Pine Tree Substrate: A Promising Alternative to Peat Moss and Pine Bark©

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INTRODUCTION

After four years of research and development at Virginia Tech, pine tree substrate (PTS) shows excellent promise as an alternative and renewable container substrate for nursery and greenhouse crop production (Wright and Browder, 2005; Wright et al., 2006; Wright et al., 2008). PTS is competitively priced, locally available, 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 (P) (a non-renewable resource) or using pine bark (PB) or some other industry by-product. The development of a new substrate for container-grown nursery crops is very timely since the availability of PB is currently unpredictable due to reduced forestry production and its increased use as fuel and landscape mulch (Lu et al., 2006). Further, the cost of peat substrates continues to rise due to transportation and growing environmental concerns over the mining of P bogs in Canada and Europe. This paper reports the current status of our research including the manufacturing process, physical properties, cost, growth trials, wood toxicity, fertility management, and post-transplant landscape evaluation.

Producing PTS. Pine tree substrate is produced by chipping freshly harvested pine logs (*Pinus taeda)* to produce chips that are approximately 2.4 cm x 2.4 cm x 0.6 cm (1 inch x 1 inch x ¼ inch). These chips are further ground in a hammermill to produce a substrate of a given particle size range designed to meet specific substrate requirements (porosity, water holding capacity, etc.) for a wide variety of plant genera and plant sizes (Saunders et al., 2006). No composting of

PTS is necessary, and the trees can be literally harvested one day and used to pot plants the next day after grinding and amending. Loblolly pine trees are native to the southeastern U.S., but have a distribution and potential planting range across much of the U.S. (Fig. 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, saving on shipping costs of raw products needed for manufacturing and deliveries of substrates to the growers. Also 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. As well, the production of PTS interfaces an already existing industry related to the paper industry where large volumes of pine wood chips are already being produced for paper production.

Cost of Pine Tree Substrate. Pine chips produced for the paper industry or for fuel can be purchased for $5 to $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. We have successfully produced a wide range of nursery and greenhouse crops in PTS including 30 genera of woody plants, 3 genera of greenhouse crops, 14 genera of bedding plants, and 7 genera of herbaceous perennials.

Post-transplant evaluation of PTS grown plants. No differences in appearance or growth index have been observed two years after transplanting into the landscape for twelve species of woody plants including 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. Evaluations indicate that plants grown in PTS establish and perform just as well as plants grown in P or PB.

Toxicity Issues. When freshly harvested trees are ground and immediately used to plant 14-day old plugs of marigold and tomato seedlings, there can be some reduction in seedling growth. The degree of toxicity was determined for 12 species of various hardwoods and softwoods, and loblolly pine was the least toxic (Rau et al. 2006). Growth inhibition was related to the level of polyphenollics in the wood. The toxicity to seedlings in PTS can be reduced by leaching the substrate with water, and some of our research indicates that aging of logs before grinding and aging of PTS after grinding can reduce the extent of toxicity. Regardless, our research has shown that by the end of production periods of more than four weeks, with proper attention to mineral nutrition, there is little if any difference in plant growth between PTS and traditional substrates. 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 (Wright et al., 2008). The addition of 25% P or 5% calcined clay to PTS has been shown to improve plant growth, especially at lower fertilizer rates. This is likely because P and clay increase 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 1.2 to 2.4 kg•m^3 (2 to 4 lbs•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. Our research has shown that higher N requirements are due in part to more nutrient leaching from PTS since the CEC is very low compared to P and PB, and more microbial immobilization of N with PTS due to the high C:N ratio of the non-composted wood. Even though there is evidence of microbial activity, it does not result in substrate shrinkage of PTS over a two to three 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. The lack of shrinkage in the face of N immobilization and some decay of PTS is likely due to increased root volume which fills the void left by the decaying PTS.

Our research has also shown that low lime additions may be required, no more than 0.9 $kg•m^3$ (1.5 $lbs•yd^3$), for optimal growth of marigold (Fig. 2). For woody nursery plants a large number of genera have been grown without lime additions with comparable growth to those grown in pine bark which requires lime depending upon the species grown. Also, an addition of sulfur is required for PTS compared to peat moss and pine bark for the growth of marigold (Fig. 3). Sulfur can be supplied as elemental sulfur, Micromax, $FeSO_4$, $MgSO_4$, or $CaSO_4$ at the rate of 0.9 $kg•m^3$ (1.5 $lbs•yd^3$).

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Figure 1. Potential planting range for loblolly pine trees in the United States (Gilman, 1994).

Figure 2. Shoot dry weights of marigolds grown in peat-lite (PL) and pine tree substrate (PTS) when amended with five rates of lime; values followed by a different letter are significantly different.

Figure 3. Shoot dry weight of marigolds grown in peat-lite (PL) and pine tree substrate (PTS) with various sources and rates of sulfur (S) amendments; values followed by a different letter are significantly different.