

## A Comparison of Nutrient Requirements Between Pine Chip and Pine Bark Substrates<sup>®</sup>

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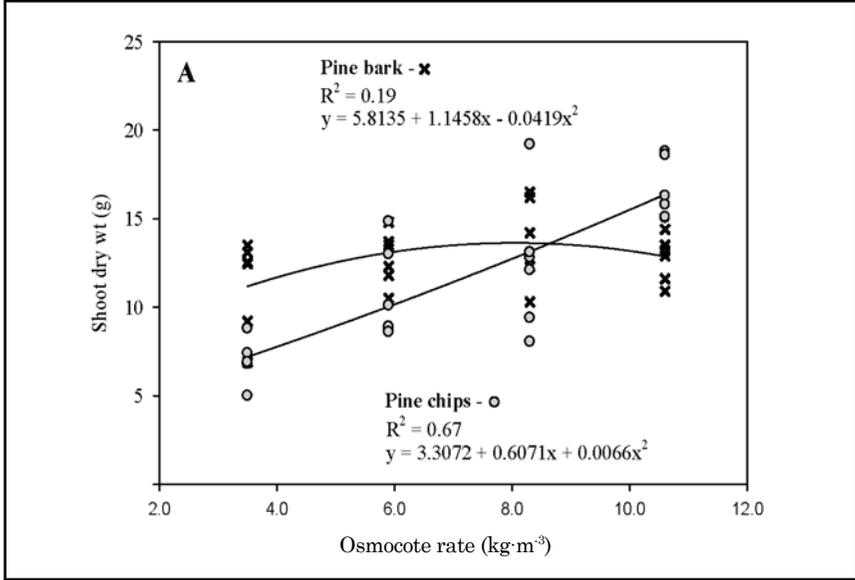
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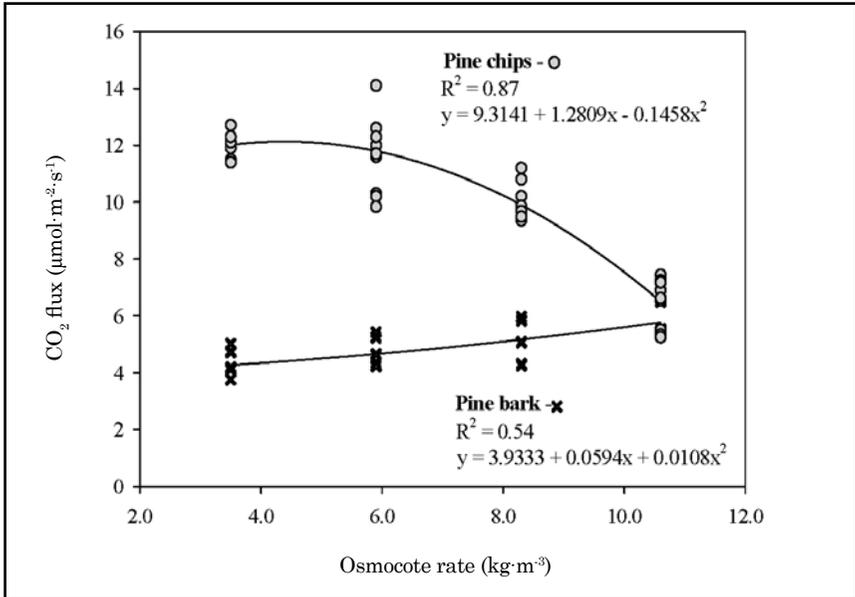
The objective was to determine the response of Japanese holly (*Ilex crenata* Thunb. 'Compacta') grown in ground pine chips (PC) or milled pine bark (PB) substrates to fertilizer rate. The PC substrate was prepared by further grinding coarsely ground debarked whole loblolly pine logs in a hammer mill. Plants were potted on 17 Aug. 2005 and fertilized by incorporating Osmocote 15N-9P-12K at 3.5, 5.9, 8.3, or 10.6 kg·m<sup>-3</sup> (6, 10, 14, and 18 lb/yd<sup>3</sup>) in PC or PB. Plants were glasshouse grown until 22 Nov. 2005. After severing the shoots for dry weight determination, substrate respiration rates (CO<sub>2</sub> μmol·m<sup>-2</sup>·s<sup>-1</sup>) were determined for the treatments using a LI-6400 soil CO<sub>2</sub> flux chamber. Maximum shoot dry weight for PB- and PC-grown plants occurred at 5.9 kg·m<sup>-3</sup> (10 lb/yd<sup>3</sup>) and 10.6 kg·m<sup>-3</sup> (18 lb/yd<sup>3</sup>), respectively. Maximum shoot dry weight for PC-grown plants was 23% higher than for PB-grown plants. Substrate respiration rates were higher in PC compared to the PB substrate. The reason that PC-grown plants required a higher fertilizer rate to achieve maximum growth than PB-grown plants may be attributed to increased nutrient leaching and microbial nutrient immobilization.

### INTRODUCTION

Producing substrates from wood products can make it possible both to limit the use of expensive materials like peat and to utilize a renewable forestry resource. Due to the relatively low cost and high availability of wood products, serious consideration should be given to the development of this material as an alternative, organic container substrate. Previously, ground melaleuca trees (*Melaleuca quinquenervia* Cav.) were shown to be an acceptable substitute for bark or sedge peat when used to grow a number of woody and herbaceous plants (Conover and Poole, 1983; Ingram and Johnson, 1983). No phytotoxicity problems were evident in these studies as long as the proportion of melaleuca did not exceed 50% of the substrate. Kenna and Whitcomb (1985) demonstrated that *Pyracantha* 'Mohave' and *Liquidambar formosana* Hance. grew as well in a substrate of woodchips, peat, and sand (3 : 1 : 1, by volume) as in a substrate composed of bark, peat, and sand (3 : 1 : 1, by volume). Wood chips for their study were produced by grinding entire trees including leaves, twigs, bark, and wood of *Quercus stellata* Wangh. and *Ulmus pumila* L. Noncomposted sawdust from Douglas fir (*Pseudotsuga menziesii* Mirb.) and western hemlock (*Tsuga heterophylla* Raf.) have also been used to grow a wide range of herbaceous and woody container crops in Canada, where sawdust is plentiful (Maas and Adamson, 1972). Most recently, Wright and Browder (2005)



**Figure 1.** Shoot dry weights of Japanese holly grown in pine bark (PB) or pine chips (PC) incorporated with four different rates of Osmocote 15N-9P-12K.



**Figure 2.** Substrate respiration rates ( $\text{CO}_2$   $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ ) for pine bark (PB) and pine chips (PC) incorporated with four different rates of Osmocote 15N-9P-12K.

demonstrated that woody and herbaceous plants could be grown in 100% PC substrate produced from a debarked loblolly pine log (*Pinus taeda* L.), compared to a 100% PB substrate. More research is needed to determine the feasibility of growing plants in a substrate composed of 100% wood material, including the fertility rate required over the production cycle of container-grown nursery crops.

The objective of this research was to study the effect of increasing fertilizer rate on growth of Japanese holly (*Ilex crenata* Thunb. 'Compacta') in 100% PC compared to PB.

## MATERIALS AND METHODS

Pine chips were produced by taking chips from roughly ground debarked pine logs and further grinding them in a hammer mill to pass through a 6.35-mm (0.25-inch) screen. Pine chips were amended with 5% (by volume) 16/30 particle size calcined clay (Oil-Dri Corp., Chicago, Illinois) and  $0.6 \text{ kg}\cdot\text{m}^{-3}$  ( $1 \text{ lb}/\text{yd}^3$ )  $\text{CaSO}_4$ . No pre-plant amendments were added to PB since none are needed for standard Japanese holly production. Treatments of Osmocote Plus (15N-3.9P-10K) (O.M. Scott Horticulture Products, Marysville, Ohio) were incorporated in PB and PC at rates of 3.5, 5.9, 8.3, or  $10.7 \text{ kg}\cdot\text{m}^{-3}$  (6, 10, 14, and  $18 \text{ lb}/\text{yd}^3$ ), respectively. Japanese holly liners were potted in 3.8-L (1-gal) plastic containers containing either PB or PC and grown on greenhouse benches in Blacksburg, Virginia. This study was a completely randomized design with six single container replications per treatment.

Physical properties of each substrate were determined according to Tyler, et al. (1993) on three replicate samples of each substrate at the beginning of the experiment. Cation exchange capacity (CEC) was determined by A & L Eastern Laboratories, Richmond, Virginia (AOAC Official Method 973.09, CEC for peat). At the end of the experiment, shoot dry weights were determined as well as substrate respiration rates ( $\text{CO}_2 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ ) for each substrate and treatment using a LI-6400 soil  $\text{CO}_2$  flux chamber (LI-COR, Lincoln, Nebraska). All data were analyzed by ANOVA using SAS and subjected to regression analysis using SigmaPlot (version 9.01 SPSS Inc., Chicago, Illinois).

## RESULTS

There was a significant substrate  $\times$  fertilizer rate interaction for shoot dry weight: at fertilizer rates of 3.5 and  $5.9 \text{ kg}\cdot\text{m}^{-3}$  (6 and  $10 \text{ lb}/\text{yd}^3$ ) shoot dry weight was higher for PB than PC; at  $8.3 \text{ kg}\cdot\text{m}^{-3}$  ( $14 \text{ lb}/\text{yd}^3$ ) dry weight was about equal for the two substrates; at  $10.6 \text{ kg}\cdot\text{m}^{-3}$  ( $18 \text{ lb}/\text{yd}^3$ ) dry weight was higher for PC than PB (Fig. 1). Substrate respiration rates ( $\text{CO}_2 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ ) were higher in PC than in PB with the magnitude of difference decreasing as fertilizer rate increased, primarily due to a large decrease in respiration for PC and a slight increase in respiration for PB as fertilizer rate increased (Fig. 2).

## DISCUSSION

This study demonstrates that a higher rate of fertilizer is required to achieve plant growth in PC comparable to plant growth in PB. The reason for this difference may be two-fold. First, PC is more porous and has a lower CEC compared to PB (Table 1), which could result in more nutrient leaching from PC. The second may relate to the higher substrate respiration for PC (Fig. 2) due to its higher C/N ratio compared

**Table 1.** Physical and hydraulic properties of two container substrates. Data were collected from three samples per substrate and represented as means.

Substrate	Total porosity <sup>z</sup>	Air space <sup>y</sup>	Container capacity <sup>x</sup> (% vol)	Bulk density (g·cm <sup>-3</sup> )	Cation exchange capacity (cmol·L <sup>-1</sup> )
Pine bark	82.9 b <sup>w</sup>	26.9 a	56.1 a	0.20 a	17.9 a
Pine chips	88.4 a	30.2 a	58.2 a	0.15 a	2.1 b

<sup>z</sup>Based upon percent volume of 7.6 × 7.6 cm core at 0 kPa.

<sup>y</sup>Total porosity-container capacity.

<sup>x</sup>Measured as percent volume of a 7.6 × 7.6 cm core at drainage.

<sup>w</sup>Means were separated using Duncan's Multiple Range Test ( $P < 0.05$ ).

to PB, leading to increased microbial N immobilization with PC (Bollen and Lu, 1957; Tisdale et al., 1993). Similar to our results (Fig. 2), previous work has shown a reduction in substrate respiration as fertilizer rate increased (Maas and Adamson, 1972). Investigating ways to increase the CEC of PC as well as reducing PC porosity to prevent leaching may prove beneficial. The influence that PC substrate respiration has on nutrient immobilization and on substrate decay over longer production periods also deserves consideration.

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