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Biochar in Utah Agriculture

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Do You Know?

- Biochar is a charcoal-like product made from biomass waste, such as wood or agricultural waste, paper mill waste, or other biological residues.
- Biochar is not a fertilizer, but may be considered as a soil amendment.
- The effects of biochar application on agricultural crop may take up to two years to see.
- Any positive effects of biochar application on agricultural soils may take up to two years to see in the crop.
- Biochar may be applied at a rate of 1 to 10 tons per acre.

Biochar as a soil amendment can have long-term benefits for the environment, in terms of sequestering carbon. But for intensive agricultural production, biochar is not quite ready for wide-scale adoption in Utah. Some factors that need to be considered in applying biochar to the soil are initial soil health, the source and production method of the char, and the variable or unknown application rates. Although crop yield may be marginally increased in biochar soils, the benefit might not outweigh the cost of the biochar itself. Recent studies in the western U.S., including one by USU Extension, have shown mixed results for certain vegetable crops.

WHAT IS BIOCHAR?

Biochar is similar to charcoal, but instead, it is produced in a controlled environment. Biomass (the "feedstock") in the form of wood or crop residue, manure, paper mill waste, etc., is burned at a very high temperature (350 – 900°C) under low oxygen, in a process called pyrolysis. The resulting product is of varying particle size, comprising about 50-75% carbon.

ADVANTAGES FOR AGRICULTURE

Most biochars have low nitrogen concentrations and thus any inherent fertilizer value is minimal and temporary. The recommendation is that biochar is applied to the soil just once, acting as a conditioner, and that nutrient amendments should also be applied yearly (if needed). Some research studies have found the following benefits of a one-time biochar application on agricultural soils (resulting in improved plant growth and crop yield):

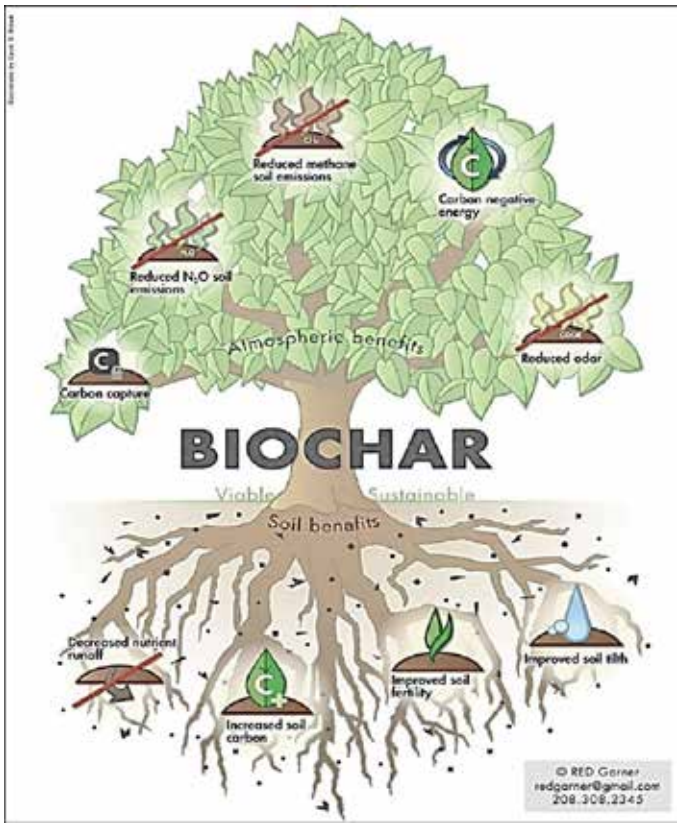

Fig. 1. Graphic illustration on the effects of biochar when applied to the soil.[1]

- greater soil nutrient retention due to cation exchange capacity
- improved efficacy of fertilizers
- higher soil water retention, particularly in sandy soils
- increased soil pH (beneficial to acidic soils)
- increased soil aeration, particularly in clay soils
- increased beneficial soil microorganisms
- greater earthworm populations due to improved soil conditions

CONSIDERATIONS IN BIOCHAR USE

In general, the positive effects of biochar may be best seen in areas with highly weathered, sandy, and/or acidic soils.

- *Initial soil health*: When biochar research started flourishing, results from tropical systems were very positive, and the excitement in biochar grew. However, those same benefits did not always translate to western U.S. temperate soils and crops. In fact, plants growing in soils that are already healthy may not benefit at all from a biochar application. As one example, a recent study published by the University of California-Davis showed that after three years, there were no long-term benefits in biochar application on a tomato-corn rotational cropping system. In addition, most Utah soils already have a high pH, so the addition of biochar may exacerbate the problem

- *Biochar source and production method*: Properties of biochar vary with both the feedstock from which it is produced and the temperature of production. And in turn, these different biochars will behave differently in soils. One type of char may show promise, another type may not, or a char may help with one type of crop but not another. Because of this, people are realizing the importance of "classifying" different biochar types based on their properties and potential crop benefits.

- *Application rate*: In soil application, biochar is persistent, and may improve soil condition over time. But specific crop application rates have not been determined. Research studies of biochar in agriculture have used one-time rates ranging from 2 to 22 tons per acre. Higher rates appear to have a diminishing effect. The need for further clarity on optimizing biochar application for increased crop yields is necessary if it is to gain widespread adoption as a soil amendment.

- *Cost*: Today, purchasing commercially-prepared biochar for agriculture is not economically feasible, with a cost ranging from $400 to $2,000 per ton. Scaling that down to backyard gardeners is a slightly more acceptable cost, with bagged products ranging from about $25 - $40 per cubic foot (covering 100 - 350 ft^2).

BIOCHAR USE IN UTAH

Over a period of three years, USU Extension investigated whether biochar as a soil amendment would improve crop yield and root rot-resistance of tomato and melon. For crop-yield comparisons, biochar (from beetle-killed pine pyrolized at 375°C) was soil-applied in 2015 at a rate

Fig. 2. Biochar may provide benefits to agricultural soils, but more research is needed.

of 10 tons/acre at the USU Experimental Research Farm in Kaysville. Each year, we compared tomato and melon fruit yields after a season grown in either biochar+fertilizer, fertilizer, or no amendment. There was no statistical improvement in yield from the biochar + fertilizer application; however, there were trends in the results:

- For the **tomatoes** in all three years, both average dry weight per plant and yield were highest in the biochar plots, with the greatest increase for both measures in year two. Average yield increase over the three years was 15%, over fertilizer alone.

- For the **melons**, both the average dry weight per plant and yield were highest in the biochar plot in the first year, but the increase in yield did not continue. In year 2, dry weight was again highest in the biochar plots, with yield second highest. By year 3, yield was lowest in the biochar plots, and dry weight was highest in the control plots, followed by the biochar plots. Average yield increase over the three years was 4% over fertilizer alone.

The root rot-resistance comparison was conducted in a greenhouse where we grew tomato and melons in potting soil either amended or not amended with the same type of biochar (2% by volume). After approximately 6 weeks of growth, half the potted plants were each inoculated with 20 rice grains coated in mycelium of a mix of *Phytophthora capsici, P. nicotianae, P. cactorum,* and *P. megasperma*. Plants were then grown with normal irrigation and fertilization for an additional 8 weeks.

Plants were then rated for disease, weighed, and roots were tested for Phytophthora with Agdia test kits. Disease was found on the inoculated plants in both soil types, and no disease was found on un-inoculated plants. This trial was repeated once more.

We had hoped to see less incidence of disease on plants growing in the biochar soils, but instead, we found that:

- For both the melons and tomatoes that were inoculated with Phytophthora, there were no differences in the number of diseased plants, symptoms (based on individual plant ratings), or average dry plant weight, between the plants growing in biochar and non-biochar media

OBTAINING BIOCHAR

Biochar can be purchased in bulk, in bags, or made on-site. In Utah, some box stores sell bagged biochar, but bulk availability is harder to find. Commercially-prepared biochar provides analysis, specifications, and application rates, but is expensive. As an alternative, some farmers are investigating on-site production of their own biochar:

- Learn to Make Charcoal at restorechar.org
- Kiln Design Resources

HOW TO APPLY BIOCHAR

Bagged or bulk products sold commercially have been tested and analyzed, and will provide application instructions. But for do-it-yourselfers, there are not currently solid application recommendations. If you decide to use your own biochar, note that studies have shown that applying raw biochar alone in poor soil has little benefit to plants and may retard growth for at least 6 months.

- Rinse raw biochar in water to remove salts and hydrocarbons.
- "Charge" it by mixing it almost half and half with organic matter or with a fertilizer.

Fig. 3. Biochar can be applied in a "broadcast-and-disk" method by banding it to the planting area only.

- The application rate depends on soil type and cropping system, and ranges from 2 to 22 tons/acre. Therefore, one option is to apply the lower rates over a period of 2-3 years to slowly build up the content in the soil.

Because of the disparity in positive, negative, and neutral results on plant growth and yield, by USU research and beyond, further investigation is needed to properly quantify the effects of biochar application in different climates and cropping systems. Indications suggest that biochar could play a role in improving sustainable agriculture. Certainly, improved recommendations for agriculture industries and residential sites are coming, but a few years down the road.

References and Additional Reading

USU Forestry: Biochar for Forest Restoration in Western States - **https://digitalcommons.usu.edu/extension_curall/1740/**

Utah Biomass Resources has a host of biochar information available, including videos about making a kiln, how biochar is made, biochar in forestry, biochar research, and more: **https://utahbiomassresources.org/index**

Photo Credits

[1] RED Garner, BioEnergy Lists. **http://terrapreta.bioenergylists.org/taxonomy/term/1324**

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