Editors' Note: This is the sixth in a seven-part series on research being performed at North Carolina State University in Raleigh, N.C.

Improving Greenhouse Substrates

Researchers are developing new sustainable organic components at NCSU.

By Bill Fonteno and Brian Jackson

In the Horticultural Substrates Lab at North Carolina State University, Brian Jackson and I are striving to improve the efficiency of substrates for greenhouse production. Our objectives are four fold.

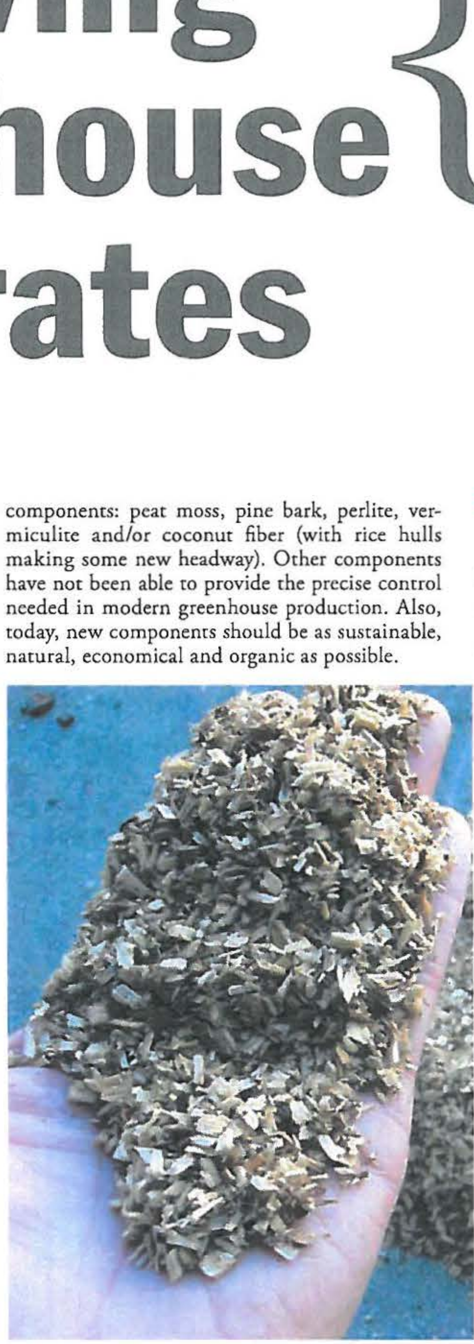
- To explore the use of wood as an organic aggregate in greenhouse mixes.
- To enhance root growth in greenhouse crops. Faster, more robust rooting would reduce transplant shock, reduce disease possibilities and perhaps reduce cropping times.
- To increase the nutrient retention of substrates. Much of the nutrients applied to containers find their way into the wastewater from the greenhouse. Improving retention improves nutrient efficiency, which means less nutrient leaching, less fertilizer and less runoff.
- To improve the overall biology of greenhouse substrates. The microbes that we find in natural soils are largely absent in container substrates. Improving the substrate environment increases the number of beneficial organisms, which reduces disease.

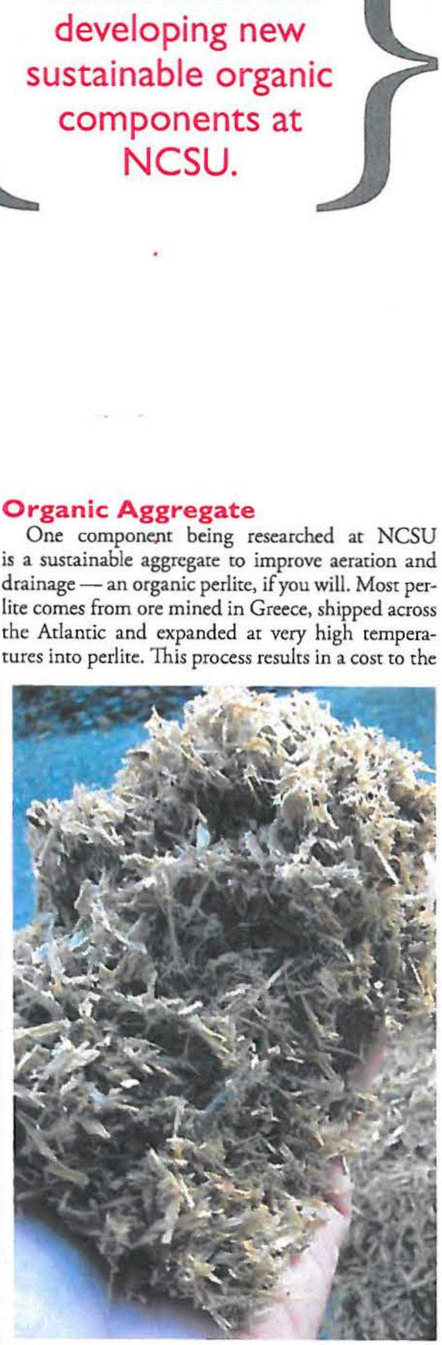
To meet these objectives, the approach being used at NCSU is to develop new, sustainable components for greenhouse substrates.

Any new component for greenhouse substrates must be highly consistent, lightweight, be readily available and reasonably priced. Here at the Horticultural Substrates Lab, we have tested thousands of samples of several hundred potential materials as possible new components over the last 35 years. However, most greenhouse mixes in the United States today are made from a handful of familiar components: peat moss, pine bark, perlite, vermiculite and/or coconut fiber (with rice hulls making some new headway). Other components have not been able to provide the precise control needed in modern greenhouse production. Also, today, new components should be as sustainable, natural, economical and organic as possible.

Organic Aggregate

One component being researched at NCSU is a sustainable aggregate to improve aeration and drainage — an organic perlite, if you will. Most perlite comes from ore mined in Greece, shipped across the Atlantic and expanded at very high temperatures into perlite. This process results in a cost to the





Processing makes a difference. These samples were initially chipped (left) or shredded (right). Further processing was the same.

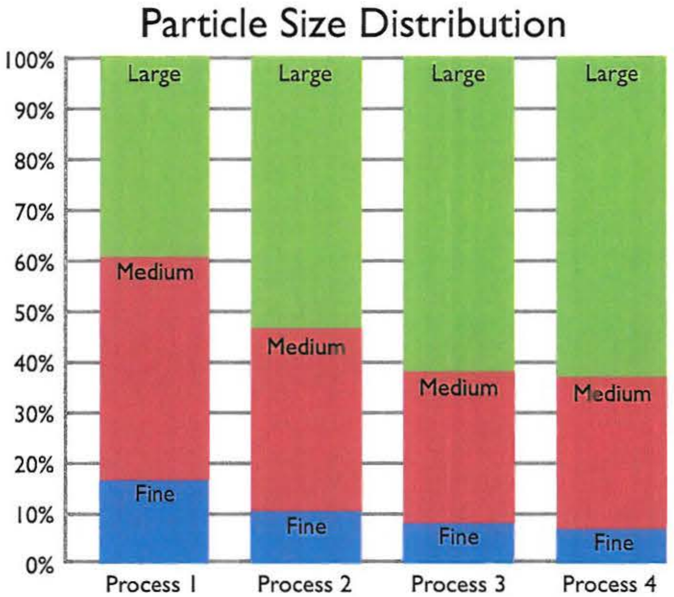


Figure 1. Particle size distribution of wood chips that were processed using four different techniques. Pine logs were initially chipped differently but all samples were then passed separately through the same ¼-inch hammermill screen. Differences in fine and large particles are significant among processing techniques and therefore will affect the physical properties (air space and water holding) of peat-based substrates when incorporated.

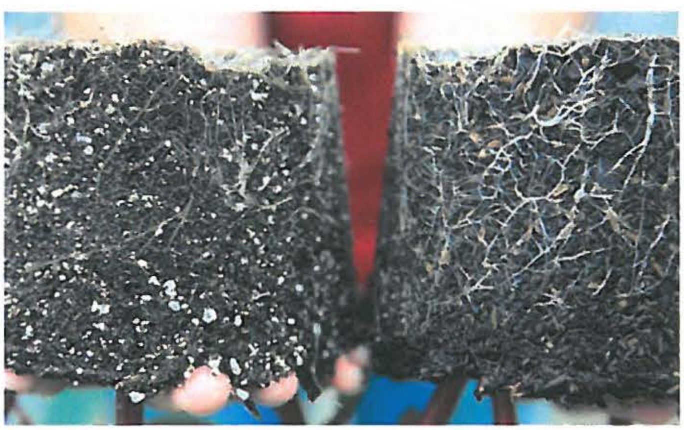
grower often more than $2 per cubic foot. The research team at NCSU is using wood ground from whole trees for a cheaper, sustainable alternative.

Grinding trees for container substrates has been investigated for a few years. However, information from NCSU researchers shows that many processing factors affect the size, shape and performance of finished wood substrate materials: the initial processing of trees (shredded or chipped), the brand/style of machine, the moisture content of the tree, the tree species, type of hammermill, screen size, etc. Variation in any one of these factors can produce very different results.

The researchers are working backwards, starting with the physical and chemical properties of current components and reverse engineering the process to get the desired results. Effects on fertility, PGRs and storage issues must also be addressed. Hopefully, the end result will be a new organic component that is sustainable and about half the price of perlite.

Enhanced Root Growth

One unexpected but consistent result in using wood-based materials in mixes is an apparent improvement in the root mass of greenhouse crops. Growers who have tried these new materials say they see more roots, larger



Root growth in substrates with perlite (left) and wood aggregate (right). Root growth seems enhanced. Quantification is underway to determine if and how this might be true.

__Top:__ Biochar is a form of charcoal. Properties include increased nutrient holding, reduced weight and improved beneficial microbial populations in soils. __Bottom:__ The Biochar Unit at NCSU. This patented process provides a continuous flow of material through a temperature controlled firebox and produces a biochar with a 66-percent reduction in weight. The gases emitted from the unit are recycled and burned, making this process nearly free of external fuel costs.

roots and faster root growth. Most of this evidence comes from removing the pot and looking at the outside of the root ball. Speculation is that the wood materials provide greater aeration, which stimulates root production. However, little data is available to corroborate these claims. The NCSU team is investigating this possibility, with strategic wood substitutions and root mass measurements. If this phenomenon can be controlled, root systems can be more robust, root-related diseases would have a tougher time getting started, transplant shock can be reduced and cropping time might be reduced.

Biochar

The use of charcoal (biochar) to improve nutrient poor soils is well documented. Charcoal is made through a process called, pyrolysis, a slow-burning process under reduced oxygen. Once an organic material has been pyrolyzed, it is lighter in weight, retains greater nutrient charge because of an increase in cation exchange capacity (CEC), and lasts for many years without degradation. In fact, enriched soils known as terra preta in the Amazon jungles of South America are fertile today, even though they were created more than a thousand years ago. Having a lightweight organic material that does not degrade would be first of its kind for substrates.

Not all biochar is created equal. Most biochar is produced on farms in the field with various low-cost (and low-tech) methods. Differences in oxygen content, feed stocks and processing (during the pyrolysis process) create variations in the desired properties listed above. So the biochar that might work for acres of nutrient-poor soils for farmers will not be consistent enough for greenhouse substrates. Agricultural engineering researchers at NCSU have developed a patented continuous line process to precisely control time, temperature and heat exposure for biochar production. This results in a much more precisely and consistently controlled product.

The potential benefits to substrates are tremendous. A wood-based aggregate can be charred to not only provide aeration, but also nutrient retention. Biochar can be crushed and added as a fine powder to improve overall CEC of mixes. Any bark- or wood-based component can be processed faster to reduce weight without affecting other attributes. Imagine reducing the weight of a truckload of substrate by 66 percent — a common weight reduction with biochar.

The key to consistency, reproducibility and success is in the processing of the wood and biochar materials. Our substrates team is working closely with the Ag Engineers at NCSU to develop consistent materials for testing. Specific attributes will be "dialed in" and tested for increased benefit.

Improved Substrate Biology

Natural microbe populations in substrates have always been low. Fungicides, high fertility, etc., have not been conducive to providing a soil environment that promotes these organisms. The high surface area and pore structure of biochar provides a habitat that favors these microbes. This may improve the root environment to stimulate the substrate biology as never before. Microbial populations are being monitored in substrates and variations of biochar will be tested for improving soil biology.

The achievement of these goals is not certain. Anyone of a dozen outside factors could prevent these efforts from coming to fruition. However, this is the closest the substrates industry has come to adding truly new choices of components for growers in many years. The NCSU researchers are optimistic that they can help in providing these new choices.

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