INDUSTRY RESEARCH

Investigating Two Biochars in Soilless Substrates

By Lesley Judd and Brian Jackson, NCSU Department of Horticultural Science

Different biochars produced from (clockwise, starting on left) pine, Georgia pine, chicken manure and rice hulls. Various particle sizes and shapes.

The use of biochar for horticultural purposes has gained interest over recent years. Biochar has the potential to be a local and renewable product. It is produced as a by-product from pyrolysis, which also creates bio-oil and syn-gas for fuel.

The term 'biochar,' however, is given to any charred biomass product, whether it is produced from a fast/slow pyrolysis or from gasification with feedstock material ranging from filed crop waste to animal manure. This has created a wide range of positive and negative results on plant growth and substrates when using biochar.

At NC State University, we are producing biochar from two waste products, pine wood chips and rice hulls, using a top-lit updraft (TLUD) gasifier in partnership with the Dept. of Biological and Agricultural Engineering. Research is being conducted to learn more about biochar products produced from gasification and the biochars' effect on container substrates and plant growth.

We have worked on characterizing the biochar both physically and chemically to understand how biochar may change the root environment for plants, and experimented with these two biochars in growing tomato (*Solanum lycopersicum* 'Better Boy').

Dr. Lesley Judd

Dr. Brian Jackson

Producing the biochar

Two cubic yards of either pine wood chips (*Pinus taeda*) or non-parboiled rice hulls were loaded into the large TLUD reactor. The feedstock material was lit at the top inside the gasifier reactor and then the reactor was quickly closed to control the gasification of the material. Combustion was sustained by regulating the amount of air entering from the bottom and passing up through the material. A vent at the top of the reactor allowed

Since 1979, the North Carolina Nursery & Landscape Association has provided over $1 million in funding to research, endowment and program activities at NC State University. This industry research, in part supported by NCNLA's member dues premiums (silver, gold and platinum) and successful fundraising events throughout the year, demonstrates the effectiveness that private-sector collaboration with a world class public institution can provide. This is just one example of how NCNLA has partnered with NC State to provide solutions for green industry businesses here in North Carolina.

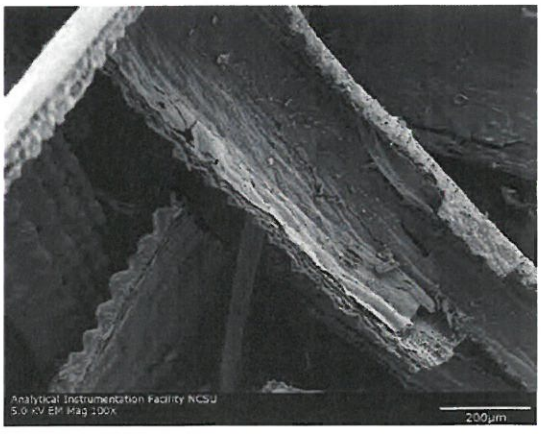
The tomato plants grown in rice biochar have larger shoots and appear to have more root growth.

Biochar has the potential to be used as a substrate component in horticulture, however currently the cost does not outweigh the benefits.

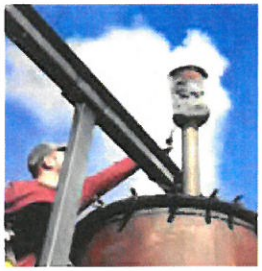
TOP: Pine wood chips and pine biochar; Bottom: rice hulls and rice biochar used in studies at NC State University.

Top-lit updraft (TLUD) gasifier

Magnified side view of a pine biochar particle



Magnified view of rice biochar particles



Syn-gas produced from gasification.

Syn-gas ignited, reducing smoke

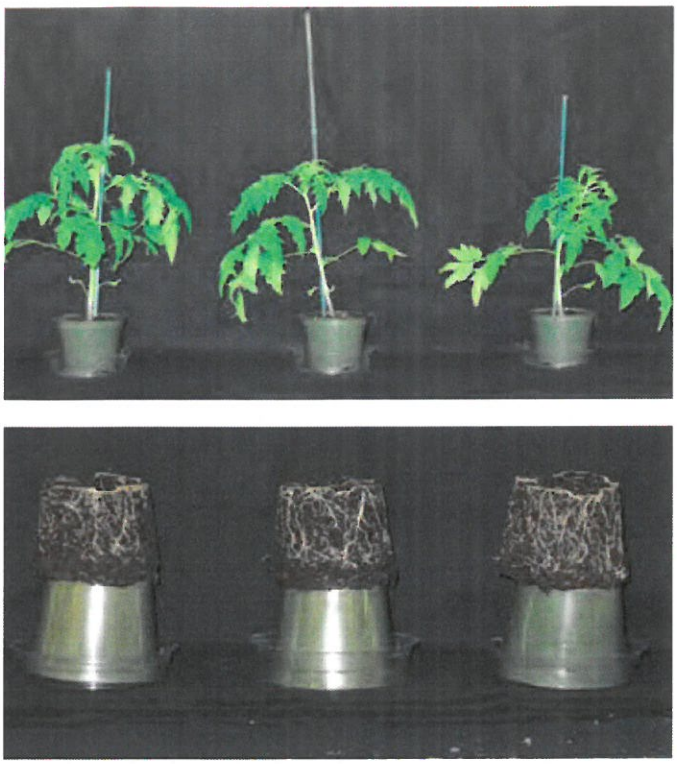
the syn-gas to leave the system, and this gas was lit to reduce the amount of smoke produced.

A temperature probe inside the reactor measured the internal temperature of the flame front and resulting biochar as the front passes. The temperature of the flame front during the production was 744° C for pine wood and 704° C for rice hulls.

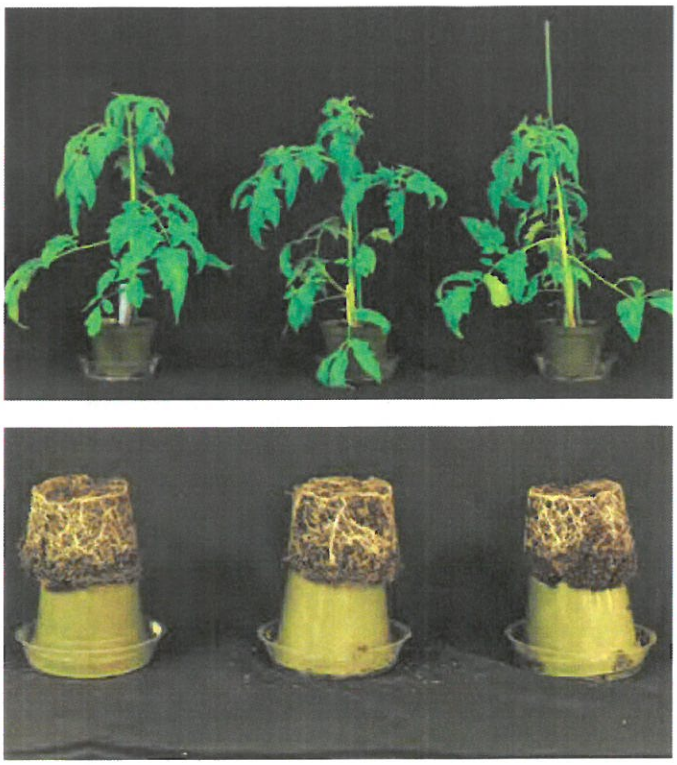
The two biochars were different in particle shape and size. Pine biochar had a pH of 8.7, while rice biochar had a pH of 9.5. The rice biochar was shown to be composed of higher amounts of potassium and silica, but had half the amount of fixed carbon compared to the pine biochar.

Testing Substrates

The study was executed in greenhouses at Raleigh, NC. Six substrates were used: peat moss at 90% (v/v)



Tomato plants after 28 days, from left: 10%, 20% and 30% pine biochar



Tomato plants after 28 days, from left: 10%, 20% and 30% rice biochar

amended with 10% pine biochar or rice biochar, peat moss at 80% (v/v) amended with 20% pine biochar or rice biochar, and peat moss at 70% (v/v) amended with 30% pine biochar or rice biochar.

The substrates containing biochar had a beginning pH of 4.0, and sufficient calcitic lime (4 lb·yd^{-3}) was added to those substrates to raise the pH to an optimal level (5.8). One tomato plug was planted into the center of a 5" container containing one of the substrates, there was 36 replications for every substrate. Plants were grown over 28 days, receiving 20-10-20 NPK fertigation daily.

The pH of the substrates ranged between 5.3 and 6.0 throughout the study. Growth indexes (GI) of the tomato plants after the first week showed tomato plants grown in 10% and 20% rice biochar had the highest GI, while 10% pine biochar and 30% rice biochar had the lowest GI.

After 28 days from planting, all three rates (10, 20 and 30%) of rice biochar had higher tomato GI than the three rates of pine biochar. The tomato plants grown in rice biochar have larger shoots, and visually the tomato plants appear to have more root growth when grown in the rice biochar.

Hurdles: Cost and Clarity

Biochar has the potential to be used as a substrate component in horticulture, however currently the cost does not outweigh the benefits. Biochar is more costly than perlite. The price averages around $200 per cubic meter — compared to perlite at $30-40 per cubic meter.

Along with the cost, another disadvantage is how the term 'biochar' is being used for any type of charred biomass, thereby creating wide variability within the product. In order to really develop a market for biochar; more definition needs to be made and reported, such as terming the product charred pine wood and stating the particle size and nutrients supplied by that material when made by a particular process at a specific temperature (which these characterizations can change with a different process/temperature/particle size). With this type of in-depth detail on different biochars, the market/availability may increase for growers and eventually decrease the cost.

Tomato plants growing in peat-biochar substrates (along with marigolds)

About the Authors: Lesley Judd recently earned her PhD in the Department of Horticultural Science at North Carolina State University, working with biochar in greenhouse substrates. Brian Jackson is an Associate Professor in the Dept. of Horticultural Science and researches alternatives for soilless substrates. This research is funded by the American Floral Endowment and the North Carolina Nursery and Landscape Association.