# NEW MEDIA COMPONENTS – ARE THEY WORTH THEIR WEIGHT IN DIRT?

By Brian Jackson and Bill Fonteno

Advances in greenhouse growing media (substrates) continue to evolve to meet current day problems, needs, and trends. Growing media selection and performance remain one of the most important factors in horticultural crop production. The Horticultural Substrates Laboratory (HSL) at North Carolina State University (NCSU) has been working on soils and growing media-related issues since 1980, and at no time during that history has our industry had more interest in new discoveries in growing media research than now. In the past eight years there have been a record number of publications (trade magazine, extension bulletins, websites, scientific journals, etc) addressing issues with traditional growing media components and introducing alternative materials. To that point, a quick look through trade/industry magazines yielded 21 articles on growing media published since 2008 and the number of scientific (research) publications is over 50 in that same time period. The HSL receives and tests roughly 1,000 samples every year from nursery, greenhouse, university, and landscape industries. Several factors have prompted the spike in grower and manufacturer interest in recent years, including:

1) Canadian peat shortage of 2011 due to unusually wet weather during the harvest months which resulted in the lowest peat supplies in decades. This saw a significant increase in growing media costs and in some cases the utilization of mixes containing peat extenders/alternatives.

2) Pine bark industry saw increased cost and lower supplies (2010-2011) due to proposed government subsidies for biofuel (Biomass Crop Assistance Program – BCAP). This threat prompted interest in alternatives for the nursery industry but also elicited concern from growing media manufacturers considering the heavy use of pine bark in many greenhouse mixes.

3) Variability in pine bark consistency, water holding capacity, and hydrophobicity from source to source (supplier to supplier). Partially as a result of the BCAP threat and partially due to trends in consumer demand, the processing and handling of pine bark has changed in recent years which has led to changes in product quality and performance in some situations.

4) High cost of perlite in growing media continues to warrant interest in alternatives. In most situations, perlite is the single most expensive media component (by volume). In addition, a more recent complaint of many growers and mix manufacturers has been the variability in perlite particle size and consistency from source to source (and from batch to batch). This variability and inconsistency leads to variable air and water properties in growing mixes.

5) General increase in transportation and fuel costs which have affected the cost of all growing media components, and as a result led to greater interest in locating and developing "local" growing media components. Transportation costs are, and will remain, the biggest concern for the growing media industry. Not only do transportation costs influence peat, perlite, and pine bark, but these costs will also be the defining factor that determines the feasibility and success of any new or alternative media component in the future.

6) The growing public perception and demand of "green," "sustainable," and "local" concepts has made its way to growers and mix manufacturers attempting to meet these market trends/demands and offer products that fit these requirements. The interest in local alternative media components has the immediate advantage of reduced freight (transportation costs) to growers and distributors but a more broad-based and novel advantage may be the opportunity for new marketing strategies. Many growing mix manufactures are already promoting new product labels that include phrases like "all natural," "organic and sustainable," and "environmentally friendly" to highlight the use of new alternative and sustainable components in their mixes.

7) Storage issues associated with long-term quality control of growing mixes that contain new alternative organic materials that are decomposing, consuming the starter charge, or experiencing substantial pH changes during storage. The rush to supply new growing mix formulations (or components) has sometimes precluded the long-term evaluations during storage (bulk or bags) that is needed for product quality assurance.

8) Lack of understanding of the processing requirements and variables that influence the manufacturing of organic materials (i.e. trees/ wood) for use in growing media. With many growers and mix manufacturers currently developing their own new mixes, many are

purchasing equipment to process raw organic materials and are not producing consistent products. Currently, there is a tremendous void of relevant information available to the horticulture industry aimed at addressing issues associated with the processing and engineering of raw organic materials for use as growing media components. Addressing this need is one of the forefront objectives of researchers at NCSU, particularly with the processing of pine trees (wood in general) to make consistent products.

## AGGREGATE ALTERNATIVES TO PERLITE IN GROWING MIXES

**Parboiled rice hulls** (PBH) have continued to gain popularity among growers in recent years. Since first being evaluated as a component in growing mixes in the early 1990s, PBH are now the second most used aggregate (after perlite) with an estimated sales volume of 10,000 tons in 2011. PBH is sold in either 4 cu. ft. bales (50 pound bags) that yield 7 cu. ft. or 30 cu. ft. bales (700 pound bales) that yield 90 cu. ft. PBH is predominately supplied by distributors in the southern United States (Arkansas, Mississippi, Louisiana). One distributer, estimates 35,000 tons of PBH are produced each year from one area of Arkansas alone. This abundant resource can provide a cheaper alternative to perlite in regions in close proximity to its origin but as distance increases the freight costs increase, potentially making it less advantageous for many growers.

**Pine wood chips** (PWC) made from loblolly pine (*Pinus taeda*) are one of the many wood-based growing media components that have been discussed in recent years. Through the extensive research of pine tree substrate's (including WholeTree and clean chip residual) there have been many suggestions made that these materials provide the porosity to peat-based greenhouse mixes that would exclude the need for perlite. Until recently, no official experimental data or recommendations have existed on how wood chips can be used as aggregates. The main reason for this was due to a lack of consistency and knowledge about how pine wood is processed. Research at NCSU in 2011 and 2012 has provided a wealth of knowledge about using PWC as an alternative to perlite. When amended with peat at ratios of 10 percent, 20 percent, or 30 percent (by volume) compared to the same ratios of perlite, no differences were seen in physical properties (air and water holding), fertility requirements, plant growth regulator rates/efficacy, disease (*Pythium* sp. and *Rhizoctonia* sp.) occurrence, or shrinkage or decomposition. Based on these results (and at those ratios), no cultural changes in crop production are needed to switch from perlite to PWC. Even though perlite can be completely substituted with PWC with no change in cultural practices, the addition of 5 percent perlite to mixes is still advised because the general public (consumers) has the perception that the white particles of perlite are actually fertilizer! It is estimated that the cost of PWC, including the acquisition or pine trees, equipment to process the trees, and actual manufacturing (energy, man hours, etc.) will be 40 percent to 50 percent cheaper than perlite. The broad geographic natural range of loblolly pine makes PWC available to local markets across much of the southeastern United States with limited/minimal freight costs. In the Ohio Valley and northeastern regions of the United States where loblolly pine is not grown, eastern white pine (*Pinus strobus*) or Norway spruce (*Picea abies*) has also been proven to be viable tree species to make wood components for mixes (Figure 1).

*Figure 1. Comparison of pine wood chips (PWC) engineered to be used as an aggregate (on left) and shredded pine tree substrate (PTS) engineered for use as a peat-extender (right). Both wood components were similar aged trees, harvested at the same time, but processed differently to yield specific desired products.*

**Growstones** (GS) have also been successfully used as an aggregate in peat-based growing mixes. Growstones are produced from waste glass that is ground and combined with calcium carbonate and heated in a kiln. According to Dr. Mike Evans, University of Arkansas, who has published research findings on the use of GS, the heat resulted in the production of carbon dioxide as the glass particles were heated and fused together trapping air spaces inside the glass. This results in an expanded lightweight product that can be ground to desired particle sizes. One of the stated advantages to using GS aggregates in mixes is their stability over long crop production cycles compared to some other organic aggregates that decompose. GS would be effective in growing mixes that may need adequate porosity and structure for long periods of time (year) as in the case of house plants. Evans has reported that GS are a feasible aggregate that provides desired physical properties and grows high quality plants similar to plants grown in substrates containing perlite or PBH (Figure 2).

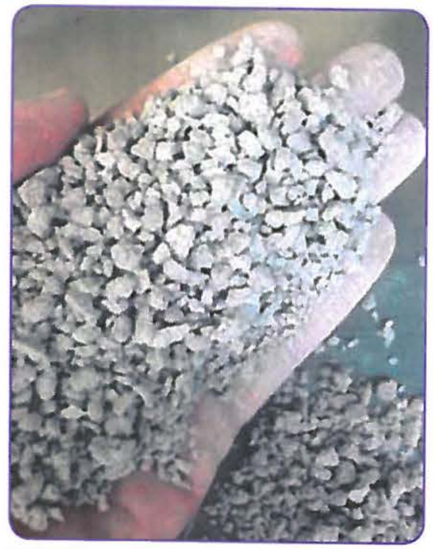

*Figure 2. Growstones aggregate.*

## PEAT ALTERNATIVES/EXTENDERS

Many materials have been touted over the years as the "replacement for peat," yet peat remains a good and viable material for containers. Despite some reports and beliefs, peat is an extremely abundant resource with approximately 270 million acres in Canada alone, of which only 0.02 percent is reported as being harvested for horticultural consumption. The peat producers (suppliers) are also going to great lengths (and expense) to "lightly" harvest peat bogs and restore them after harvest in a way that has minimal impact on the environment.

There are materials currently on the market that are able to be used like peat or in conjunction with peat. These we call alternatives or extenders, not "replacements," as it is not possible to "replace" peat due to its specific properties and success as a growing media, but instead only find suitable substitutions to it. Most growers that use peat in their mixes have grown accustomed to the water and fertility practices that ensue. Completely removing peat generally calls for altering these practices. However, the following materials have been used with peat as extenders in volumes that do not appreciably alter water and nutrition factors.

**Coconut coir** continues to have a large presence in the growing media markets and it is the most used/sold of all non-peat materials. Coir has similar water holding properties like peat, but water flow through the coir is different than peat, i.e., coir dries differently than peat. Coir's pH is higher, and the salts in coir can be much higher than peat but are variable with coir source. Coir also does not have the waxy coating that peat does, so coir wets up much easier than peat. Research shows that you can generally substitute up to half of your peat fraction with coir with no change in water or fertility practices. Above that, your watering will change.

**Wood substrates**, particularly pine tree substrates, have made the biggest push in the industry in recent years. It was just a few short years ago when the first work was published (2005) on the concept of using fresh, non-composted pine wood as a viable alternative to peat moss in the production of greenhouse crops. At that time, the idea of using fresh wood in mixes was met with much skepticism (with good reason) by the industry, academics, and manufacturers. As more and more researchers (university and mix manufacturer R&D folks)

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looked into this material and came to the same conclusions that there is indeed great potential with using wood, the perceptions have become more positive and now are very optimistic. Since 2005, more research has been conducted and reported on the use of wood-based substrates or substrates containing wood components, than any other alternative material. Reasons for the high interest in pine tree substrates include: the availability of pine trees (specifically loblolly pine) in the United States; the renewability and sustainability of using pine trees; pine trees are fast growing and conceivably can be grown specifically for use as a substrate component – growing the media of the future; wood/pine fiber has a low bulk density, light weight and can be easily compressed for shipment; crops grown in mixes containing wood have consistently shown increased/improved root growth and; pine wood does not breakdown, shrink or really even lose its yellow color during crop production, not even long-term 3- to 4-month crops.

It is important to point out that there is a difference in pine tree substrates (often referred to as pine/wood fiber) used as peat extenders and those that are used for aggregates (PWC described above). Pine wood processed in a fashion to be a peat extender (see section below on processing differences) will be more fiberous in nature, hold and release water similar to that of peat, and can be used up to 40 percent in a growing mix without many – if any – changes to irrigation and fertility practices. Above 40 percent, nitrogen tie-up will be a problem for some crops and increased fertilizer rates will be needed. Wood inherently has a high pH, ranging from ~5.0 to 6.0 most often, depending on the season of year the trees are harvested. Less lime may be required for mixes containing >30 percent wood to prevent pH levels from being too high during crop production. Root growth of greenhouse crops grown in mixes containing pine tree substrates (as peat extenders or perlite replacements) has been observed and reported for many years to be enhanced both in speed of rooting and overall root mass. Research in 2011-2013 at NCSU has proven this phenomenon to be factual, and researchers there are now focusing on how to further modify and improve greenhouse mixes with wood for the specific purpose of enhancing root growth. This could mean quicker production time (plugs, cell packs, containers) to form root balls. As of the beginning of 2013, there are several mix companies that offer substrates containing wood. More are coming...

**Composted dairy manure** (cowpeat, cow fiber) is the "relatively new kid on the block." Dairy manure has been around for many years, as an abundant by-product of the dairy industry. Previous work (including Dr. Paul Nelson at NCSU and more recently Dr. Mike Evans at the University of Arkansas) has evaluated the potential of dairy manure's use in greenhouse growing media. There hasn't been much interest or high demand for this product to-date, with localized exceptions in areas with abundant supplies of manure readily available. Most use of dairy manure in the past had high salts and was heavy (held too much water and was expensive to transport). New technologies are able to separate lighter components of the manure for anaerobic digestion creating a lighter, fluffier compost, similar to peat. The pH is rather basic (>8.0) compared to peat and salts can be an issue. Some processors are running dairy manure through anaerobic digestion and then further curing the material before using.

*Figure 3. Dairy fiber compost used as a peat-extender.*

**Composts** are arguably one of the most sustainable growing media components due to their production from locally or regionally produced waste products. Back in 2011 when the Canadian peat harvest was so low, the concern over peat availability was high across the country; composts were some of the first materials considered for extending the peat supplies. If produced correctly, composts are consistent materials that can be beneficial as amendments to mixes by adding water retention and beneficial microorganisms. If produced incorrectly (as many are) composts can have phytotoxicity issues, lack uniformity, and have excessive EC (salt) concentrations and pH levels. The feedstock and process for composting is critical. Compost from yard waste or fish processing facilities are different. Food waste and composted bark produce different materials. Many composts are more variable than desired and are usually heavy (adding shipping weight). This is more suited for in-ground use than precision growing mixes. However, a source separated material from a good composter can be used as a local source. But in general, this material is highly variable. Dr. Matt Taylor, research scientist at Longwood Gardens, has worked with compost for many years and continues several projects investigating the process of using composts as additions in growing mixes. He warns that the high pH of composts need to be considered when amending peat-based substrates and that lime application rates to these mixes may need to be lowered (or completely excluded) based on the percent of compost being used in the mix.

## VALUE ADDED GROWING MEDIA COMPONENTS

**Biochar** is a general term for carbonaceous materials that have been produced by exposing organic matter to high temperatures in the absence of oxygen. Biochar can be made from any organic material, most likely waste materials or by-products of agricultural or forestry industries. Common characteristics of many types of biochar are that they are highly resistant to decomposition, are very porous, light in weight, and have high cation-exchange-capacities. An extensive amount of research has been conducted for decades on the use and benefit of biochars on soil development and crop growth. The vast majority of all research has been focused on field crops, both agronomic and horticultural. Only recently has there been an interest and initiative to investigate the potential benefits of biochar incorporation into growing mixes for greenhouse or nursery crops. For this reason, there isn't much information available, but some research suggests biochars' use in container crop production increases cation-exchange-capacity (CEC) in mixes, provides moderate fluctuation of nitrate levels during crop production, and alleviates certain disease progression caused by *Phytophthora* (Figures 4 & 5).

## OLD & NEW MEDIA COMPONENTS: IT'S ALL IN THE PROCESSING

The initial processing/harvesting of materials slated for use as growing media components is as important as any other factor or step in the production of and successful use of growing media. Processing is likely THE most important factor. If not processed correctly, other factors including blending, handling, storage, amendments

*Figure 4. Pine wood chip biochar.*

*Figure 5. Rice hull biochar.*

(lime, starter charges, wetting agents, etc.) are of secondary importance in many cases. Processing is also the key to being able to consistently reproduce any growing media or media component from region to region, season to season, or year to year.

## SOME IMPORTANT PROCESSING CONSIDERATIONS FOR A FEW TRADITIONAL AND NEW ALTERNATIVE GROWING MEDIA COMPONENTS

**Peat:** Canada versus Europe. The species of Sphagnum moss in Europe and Canada are very similar. However, the processing of these materials could not be more different. The Europeans began harvesting peat for fuel and as a growing medium over 500 years ago. The method of extraction was to use sharp shovels and carve out blocks or bricks of peat that they let dry and then fraction into four fractions to be used in substrates. Many Europeans have mixes made entirely of peat, with coarse medium and fine fractions blended for the proper air and water ratios. The Canadians began harvesting peat much later and have used harrows to remove 1 to 3 inches of peat from large bog areas, then vacuum the peat up, and compress it into bales. Once expanded, the Canadian and European peats have very different properties because of the way they were initially harvested and processed. These processing differences are also responsible for the current status of the peat bogs: European bogs have been deeply harvested and caused ecological damage, whereas the Canadian bogs are not harvested as deeply and are now re-growing *Sphagnum* in used bogs.

**Bark:** Both fresh pine bark and aged pine bark have been utilized by growers and analyzed by researchers to determine the best management practices for their utilization in growing mixes.

Factor 1: Fresh versus Aged
Aging is a modified composting process where the bark is piled on the ground in windrows and allowed to age for a period of time, usually six months to one year. These piles are typically turned periodically to release heat buildup and allow consistent aging throughout the piles. Aged bark will have more fines (due to decomposition) than unaged bark and will theoretically hold more water once used in a growing media. Fresh bark tends to have more "white wood," due to it not being decomposed during an aging process. White wood is a term used to describe the actual pine wood, or xylem, and that accompanies the bark during the debarking process. Freshly harvested bark also possesses a much higher amount of its naturally occurring waxes and acids than that of aged bark causing it to repel water (hydrophobic) which complicates irrigation, wetting, and re-wetting during crop production.

Factor 2: Harvest Season
The harvest date of trees also plays a role in the variability of pine bark. Trees harvested (and bark removed) in the colder months will be more uniform, while trees (bark) harvested in the spring months tend to be more varied, "stringy," and contain more white wood. During the spring, sap is flowing in the pine trees so when the bark is removed from the tree it tends to peel and stick together more than bark that is removed in the colder months when the sap is not flowing.

Factor 3: Hammer milling and Screening
Pine bark that arrives to the facilities of bark suppliers can be handled and processed in various ways. Two common (and very different) ways are: fresh bark is processed through a large tub grinder and then screened to separate large pine nuggets, mini pine nuggets, and fines. The nuggets and mini nuggets are then often bagged and sold retail as decorative landscape mulches and the "fines" portion are then aged and used as/in growing media; fresh bark is not screened or separated in size fractions but instead the entire load of fresh bark is hammer milled (usually through 3/8 inch to 5/8 inch screens) to yield a single end product. After milling the bark is then aged. The only similarity in the end products from the two different processes above is that they are both fresh. Otherwise, they now have completely different properties (percent fines, water holding, air space, wettability, hydrophobicity, aging potential, nutrient immobilization, etc) and therefore will react differently when used in a growing mix.

**Coir:** Coir is made from ground coconut husks. These husks are from one to three years old before grinding. The age of the husk can affect the fiber quality. Some coir comes from independently-owned coconut plantations with a grinder on the back of a tractor that goes from farm to farm versus a processing plant at a central location. Quality control varies as does the salt (EC) content within the husks. Compression ratios vary from 5 to 10 times, affecting expansion and yield. Blocks are either ground or hydrated to expand. Both change the expansion rate and resulting properties of air and water holding.

**Wood fiber/Pine Tree Substrates:** Recent processing technologies and discoveries have enabled manufacturers to produce different wood components that serve different roles when incorporated in growing mixes. As previously described, pine wood can be used as either a perlite or a peat substitute. Processing of freshly harvested pine trees is the key to making different products from the same trees. If trees are harvested and first passed through a "shredder" to reduce the log to smaller pieces before being further processed in a hammer mill the end result will be more "fiberous" (peat-like) compared to pine logs that are first passed through a "chipper" and then further processed through a hammer mill to produce "blockular" wood chips that have clean edges, no fibers, and are sized similar to perlite particles. Many additional factors other than machine type are important in the processing of wood including screen size of hammer mill, size (horse power) of hammer mill, air handling system of hammer mill, moisture of wood at the time of grinding, and species of wood being ground as well as several others. To produce a consistent wood product these processing factors must be considered. When first working with pine tree substrates in 2005 I (Jackson) asked myself "Here is pine wood, what can I do with it and how can I make it work?" Based on the processing breakthroughs we have made in recent years and other new advances, I now ask the question, "Here is pine wood, what would I like to do with it?"

**Biochar:** There are, in fact, many processes that can be used to make biochar including torrefaction, pyrolysis, and gasification. These processes differ in the temperature ranges and exposure time/speed of the organic feedstock to those temperatures. These factors result in biochars with varying physical and chemical properties. There is currently a lot of research being conducted around the country by private companies, universities, USDA researchers, and private individuals who are working to find and capitalize on potential benefits of using biochar in growing mixes. As a result of the process(es) of making biochar, it is conceivable that many unused or underused organic waste materials could now be used as a value added product. The main issue that should not be overlooked by companies or individuals who are working with biochar is that, like compost, biochar is extremely variable from source to source and one biochar is not like another.

**Compost:** Like biochar, "compost" in general should be considered more of a verb than a noun in that the variability, inconsistency, and lack of reproducibility are extreme unless very specific guidelines and procedures are followed. With proper processing, protocols and feedstocks compost can be a viable and reproducible media component, especially when used at low percentages (5 percent to 15 percent).

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### BOTTOM LINE

There have been, are, and always will be issues relating to growing media that deserve attention and consideration by both growers and mix manufacturers. The upside to this reality is that there has been a lot of valid research conducted on the discovery, development, and use of many successful alternative media components in the past 8 to 10 years. Much research has also improved the use and effectiveness of our traditional staple materials (peat and bark). Looking forward, the biggest factors in determining if any new or alternative components are viable are location of the grower, proximity of growing media components, and the transportation costs associated with them. Every grower and mix manufacturer must look at their own situation and assess what materials are cost effective to be worth their investment.

Growers should be cautious when changing mixes or trying new components. But they should realize that the mix formulas they have come to trust might be more altered than they think. Many of the larger mix companies have several processing facilities across the country. Or, many distant companies will contract with other closer companies to make mixes for them to reduce transportation costs. In both cases the components that make up the mix in each region could be different. However, these different formulations would generally perform the same in production. Based on the broad range of local alternative components, most locations will have materials available to them that are viable options for cutting costs while maintaining proper growing media quality. After all, the goal of researching these new materials is not to change grower practices, but to provide stable, sustainable, and cost effective alternatives to growers.

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