From Forest Nursery Notes Winter 2013

230. © Storage time and amendments affect pine tree substrate properties and marigold growth. Taylor, L. L., Niemiera, A. X., Wright, R. D., and Harris, J. R. HortScience 47(12):1782-1788. 2012.

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Storage Time and Amendments Affect Pine Tree Substrate Properties and Marigold Growth

Linda L. Taylor[1], Alexander X. Niemiera, Robert D. Wright, and J. Roger Harris
Department of Horticulture, Virginia Polytechnic Institute and State University, 301 Saunders Hall, Blacksburg, VA 24061

Additional index words. pH, cation exchange capacity, electrical conductivity, carbon-to-nitrogen ratio, bulk density, particle size distribution, *Pinus taeda*, loblolly pine, *Tagetes erecta* 'Inca Gold'

***Abstract*. Pine tree substrate (PTS) is a relatively new alternative to the commonly used pine bark and peat-based substrates for container crop production. Physical and chemical properties of freshly manufactured PTS have been studied; however, this new substrate will sometimes be manufactured and stored for later use by growers. The objective of this research was to determine how chemical and physical properties of PTS were affected by storage duration with or without amendments of limestone or peatmoss. We also studied how the growth of marigold was influenced by PTS storage time and by lime and peat amendments. Substrate properties studied were pH, cation exchange capacity (CEC), electrical conductivity (EC), carbon-to-nitrogen ratio (C:N), bulk density (BD), and particle size distribution. Pine tree substrate was manufactured by hammermilling chips of ≈15-year-old loblolly pine trees (*Pinus taeda* L.) through two screen sizes, 4.76 mm (PTS) and 15.9 mm [amended with peat (PTSP)]. Pine tree substrate and PTSP were amended with lime at five rates and a peat–perlite mix (PL) served as a control treatment. Substrates were prepared, placed in plastic storage bags, and stored on shelves in an open shed in Blacksburg, VA. Substrates were subsampled at 1, 42, 84, 168, 270, and 365 days after storage. At each subsampling day, twelve 1-L containers were filled with a subsample of each treatment. Six of the 12 were left fallow and six were planted with 14-day-old marigold (*Tagetes erecta* L. 'Inca Gold') seedlings. Substrate was also collected for analysis of CEC, C:N, BD, and particle size distribution. The pH of non-limed PTS decreased during storage, and at least 1 kg·m^{-3} lime was needed to maintain PTS pH 5.4 or greater over the 365-day storage period (Day 1 pH = 5.8) and 2 to 4 kg·m^{-3} was needed to maintain PTSP pH 5.4 or greater for 365 days (Day 1 pH = 5.2). EC measurements were highest at Day 1 (1.02 to 1.21 dS·m^{-1}) in all treatments and decreased by Day 42. Cation exchange capacity decreased over time in non-limed PTS and PTSP. Carbon-to-nitrogen ratio and BD remained the same over time for all treatments. There were minor changes in particle size distribution for limed PTS. Marigold growth in all limed PTS and PTSP treatments was equal to or greater than in PL, except at Day 1; the lower growth in PTS and PTSP at Day 1 compared with PL suggests that freshly manufactured PTS may contain a phytotoxic substance that was not present in PTS by Day 42. Pine tree substrate and PTSP are relatively stable when stored as described previously, except for a pH decrease that can be prevented with additions of lime before storage.**

Pine bark and peatmoss are widely used substrates for container-grown crops in the greenhouse and nursery industries. There have been many recent research reports on the development of alternative soilless substrates. This research stems from the increasing cost in addition to decreasing availability of pine bark and the cost and sustainability of peatmoss mining. A wide variety of materials has been investigated and wood-based substrates show promise as alternatives to peatmoss and pine bark. Several of these wood-based substrates are from coniferous species (softwoods) and are produced from chipped and ground trunks (with bark; termed PTS; Wright et al., 2006); chipped and shredded trunks with low bark amounts (Gruda and Schnitzler, 2004; Gumy, 2001); whole shoot portions (needles, limbs, bark and trunk; termed WholeTree®; Fain et al., 2006, 2008a); or wood, bark, foliage, and other materials [remains from in-field chipping operations for the paper industry; termed clean chip residual (CCR); Boyer et al., 2008]. Cost, availability, and sustainability issues of bark and peat substrates can be bypassed by using these substrate alternatives. These wood-based substrates can be produced from tree species that are native to wide geographic ranges and can be grown specifically for this purpose, harvested, and replenished locally.

Softwood-based substrates have been shown to be suitable for at least some horticultural crop species and produce plant growth that is similar to, or greater than, plants grown in pine bark or peatmoss (Boyer, 2009; Fain et al., 2008b; Gruda and Schnitzler, 2004; Wright et al., 2008). In these studies, substrate particle size and effects of amendments such as lime, peat, pine bark, and sand were investigated. Fertilizer regimes have also been investigated because nitrogen (N) immobilization can decrease plant-available N in uncomposted wood substrates. Research has shown that a higher N application rate for some wood-based substrates is required to compensate for immobilized N compared with N application rates for conventional substrates (Gruda et al., 2000; Jackson et al., 2008a, 2008b; Wright et al., 2008). However, Boyer et al. (2012) have reported that N immobilization in CCR is similar to that in pine bark and therefore can be fertilized similarly. In nearly all of these studies, substrates were manufactured just before use or, in a few cases, stored for up to 144 d. However, substrate manufacturers and growers may store these substrates for later sale or use, and research on the effects of wood-based substrate storage is needed.

Few studies have investigated the effects of storage on wood-based substrate properties and plant growth. Kostov et al. (1991) investigated the decomposition of composted sawdust and pine bark on microorganism activity (CO_2 evolution, ammonification, nitrification) and density. Dickinson and Carlile (1995) conducted a study on combinations of composted pine and spruce bark and chipboard and paper waste. Neither of these aforementioned studies used uncomposted and untreated wood constituents.

Gaches et al. (2011) found that dry weight, growth index, and bloom count of *Tagetes patula* L. 'Little Hero' marigold and *Petunia* ×*hybrida* Vilm. 'Dreams White' petunia were higher in a ground pine tree, peat substrate (1:1, v:v) that was aged for 94 and 169 d than in those produced in the same substrate that was recently manufactured. The authors suggest differences in air space and container capacity, rate of N immobilization, and the presence of an allelopathic chemical in recently manufactured substrate as explanations for growth differences. A pH decrease has been observed in both stored PTS and loblolly pine logs (R. Wright, unpublished data) indicating that PTS may need lime amendment. Lime addition to wood-based substrates, similar to additions to bark and peat substrates, neutralizes protons. Lime amendment is suggested when PTS is amended with peat (Jackson

Received for publication 1 Aug. 2012. Accepted for publication 16 Oct. 2012.
The research was funded in part by the Virginia Agricultural Council and the Virginia Nursery and Landscape Association.
The technical assistance of Velva Groover is gratefully acknowledged.
This article is a chapter of a submitted dissertation by Linda L. Taylor for the degree of Ph.D. in Horticulture.
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[1]To whom reprint requests should be addressed; e-mail lltaylor@vt.edu.