A New Substrate for Container Crops

Researchers from Virginia Tech have concluded that pine tree substrate shows promise as an alternative to peat moss and pine bark for nursery and greenhouse production.

by Dr. Robert D. Wright *and* Brian E. Jackson

After more than four years of research and development at Virginia Polytechnic Institute and State University (Virginia Tech), Blacksburg, pine tree substrate (PTS), manufactured by grinding freshly harvested pine trees, shows excellent promise as an alternative and renewable container substrate for nursery and greenhouse crop production. Once in commercial production (we are uncertain as to the timetable at this point), PTS will be competitively priced, locally available (where pine trees can be grown) and of consistent high quality. This is a totally different approach to container substrate production in that a new material is created for use as a container substrate rather than mining peat (a nonrenewable resource) or using pine bark or some other industry byproduct of inconsistent quality and limited availability.

The development of a new substrate for container-grown nursery crops is timely because the availability of pine bark is currently unpredictable due to reduced forestry production and its increased use as fuel and landscape mulch. Further, the cost of peat substrates continues to rise due to transportation and growing environmental concerns over the mining of peat bogs in Canada and Europe.

This article reports on the current status of our PTS research, including the manufacturing process, physical properties, cost, growth trials, fertility management, post-transplant landscape evaluation, wood toxicity and commercialization efforts.

A typical stand of loblolly pine trees. Pine tree substrate can be produced by chipping freshly harvested loblolly pines.

Seven-gallon *Ligustrum* is shown growing in pine tree substrate.

What is PTS? PTS is made by chipping freshly harvested loblolly pine trees (*Pinus taeda*), which produces chips approximately 1 inch by 1 inch by one-fourth of an inch. These chips are further ground in a hammer mill to produce a substrate of a given particle size range designed to meet specific substrate requirements (such as air space and water-holding capacity) for a wide variety of plant genera and container sizes. Our research has shown that chips produced from pine logs (with or without bark) or entire pine trees, including limbs and needles, are acceptable for producing PTS (no plant growth difference was observed with the inclusion of bark, limbs or needles compared to growing in pine wood only). No composting of PTS is necessary, and the trees can be harvested one day and used to pot plants the next day after grinding and amending.

Loblolly pine trees are native to the southeastern US, but have a distribution and potential planting range across much of the US. The large potential growing area for loblolly pine means that trees can be grown in close proximity to greenhouse and nursery operations across a large portion of the country, saving on shipping costs of raw products needed for manufacturing and delivering substrates to growers. Also, the harvest of pine trees is less weather-dependent than peat harvest, and pine trees are renewable and pose fewer environmental concerns associated with harvest.

We have also found that substrates produced from pine trees are of consistent quality, regardless of the time of year that trees are harvested. The production of PTS interfaces the already existing paper industry for which large volumes of pine wood chips are produced for paper production. We evaluated 12 different tree species, including hardwoods and other pine species, for producing PTS and found that loblolly pine is the best choice overall in terms of substrate stability and plant growth.

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This 1-gallon petunia has a healthy root system and is ready for marketing.

One advantage to PTS — apart from the fact that it can be produced at a reduced cost in close proximity to growers where pine trees are available — is that physical properties, such as particle size, can be easily altered to meet the needs of particular plants and container sizes by the degree of grinding. The degree of grinding is controlled by the screen size with which the hammer mill is fitted. Screens with larger holes produce PTS with more coarse particles, and screens with smaller holes produce PTS with finer particles.

For example, we have found that substrate air space ranged from 18 percent to 39 percent for PTS ground in a hammer mill, with screens ranging in size from one-sixteenth of an inch to one-fourth of an inch. An air space range of 10 percent to 30 percent is often quoted as being ideal for container substrates. Container capacity (the amount of water the sub-

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Pine chips readily available from the timber industry are ground in a hammer mill to produce pine tree substrate.

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strate holds) ranged from 43 percent to 65 percent, which is within the range of 45 percent to 65 percent that is normally considered acceptable. These results demonstrate that 100 percent PTS can be produced with physical properties similar to commercial substrates.

However, the increased grinding time required to produce a PTS with a particle size fine enough to possess physical properties similar to peat moss or aged pine bark may be cost-prohibitive due to energy and labor costs associated with grinding. Large-particle PTS prepared with larger screens — thus less expensive to produce — could be amended with materials, such as peat moss, aged pine bark or sand, to increase water-holding capacity and decrease aeration. These amendments could also increase the cation exchange capacity of the PTS, which is quite low compared to peat moss or aged pine bark.

Cost of producing PTS. Pine chips produced for the paper industry or for fuel can be purchased for $5 to $6 per cubic yard. After adding the costs of grinding and extra fertilizer, one could conceivably produce a substrate for well under $15 per cubic yard compared to more than $40 for traditional peat substrates and $20 or more for aged pine bark, depending upon shipping distance.

Growth results. We have successfully produced a wide range of nursery and greenhouse crops in PTS, including 30 genera of woody plants, three genera of greenhouse crops, 14 genera of bedding plants and seven genera of herbaceous perennials. Root growth of annual and woody plants grown in PTS is equal —

Chrysanthemum 'Baton Rouge' grows better at lower fertilizer rates in peat-lite (top) than in pine tree substrate (bottom), but at 300 parts per million, growth is no different.

and most often better — than root growth of the same plants in peat moss or pine bark. This is likely due to the greater air space, but similar water-holding capacity, of PTS compared to traditional substrates.

Fertilizer requirements. In most studies, additional fertilizer is required for PTS compared to commercial peat moss or pine bark substrates. Our research has concluded that it takes approximately 100 parts per million more nitrogen from a 20-10-20 soluble fertilizer to produce comparable growth of bedding plants, poinsettia and chrysanthemums in PTS than in peat substrates. However, the addition of 25 percent peat moss or aged pine bark to PTS has been shown to improve plant growth, especially at lower fertilizer rates. This is likely because peat moss and pine bark increase the retention of nutrients available for plant uptake by increasing the cation exchange capacity of PTS. For woody plants, it has been shown that an additional 2 to 4 pounds per cubic yard of controlled-release fertilizer is required (depending on species, PTS particle size and irrigation regime) for optimal plant growth in PTS compared to pine bark.

Our research also has shown that the higher nitrogen requirements are due in part to more microbial immobilization of nitrogen in PTS because of the high carbon-to-nitrogen ratio of the noncomposted wood. But even though more nutrients are added, we have found that less nitrogen actually leaches out of PTS compared to traditional substrates. Thus, en-

We evaluated 12 different tree species ... for producing [pine tree substrate] and found that loblolly pine is the best choice overall in terms of substrate stability and plant growth.

Two years after transplanting to the landscape, *Dianthus* grown in either pine tree substrate or pine bark shows no difference in growth and plant quality.

Workers pot *Spiraea* in pine tree substrate for evaluation as a container substrate.

Pin oak and red maple grown in 15-gallon containers in pine tree substrate and pine bark show no difference in plant size and quality after three years in the landscape.

vironmental concerns related to fertilizer leaching and contaminating the environment are not an issue.

Lime and sulfur requirements. According to our research, adding lime is not required for PTS due to the inherently high pH (around 6.0) of freshly harvested and ground pine wood. However, when peat moss and pine bark are put into PTS, lime is required in proportion to the ratio of peat moss and pine bark added. For woody plants, a large number of genera have been grown without lime additions that have comparable growth to those grown in pine bark, which requires lime depending upon the species grown. Also, the addition of sulfur is required for PTS when growing marigold. Sulfur can be supplied as elemental sulfur, Micromax, ferrous sulphate, magnesium sulfate or calcium sulfate at the rate of 1½ pounds per cubic yard.

Substrate stability during production. Even though we have demonstrated higher microbial activity in PTS compared to peat moss or pine bark, it does not result in substrate shrinkage over a two- to three-month plant production cycle for greenhouse crops. Even after two years in larger containers with woody crops, no visible degradation or shrinkage occurred with the PTS substrate compared to pine bark. The lack of shrinkage in the face of microbial activity and some decay of PTS are likely due to increased root volume, which fills the void left by the decaying PTS.

Three-gallon Japanese holly grown in pine tree substrate shows a healthy root system and no shrinkage of substrate after two years in a container.

Shelf life and landscape performance. We have found that plants grown in PTS and maintained under retail or residential conditions retain their quality and do not dry out differently or require any more irrigation than plants produced with traditional substrates. Also, no differences in appearance or growth index have been observed two to three years after transplanting into the landscape for 12 species of woody plants, including red maples (*Acer rubrum*) and pin oaks (*Quercus palustris*), planted from 15-gallon containers.

The landscape performance of four annual species and five perennial species also shows no differences in visible appearance or growth index. This indicates that plants grown in PTS establish and perform just as well as plants grown in peat moss or pine bark.

Toxicity issues. When freshly harvested trees are ground and immediately used to plant 14-day-old plugs of marigold or tomato seedlings, there can be some reduction in seedling growth compared to plants grown in peat moss or pine bark. We determined the degree of toxicity for 12 species of various hardwoods and softwoods, and loblolly pine was the least toxic. Growth inhibition was related to the level of polyphenolics in the wood. Leaching the substrate with water can re-

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'Green Giant' arborvitae grown in either pine tree substrate or pine bark shows no difference in growth and plant quality three years after transplanting to the landscape.

Marigolds grown in either pine tree substrate or pine bark show no difference in plant size and quality after 10 weeks in the landscape.

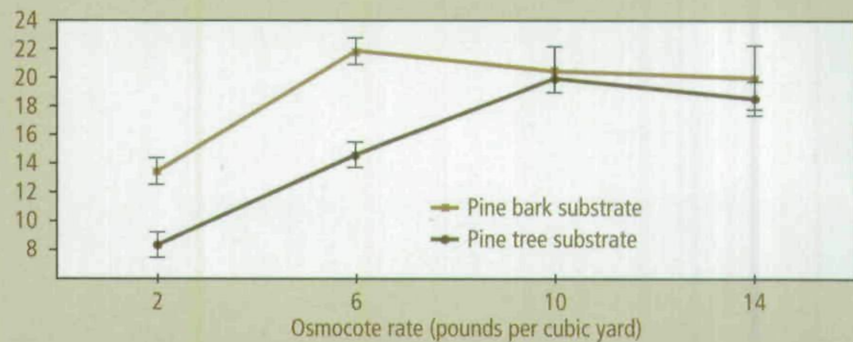
Hammer mill screen size

Grinding pine chips in a hammer mill with larger screens (one-fourth of an inch) compared to smaller screens (one-sixteenth of an inch) decreases growth of 'Inca Gold' marigold due to decreasing container capacity and increased aeration.

Hammer mill screen size	Marigold shoot dry weight (grams)	Percent air space	Percent container capacity
1/16 inch	3.9	18.2	65.1
3/32 inch	3.7	23.2	62.5
1/8 inch	3.1	31.8	54.8
3/16 inch	3.3	31.3	47.9
1/4 inch	2.8	39.1	43.3

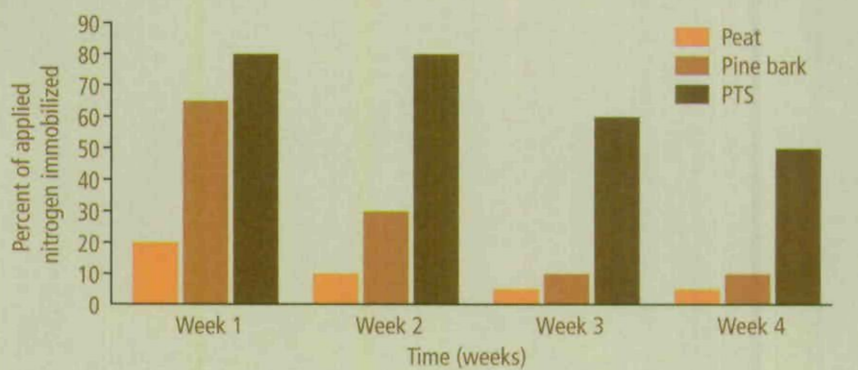
Growth comparison

Azalea requires approximately 4 pounds per cubic yard more of a controlled-release fertilizer for optimal growth in a pine tree substrate than in a pine bark substrate.



Nitrogen percentage

A greater percentage of nitrogen is immobilized in pine tree substrate (PTS) compared to a peat moss or pine bark substrate.



duce the toxicity to seedlings in PTS, and some of our research indicates that the aging of logs before grinding, as well as the aging of PTS after grinding, can reduce the extent of toxicity. Regardless, our research has shown that toxins quickly dissipate with irrigation, and with proper attention to mineral nutrition, there is little — if any — difference in plant growth between PTS and traditional substrates.

Commercialization. Due to enthusiastic grower interest in PTS, an effort is underway with a number of growers to test PTS on a wide range of nursery and greenhouse crops. To date, plants in PTS are doing as well as in pine bark or peat moss. Commercial substrate producers see the potential of PTS as a viable container substrate, which could reduce the cost of substrates to their clients. We are thus working with these companies to evaluate PTS for commercial production and marketing. The opportunity also exists for larger growers to purchase a hammer mill and produce PTS for themselves where pine chips are available.

Our efforts in the near future will focus on commercialization of PTS by helping growers and commercial substrate companies apply research results from our many experiments to the production and utilization of PTS.

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