BIOCHAR IN GROWING MEDIA: DOES IT HELP OR HURT PLANTS?

August 2022

KEY POINTS

- The effect of biochar varies depending on the proportion used in potting mix and how the biochar was made (feedstocks and temperature).
- A high proportion of biochar (e.g., 50% by volume) in a growing medium can impair plant growth.
- Lower proportions of biochar (e.g., 5-15% by volume) have potentially beneficial effects on plant growth, fruit size (tomatoes and peppers) and soil life.

INTRODUCTION

Biochar is a charcoal-like substance created by burning organic materials, often wood or woodchips, in an oxygen-deprived situation (pyrolysis). There has been a lot of hype about biochar with extravagant claims made about its potential to sequester carbon (thereby mitigating effects of climate change) and also to improve crop yields.

The reported benefits of biochar include:

- Greater uptake of nitrogen (N) stimulating plant growth
- Stimulation of beneficial soil life, including mycorrhizal fungi
- Increased cation exchange capacity (ability the soil's ability to retain nutrients)
- Increased nutrient availability
- Reduced nutrient leaching
- Improved soil porosity
- Greater water retention in soil

Many of these claims reflect the effect of biochar in tropical soils, often acidic low-fertility soils. How does biochar work in Canadian soils? Is biochar a valuable soil amendment for Canadian greenhouses? With support from the Organic Science Cluster, the potential of biochar to affect the growth and health of potted plants in greenhouses is being studied by Drs. Martine Dorais (Laval University), Valérie Gravel (McGill University) and Vicky Lévesque (AAFC Kentville Research and Development Centre).

The scientists investigated the link between biochar and plant growth, and its effect on beneficial and harmful soil organisms. In particular, the scientists studied the impact of biochar on root colonization of *Pythium ultimum*, a pathogen that can cause damping off and root rot, and beneficial endomycorrhizae (also known as arbuscular mycorrhizal fungi). Endomycorrhizae fungi have symbiotic relationships with many plant species. The fungi form growths on plant roots which improves the ability of plants to extract water and nutrients, particularly phosphorus, from the soil. The fungi can also protect plants from pathogenic fungi including *Pythium*.

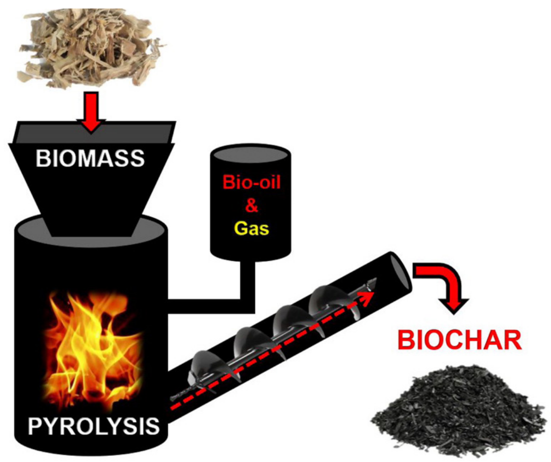

Figure 1: Biochar is produced by pyrolysis of organic materials (Vicky Lévesque, Maren Oelbermann, and Noura Ziad)

BIOCHAR IN POTTING MIX

Experiment 1: Effect of biochar on seedlings: germination and resistance to Pythium

Researchers examined the effect of biochar on crop germination and establishment including in soils inoculated with *Pythium ultimum.*

Sweet pepper, basil, coriander, geranium and lettuce were planted in an organic peat-based medium. For half of the seedlings, the mix contained biochar at 50% of the soil medium by volume. Later, seedlings of these crops were transplanted in four different potting mixes. Half contained 50% biochar (by volume); the others had no biochar. For both of these groups, half were inoculated with *Pythium*. The plants were given liquid organic fertilizer and allowed to grow another 8 weeks.

Results: Biochar appeared to have a negative or neutral effect on germination. For sweet pepper, geranium and coriander, the biochar did not seem to affect germination rates. However, basil and lettuce had up to 46% lower germination rates when biochar was added.

Biochar's effect on transplants was mixed. Coriander grew better when biochar was in the potting mix, lettuce was negatively affected and there was no significant effect on the other crops. For *Pythium*-inoculated plants, the pathogen generally had greater colonization of the roots when biochar was in the medium but there was no sign of damage to the roots or to plant development.

Experiment 2: Effect of varying rates of biochar in different soil types

Greenhouse tomato seedlings were transplanted into six different organic soils ranging from sandy soil, loam to muck. For each of these, there were four biochar treatments - 0, 10, 30 and 50% biochar by volume. Half the pots of each treatment were inoculated with *Pythium*.

Sweet pepper, geranium and basil seedlings were transplanted into media containing 0-30% biochar as well as an endomycorrhizal inoculant.

Results: A high proportion of biochar (50% of potting mix by volume) led to smaller plants regardless of soil type. Biochar did not appear to have an effect on the colonization of roots by *Pythium*, but inoculation with *P. ultimum* had a negative effect on plant growth in all treatments.

In terms of mycorrhizal fungi, biochar did not seem to have a significant effect on plant size or colonization by these beneficial fungi.

THE POTENTIAL OF BIOCHAR

It appears that including up to 30% (by volume) of biochar in potting mix is not likely to harm plants but higher rates (50+%) may stunt plant growth.

The negative effect on growth may be due to the extremely high carbon to nitrogen ration (C:N) of biochar. For example, softwood biochar can have a C:N of 360:1. A portion of the C added by biochar can be used by the soil microbes as a food source. The low N content of the biochar may require microbes to draw N, especially nitrate, from the soil solution in order for them to digest the biochar C. This immobilization of nitrate reduces its availability to plants, which may affect yields if the soil N supply is inadequate. However, it also has the benefit of reducing nitrate leaching by removing nitrate from the soil solution. In Experiments 1 and 2, the liquid fertilizer was high in nitrates and that may have provided sufficient N both to the plants and to the microbes that consume the available biochar C.
The Organic Science Cluster researchers also investigated biochar's complex effect on soil life. Biochar provides suitable habitat for soil microorganisms due partially to its ability to hold organic matter and nutrients.

The finding that the plants grown in biochar had higher rates of *Pythium* colonization but no subsequent reduction in growth (Experiment 1) suggests that biochar might stimulate plant defences. This could be due to chemicals in the biochar or the effect of beneficial microorganisms that were stimulated by the biochar. For this experiment, the biochar content was high (50% of medium by volume).

At lower rates of biochar in Experiment 2, there was no significant effect on *Pythium*. However, the soils in this experiment had already been used to grow tomatoes and contained diverse soil life, compared to the substrate used in Experiment 1. The microorganisms present in the 'used' soil may have also suppressed *Pythium*.

In a related project, Drs. Vicky Lévesque and Dorais found that not all biochars have the same effect on the soil. They compared biochars made from maple and pine. Both affected soil properties and soil life, but in different ways. At relatively low rates of biochar (5-15% by volume), biochar had several benefits. Plants became more efficient in water uptake. More N and P were available to plants, and the biochar-amended medium contained more species of bacteria including potential plant growth promoting bacteria. The end result was good news for the greenhouse producer: heavier tomatoes and sweet peppers.

The nature of biochar is influenced by the feedstocks (materials burned) and the pyrolysis temperature. For example, depending on the feedstocks, the pH of biochar ranges from 4-12, and the choice of an acidic or alkaline biochar can alter its effect on plant growth.

In addition, the temperature at which biochar is created is another critical factor. When created at higher temperatures (e.g., 600C compared to 300C), biochar's C:N increases – this means biochar created at higher temperatures may have an increased ability to sequester carbon but might also impair plant growth by tying up nitrogen. Also, biochar created at higher temperatures may have lower water-holding capacity and cation exchange capacity (ability to retain nutrients).

DID YOU KNOW?

Interest in biochar is linked to the discovery of 'Terra Preta' in Amazonia. This soil is remarkable due to its high level of nutrients and organic matter, which is all the more surprising given the infertile soil surrounding Terra Preta. It is believed that Terra Preta developed over thousands of years from the charcoal, bones, manure and other waste from early farmers.

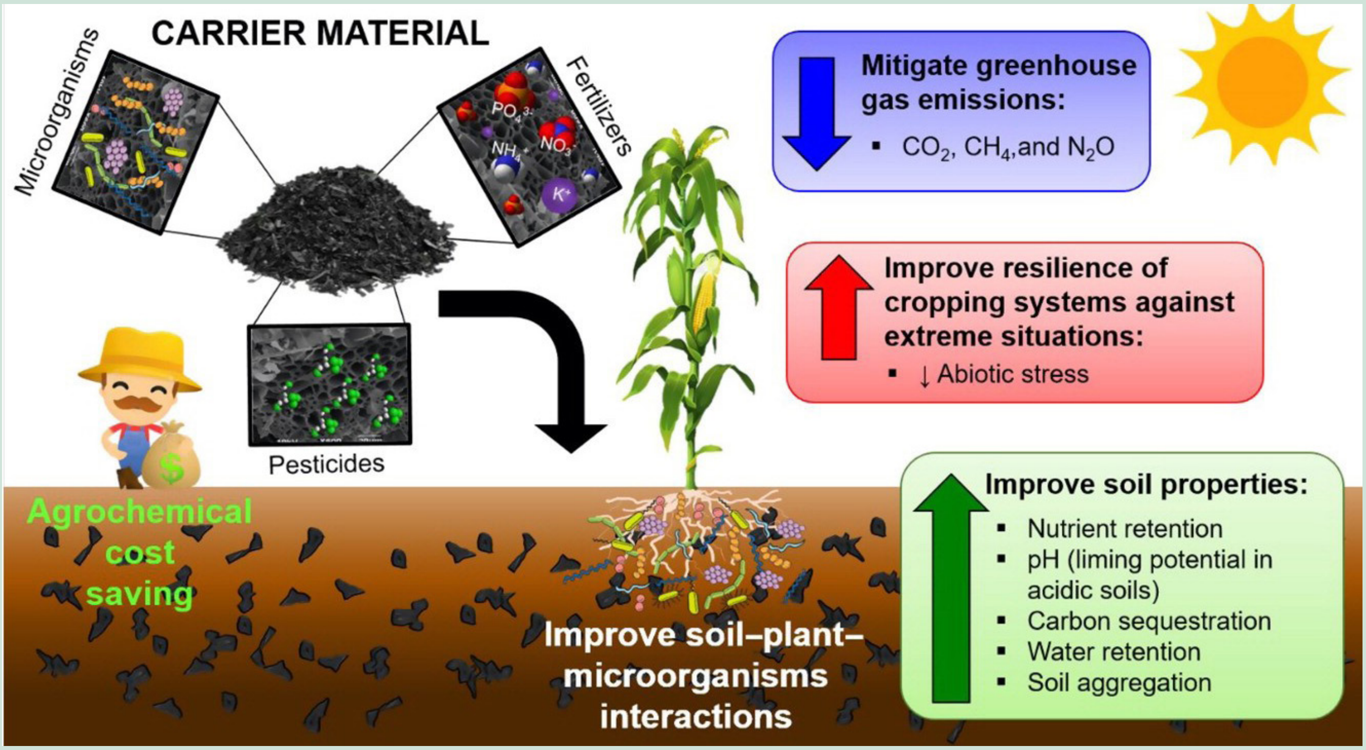

Figure 2: Potential benefits of using biochar as a soil amendment.

CONCLUSION

The take-away message: biochar might not be the panacea some claim. However, using 5-15% biochar in potting mix has potential for reducing soilborne disease, reducing nutrient leaching, improving soil quality and, ultimately, increasing yields. More research is needed to identify the best ways to create biochar and how to use it in greenhouse production.

ABOUT THE ORGANIC SCIENCE CLUSTER

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