded field adjacent to a nearby creek. Five rates of biochar were applied: 2.7, 5.5, 8.3, 16.6 and 33.2 ton/acre and compared with a no biochar check (Figure 3, creek is located in the southwest area of the field along the treeline).

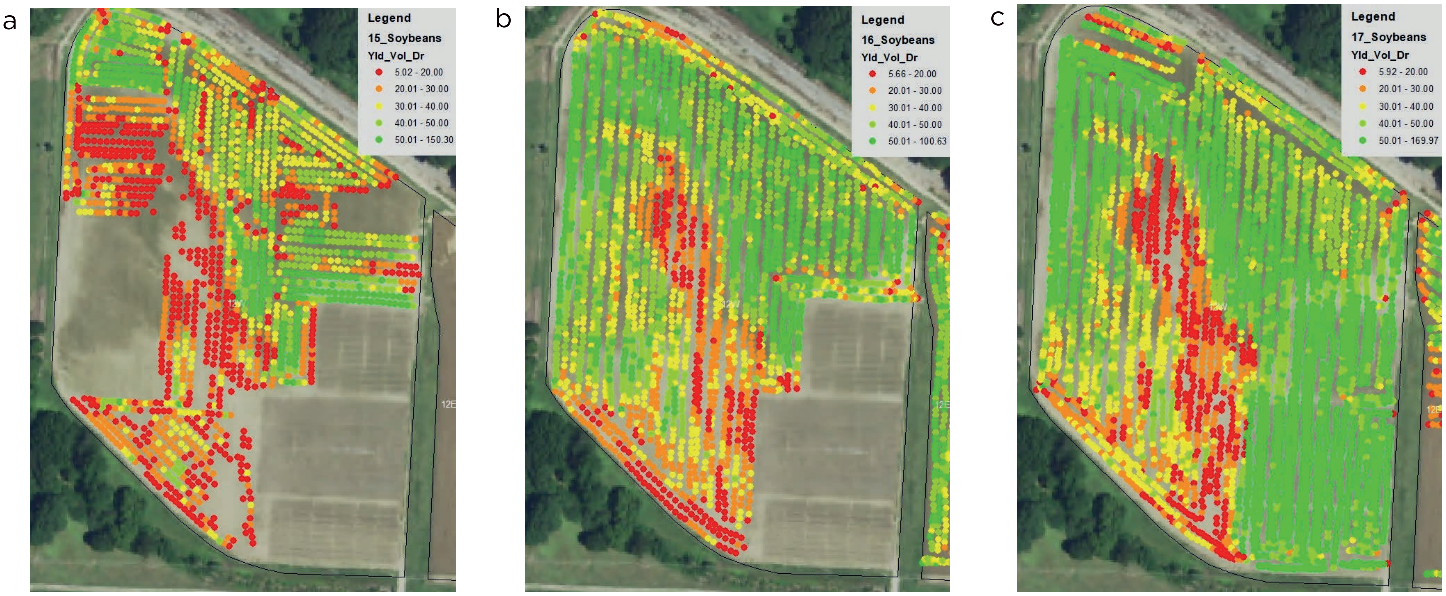

Figure 3. Yield maps for poor sandy soil at West Tennessee AgResearch and Education Center 2015 (a) 2016 (b) and 2017 (c), (research plots area during 2018 and 2019).

Biochar was surface-applied in the field in early 2018 prior to planting soybeans. In the 2018 and 2019 seasons, soybean growth and development were monitored (Figure 4). Measurements taken during the growing seasons included soil bulk density; soil organic carbon; soil water infiltration; plant relative water content (RWC); visual rating for plant wilting (WS) on a 0 to 5 scale, with a score of 0 indicating no wilt and a score of 5 indicating complete kill; and final yield (two center rows were considered for yield). Applying 33.2 tons biochar per acre reduced the topsoil bulk density (from 1.6 to 1.1 g cm^3) and increased the total organic carbon. Water infiltration rates were significantly reduced with all rates of biochar, and soil moisture contents increased when biochar was applied at rates more than 8.3 tons per acre (taes.tennessee.edu/publication/show_pub.asp?pub=28778).

Figure 4. Biochar was surface-applied then lightly disked into the soil before planting soybeans. Photo credits: Forbes Walker (left), Avat Shekoofa (middle), Kendall Sheldon (right)

Under field conditions, soybean plants growing in plots amended with 5.5 and 8.3 tons per acre biochar in a marginal fine sandy loam soil had the lowest wilting scores in 2018. But in 2019 the lowest wilting score in August, was recorded for soybean plants in plots only amended with 8.3 tons per acre biochar (Figure 5a).

The average relative water content (RWC) was significantly higher than the no biochar check for soybean plants growing in plots amended with 2.7 and 8.3 tons per acre in 2018 and all amended plots with biochar in 2019 (Figure 5b). Soybean yields varied by year and were sometimes reduced with biochar application. Application of 2.7 and 8.3 tons per acre biochar rates significantly improved yield in 2018 but not in 2019 compared to the no biochar check (Figure 5c). In 2018, rainfall distribution was more limited in July and August (Table 1), creating drier soil conditions and biochar amended soils likely supplied more water to the crop. Wetter conditions in 2019 probably led to overly saturated conditions in biochar plots, which was not helpful for soybean growth or yield.

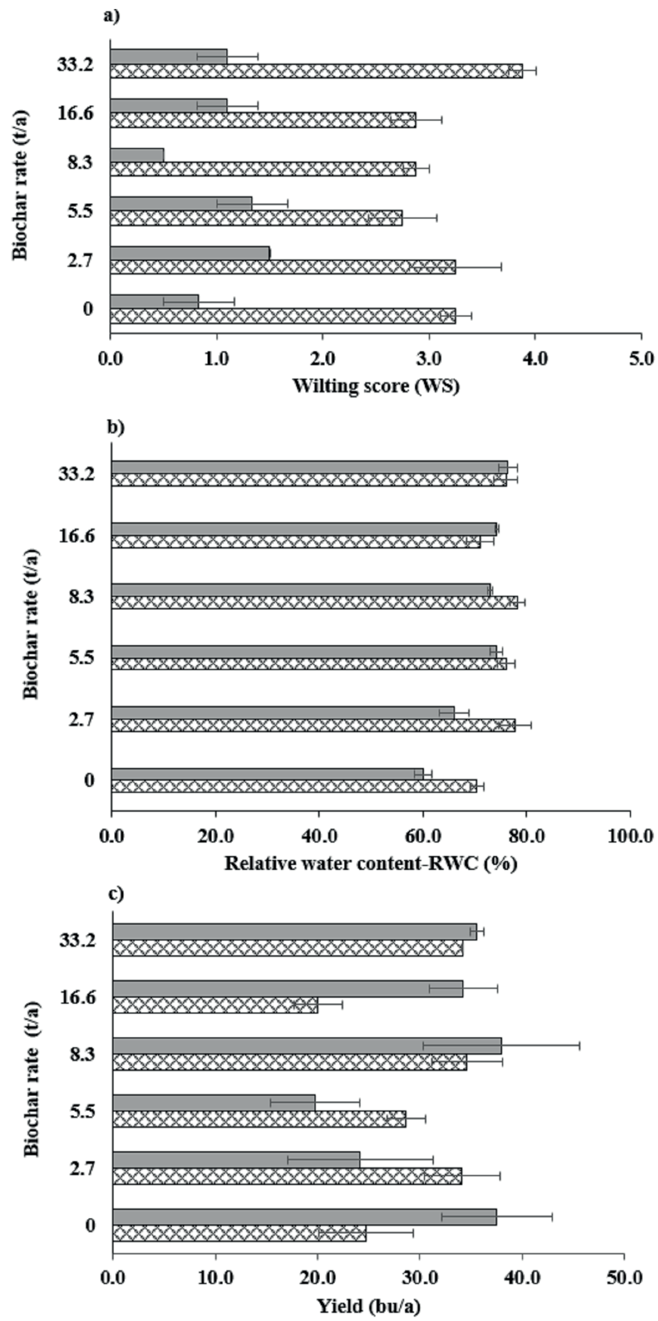

Figure 5. (a) Soybean average wilting scores in August, (b) RWC for both years, and (c) yield responses in a fine sandy loam soil to varying biochar rates application. Pattern and gray bars represent 2018 and 2019 data collection, respectively. Error bars represent standard error of the mean.

Conclusion

Results suggest that lower rates of biochar may improve soybean productivity in dry years compared to no-biochar in sandy soils which have very limited yield potential. Under field conditions in a marginal fine sandy loam soil, some rates of biochar improved the performance of soybean in mid-August by higher RWC percentage (Figure 5b). Applying lower and mid rates of biochar (i.e., 2.7 and 8.3 tons per acre) significantly increased soybean yield by almost 30 percent in a drier year (2018) but not in a wetter year (2019) (Figure 5c). This was most likely due to differences in annual rainfall amounts and distribution.

Growers should be aware that a biochar application is a long-term lasting treatment to a field, and crop yield improvements may only be seen in dry years. There are potential agronomic issues stemming from the use of this type of material, namely reduced yields in wet years. Additionally, biochar may bind soil-applied herbicides, making them less effective. Farmers may need to apply higher rate of herbicides to offset this loss in weed control efficacy. In our research, with the higher biochar additions competition from grasses were quite common and the application of herbicides were less effective in plots with higher biochar rates.

Resources

- http://www.css.cornell.edu/faculty/lehmann/publ/First%20proof%2013-01-09.pdf
- https://aces.nmsu.edu/pubs/_circulars/CR690/welcome.html
- https://www.canr.msu.edu/news/biochar-an-emerging-soil-amendment
- Ceylan, S. 2020. Effects of soil conservation practices on soil properties in a continuous cotton and a continuous soybean system in West Tennessee. MS. Thesis University of Tennessee. http://taes.tennessee.edu/publication/show_pub.asp?pub=28778

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