# Pine Tree Substrate: Current Status

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**Significance to Industry:** After several years of continued research and development, pine tree substrate (PTS) shows excellent promise as an alternative and renewable container substrate for nursery and greenhouse crop production. PTS is competitively priced, locally available, and of consistent high quality.

**Nature of Work:** Pine bark (PB) and peat moss (P) are the two most common substrate components currently used for horticulture crop production in the southeastern U.S. The availability and cost of PB remain unpredictable due to reduced forestry production and increased use as fuel and landscape mulch (5). The cost of P substrates continue to rise due to transportation and growing environmental concerns over the mining of P bogs in Canada and Europe. Alternative substrates for container production of horticultural crops are therefore important. Alternative substrates produced from wood and wood based products have been investigated as suitable substrates or substrate components in horticulture crop production (1, 2, 7). European research in this area has been conducted for two decades, resulting in numerous successful commercialized wood substrates (4, 6). More recently, a substrate has been developed from ground whole loblolly pine logs (*Pinus taeda* L.) to successfully produce numerous annual, herbaceous, and woody crops (7, 8, 9).

The objective of this research has been the development of a substrate produced from trees that could be manufactured to meet the needs of the horticulture industry by providing a cost effective and reliable alternative to traditional substrates. This paper reports the status of nearly four years of extensive research that has been conducted at Virginia Tech on the development of PTS including manufacturing process, particle size, cost, growth trials, wood toxicity, fertility management, and post-transplant landscape evaluation. 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 P (a non-renewable resource) or using PB (a by-product of another industry).

**Results and Discussion:** *Producing PTS.* Pine tree substrate is produced by further grinding coarse (1.0 inch x 1.0 inch x ¼ inch) loblolly pine chips (from chipped pine logs) with a hammermill to produce a substrate designed to meet specific substrate requirements (porosity, water holding capacity, etc.) (Table 1) for a wide variety of plant genera and plant sizes. Pine tree substrate is made from freshly ground loblolly pine trees that are native to the southeastern U.S., but have a distribution and potential planting range across much of the U.S. (Figure 1). 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. Using locally-available pine trees results in reduced shipping costs and fuel surcharges that typically occur when purchasing P or PB substrates from long distances. Likewise the harvest of pine trees is less weather dependent than peat harvest, pine trees are renewable and pose fewer environmental concerns associated with harvest, and substrates produced from pine trees appear to be of consistent quality over time.

*Cost of Pine Tree Substrate.* Pine chips produced for the paper industry or for fuel can be purchased for $5-$6 per cu. yd. After adding the costs of grinding and fertilizer, one could conceivably produce a substrate for under $15 per cu. yd. compared to $40 plus for traditional P substrates and $15 plus for aged PB. Since PTS is ground to the correct particle size to provide the desired aeration and water holding capacity, there is no cost associated with adding aggregates such as perlite and vermiculate as required for P substrates.

*Growth Results*. Due to the manufacturing of PTS to provide desired substrate physical properties (air space and water holding capacity), irrigation requirements for PTS during production can be similar to commercial substrates. A wide range of greenhouse crops have been produced successfully with PTS including chrysanthemums, poinsettia, as well as fourteen other genera of bedding plants and vegetables, and seven genera of herbaceous perennials. In some instances when freshly harvested trees are ground, there can be a considerable growth reduction of young marigold and tomato seedlings when planted as 144 cell plugs into PTS. However, aging of logs before grinding and aging of PTS after grinding reduced the extent of toxicity. Woody plants have been thoroughly tested in PTS with results indicating that over thirty species exhibit comparable growth to plants grown in PB. Root growth of annual and woody plants grown in PTS is equal, and most often better, than root growth of the same plants in P or PB.

*Fertilizer Requirements*. In most studies additional fertilizer is required for PTS compared to commercial P or PB substrates. Research has concluded that it takes about 100 ppm more N from a 20-10-20 soluble fertilizer to produce comparable growth of bedding plants, poinsettia and chrysanthemums in PTS compared to P substrates. The addition of low rates of P or 5% calcined clay to PTS has been shown to improve plant growth, especially at lower fertilizer rates. This is likely because P increases the retention of nutrients available for plant uptake by increasing the cation exchange capacity (CEC) of the PTS. For woody plants it has been shown that an additional 2-4 $lbs \cdot yd^{-3}$ controlled release fertilizer is required (depending on species, PTS particle size, irrigation regime, etc.) for optimal plant growth in PTS compared to PB. Reasons for the higher N requirement are likely two-fold: there is more nutrient leaching from PTS since the CEC is very low compared to P and PB, and there is microbial immobilization of N with PTS due to the high C:N ratio of the non-composted wood. Evidence of a higher level of microbial immobilization of N has been documented by demonstrating that substrate respiration (measure of microbial activity) for PTS is about 5 times higher than that of P and 3 times higher than PB. Even though there is evidence of microbial activity, it does not result in substrate shrinkage of PTS over a 2 to 3 month plant production cycle for greenhouse crops. Even after two years in larger containers with woody nursery crops no visible degradation or shrinkage has occurred with the PTS substrate compared to PB.

*Post-transplant evaluation of PTS grown plants*. No differences in appearance or growth index has been observed after 2 years for twelve species of woody plants including red maples (*Acer rubrum* L.) and pin oaks (*Quercus palustris* Muenchh.) 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. Evaluations indicate that plants grown in PTS establish and perform just as well as plants grown in P or PB.

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**Table 1**. Physical properties of peat (P) and pine tree substrate (PTS) produced with a hammermill fitted with five screen sizes.

| Substrates | Air space (% vol) | Container capacity (% vol) | Available water (% vol) | Percent Fines (<0.5 mm) |
|---|---|---|---|---|
| P | 16.8 | 68.4 | 46.1 | NA |
| PTS | | | | |
| 1.59 mm | 18.2 | 65.1 | 50.4 | 54 |
| 2.38 mm | 23.2 | 62.5 | 42.8 | 47 |
| 3.18 mm | 31.8 | 54.8 | 33.6 | 29 |
| 4.76 mm | 31.3 | 47.9 | 25.7 | 20 |
| 6.35 mm | 39.1 | 43.3 | 19.8 | 14 |
| Significance (PTS) | L*** | L*** | L*** | L** |

**Figure 1**. Potential planting range for loblolly pine trees in the United States (1).