Pine Tree Substrates for Container Crops: Current Status and Overview©

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Researchers in the Department of Horticulture at Virginia Tech have been studying the use of ground pine trees, referred to as pine tree substrate (PTS), as a new container substrate for greenhouse and nursery crops since 2004. This research is a totally different approach to container substrate production in that a new material is created for use as a container substrate rather that mining peat or using a by-product of another industry such as pine bark. The development of a new substrate for container-grown nursery crops is very timely since the availability of pine and Douglas fir bark is currently unpredictable due to reduced forestry production and its increased use as fuel and landscape mulch. This article reports the current status of PTS research including plant growth trials, stability during long-term crop production, new methods of substrate construction, PTS storage, and commercialization efforts.

DESCRIPTION AND BACKGROUND OF PINE TREE SUBSTRATE

Pine tree substrates can be produced from freshly harvested pine trees that are chipped and ground (with or without bark, limbs, needles, etc.) in a hammer mill (no plant growth difference was observed with the inclusion of bark, limbs, or needles compared to growing in pine wood only). Loblolly pine (*Pinus taeda*) has been the most promising and heavily researched pine species for substrate production. Current research has also shown the successful use of eastern white pine (*P. strobus*) as a PTS, which greatly expands the potential of producing PTS further into the Northeastern U.S.A. (Wright et al., 2009). The use of loblolly and white pine covers a geographic range which is in close proximity to many greenhouse and nursery operations across a large portion of the country, thereby saving on shipping costs of raw wood materials needed for manufacturing, and deliveries of substrates to growers. Pine trees of any age can be harvested and processed into a substrate. It is even likely that pine plantations could be specifically planted and harvested solely for substrate production. 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 (Jackson, 2008).

PLANT GROWTH TRIALS

The successful production of numerous woody and herbaceous species has been reported in previous research reports, as well as the need for additional fertilizer during crop production compared to plants grown in bark or peat-based substrates (Jackson et al., 2008a; Jackson et al., 2008b; Wright et al., 2008a). In addition to comparable shoot growth of plants grown in PTS, one main observation of PTS-grown plants is the prolific root growth which is often greater that in plants grown in bark or peat. It is thought that the higher percentage of air space in PTS, while still supplying adequate water, is the reason for accelerated plant root growth. We have also shown that a wide range landscape annuals, landscape herbaceous perennial and woody landscape shrubs, and shade trees when grown in PTS survive and grow as well in the landscape as those grown in pine bark. In addition to our research and plant growth trials, several nurseries in the Mid-Atlantic region have trialed large evaluations of PTS in their operations with very positive results and no reports of plant growth differences compared to plants grown in bark.

SUBSTRATE STABILITY AND SHRINKAGE DURING CROP PRODUCTION

One of the major concerns for growers has been related to the stability of PTSs during long-term crop production. To help answer these questions, a 2-year study with 5-gal containers of PTS and pine bark were evaluated under outdoor nursery conditions. The physical properties including container capacity and air space of PTS and pine bark were within recommend ranges at the beginning of this study, with PTS having 55% container capacity and 36% air space. After 70 weeks, PTS had a container capacity of 60% compared to 64% for pine bark, while air space was at 29% for PTS and 20% for pine bark (Jackson et al., 2009a). As expected, due to decomposition of both substrates, container capacity increased over time while air space decreased. As well, after 70 weeks, substrate shrinkage in the containers was similar for both pine bark and PTS, both around 17% (Jackson et al., 2009a). The similarity in shrinkage despite known higher rates of decomposition in PTS was due to the increased root volume of the PTS-grown plants which fills the void left by the decaying wood particles.

METHODS OF PTS CONSTRUCTION

One advantage of PTS 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 in the hammer mill. 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. 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 cost and labor associated with grinding. Studies have shown that the output of PTS produced in a hammer mill with no screen in place would be about 76 kg/hp-h (horsepower-hour) compared to only 16 kg/hp-h for a hammer mill fitted with a $^{3}/_{16}$-in. screen. The lower output for producing a smaller particle PTS would also likely require a more expensive hammer mill designed to move material (coarse pine chips) through a smaller screen.

Our research has shown a different approach to producing a PTS-based substrate involves mixing and amending different wood particles and other materials together to produce a cheaper substrate that still had desirable physical properties. One of the more cost and time effective substrate blends was derived from large PTS (produced with no hammer mill screen) that was mixed with about 50% PTS produced with $^{3}/_{16}$-in. screen to yield substrate with ~45% water-holding capacity which is comparable to many bark mixes (Wright et al., 2008b). This blending method increased PTS output overall by about 50% (volume of PTS produced per hour) while constructing a substrate with adequate physical properties. Plant growth trials in these substrates were comparable to 100% PTS produced from $^{3}/_{16}$-in. screens and also comparable to plants grown in peat-based substrates. Research has also shown that coarse PTS produced with no screen can have acceptable container capacities (above the recommended 45%) when mixed with 25% peat moss or ground with 25% aged pine bark produced with a hammer mill. Testing of these PTS mixes showed equal growth of azalea and spirea after one growing season compared to plants grown in 100% pine bark.

Using PTS with larger particles mixed with peat moss or pine bark may reduce the need for extra fertilizer as shown with substrates made with 100% PTS or peat moss, since our research has shown that reduce substrate microbial activity and nitrogen immobilization when PTS particle size increases or when additions of peat moss and pine bark are made to PTS (Jackson and Wright, 2009). As well, recent industry trends for the production of large woody plants in large containers (greater than 15-gal for over 2 years), production of PTS composed of larger particles, would decay less rapidly and facilitate substrate stability over these long production periods (Wright et al., 2008b).

Research has shown other benefits of a PTS constructed by amending ground wood chips with 25% of either pine bark, compost, or peat moss and they include: (1) Reduction of PTS production costs, (2) Improved physical and chemical properties of PTS, and (3) the creation of a dark-colored PTS similar to traditional substrates which may be a criteria that some growers/manufacturers want because of consumer preference/expectation. Conversely, some growers are amending peat-based substrates with wood chips as a replacement for perlite, which is expensive. Growers and some substrate companies who have conducted plant growth trials are replacing up to $^{1}/_{3}$ of their peat with PTS, in addition to testing it as a 100% substrate.

PINE TREE AND PINE TREE SUBSTRATE STORAGE

Based on our years of research and observations, adding lime is not required for PTS due to the inherently high pH (~5.8–6.0) of freshly harvested and ground pine wood. The higher/acceptable pH of PTS without liming seems to only be the case when PTS is produced from pine trees that are processed into substrate within 2 months of being harvested, or when PTS is produced from freshly harvested trees and stored (as substrate) for up to 2 months before being used in production (Jackson et al., 2009b). Further studies indicate that after 2 months of storage (as a substrate), and up to 1 year, the pH deceases and therefore lime additions are needed before use in production. Pine trees (logs) harvested and stored outdoors in piles for up to 1 year can be chipped and ground (hammer milled) to produce PTS without any negative effects on plant growth, again when attention is paid to adjusting pH levels which drop during log storage as with PTS storage. PTS has shown to be weakly buffered (does not resist pH change), so only low amounts of lime (1.5–3.0 lbs/yd^3) addition are needed to raise the pH from ~3.5 to 5.5–6.0 (Jackson et al., 2009b). It is also important to note that since PTS is often amended with peat moss or aged pine bark (to improve physical and chemical properties) that lime is then required in proportion to the ratio of peat moss or pine bark added.

COMMERCIALIZATION EFFORTS

As a result of grower success at producing greenhouse and nursery crops commercial substrate producers are investigating ways in which PTS could be used to reduce the costs of substrates to their clients. The opportunity also exists for larger growers, or a consortium of smaller growers, to purchase a hammer mill and produce PTS for themselves where pine chips are available.

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LITERATURE CITED

Jackson, B.E. 2008. Chemical, physical, and biological factors influencing nutrient availability and plant growth in a pine tree substrate. Virginia Polytechnic Institute & State Univ., Blacksburg, Virginia. PhD Diss.

Jackson, B.E., R.D. Wright, J.F. Browder, J. R. Harris, and **A.X. Niemiera.** 2008a. Effect of fertilizer rate on growth of azalea and holly in PB and pine tree substrates. HortScience 43:1561–1568.

Jackson, B.E., R.D. Wright, and **M.C. Barnes.** 2008b. Pine tree substrate, nitrogen rate, particle size, and peat amendment affects poinsettia growth and substrate physical properties. HortScience 43:2155–2161.

Jackson, B.E., and **R.D. Wright.** 2009. Wood particle size and peat amendment in pine tree substrates influences microbial activity and nitrogen immobilization. Acta Hort. (submitted).

Jackson, B.E., R.D. Wright, and **J.R. Seiler.** 2009a. Changes in chemical and physical properties of pine tree substrate and pine bark during long-term nursery crop production. HortScience 44:791–799.

Jackson, B.E., R.D. Wright, and **N. Gruda.** 2009b. Container medium pH in a pine tree substrate amended with peat moss and dolomitic limestone affects plant growth. HortScience 44:1983–1987.

Wright, R.D., B.E. Jackson, J.F. Browder, and **J.G. Latimer.** 2008a. Growth of chrysanthemum in a pine tree substrate requires additional fertilizer. HortTechnology 18:111–115.

Wright, R.D., B.E. Jackson, and **M.C. Barnes.** 2008b. Pine tree substrate construction for optimal water holding capacity and air space. Proc. Southern Nursery Assoc. Research Conf. 53:52–54.

Wright, R.D., B.E. Jackson, and **M.C. Barnes.** 2009. White pine as a pine tree substrate. Proc. Southern Nursery Assoc. Research Conf. 54:221–223.