Pine Tree Substrate: Fertility Requirements

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Significance to Industry: Understanding the reasons for additional fertilizer requirement in pine tree substrate (PTS) allows for more accurate fertility management when growing plants in this substrate. Despite the higher fertilizer requirement, the potential for PTS to be successfully used in greenhouse and nursery crop production is evident in the promising results that have been reported in recent years.

Nature of Work: Recently, much work has been published on the use of alternative substrates produced from wood and wood based products as suitable substrates, or substrate components, in horticulture crop production (1, 7, 8). The need for alternative substrates is caused in part by the decreasing availability and increasing costs of pine bark (PB) and peat moss (P).

Work in Europe has been conducted for over two decades on the development of alternative and renewable substrates composed of wood. Researchers have had success using wood substrates, and have developed several commercialized products currently available to growers (5). More recently at Virginia Tech, PTS has been developed from ground whole loblolly pine logs (*Pinus taeda* L.) to successfully produce numerous annual, herbaceous, and woody crops (7, 8). However, the problem with wood substrates is their requirement for higher fertilizer applications to achieve optimal plant growth. Jackson et al., (4) reported that Japanese holly (*Ilex crenata* Thunb.'Compacta') required an additional 1.8 $kg \cdot m^{-3}$ (4 $lb \cdot yd^{-3}$) of controlled release fertilizer when grown in PTS to achieve comparable growth to plants grown in PB. Greenhouse crops have also shown the need for additional fertilizer based on work by Wright et al., (9) who reported that chrysanthemums grown in PTS required an additional 100 ppm N to perform as well as plants grown in a commercial P substrate. It is has been hypothesized that N-immobilization is the primary reason for the lower nutrient levels that are reported in growth trials when using PTS, but it has not been proven (4, 9). Numerous authors have reported that N-immobilization occurs in wood substrates during the production of horticulture crops (2, 3, 5), however no studies have been conducted on PTS to understand its N-immobilization rate during crop production. The higher fertilizer requirement for PTS compared to

PB and P is of concern and must be addressed before PTS can become a viable substrate for nursery and greenhouse crop production.

The objective of this work was to determine if N-immobilization is occurring in PTS causing the need for additional fertilizer applications to maintain acceptable nutrient levels (and plant growth) compared to PB and P. Pine chips were produced by taking chips from roughly ground pine logs (freshly harvested) and further grinding them in a hammer mill (Meadows Mills, Inc., North Wilkesboro, NC) to pass through a 4.76 mm (3/16 inch) screen. Pine chips were pre-plant incorporated with 0.6 $kg\cdot m^{-3}$ (1 $lb\cdot yd^{-3}$) $CaSO_4$. Pine bark and P were pre-plant incorporated with 2.7 $kg\cdot m^{-3}$ (6 $lb\cdot yd^{-3}$) dolomitic lime and 0.6 $kg\cdot m^{-3}$ (1 $lb\cdot yd^{-3}$) $CaSO_4$. Twelve day old marigold seedlings were planted in 2 liter (2 quart) containers containing the different substrates. All plants were equally fertilized three times per week with a 200 ppm NO_3-N fertilizer derived from $Ca(NO_3)_2$ and KNO_3 sources as outlined by Handreck (3) and grown for 28 days (4 weeks) on greenhouse benches in Blacksburg, VA. Every 7 days three single container reps of each substrate were taken from the greenhouse and prepared for nitrogen drawdown index (NDI) testing to determine N-immobilization (2). N-immobilization is estimated by measuring the difference in NO_3-N available in the substrate solution after different lengths of incubation. The final NDI is represented as a range between 0-1 with a value of 1 representing no N-immobilization and a value of 0 representing severe N-immobilization. After 4 weeks shoot dry weights were determined on six container replications as well as substrate respiration rates (μmol $CO_2\cdot m^{-2}\cdot s^{-1}$) for each substrate using a LI-6200 (LI-COR, Lincoln, NE) and a CO_2 flux soil chamber designed to take nondestructive respiration measurements from the substrate filled containers. Substrate CO_2 efflux is considered an assessment of microbial metabolic activity and therefore is an indicator of the potential for N-immobilization to occur (6). The experiment was a completely randomized design with fifteen single container replications per substrate. Data were analyzed using GLM procedures and means separation using Least Significant Differences (P = 0.05).

Results and Discussion: Results from the NDI show that PB and PTS have significantly higher rates of N-immobilization occurring over 4 weeks than does P (Figure 1). Peat does show initial N-immobilization during the first two weeks (Figure 1), a reason why commercial P substrates are most often pre-charged with an N source to compensate for initial losses. The severity of N-immobilization decreases during the four weeks for all substrates suggesting that less fertilizer is required after the first 2-3 weeks of plant production to satisfy the needs of the plants and microbial immobilization of N. The authors have made personal observations that the initial fertilizations during the first week of herbaceous plants (after being transplanted into PTS) are the most critical for plants in PTS to perform as well as plants in PB or P. Data from the NDI analysis showing severe initial N-immobilization in PTS helps to explain the possible reason for those observations. Substrate respiration rates were highest in PTS followed by PB (Figure 2), indicating increased microbial activity in these substrates. Higher CO_2 rates (microbial activity) are likely due to the higher C:N ratio of PB and even more so in PTS compared to P. Plant growth decreases as CO_2 efflux increases in PB and PTS, with PTS plants being less than half the size of plants in PB and P (Figure 2). These data suggest that plant growth was reduced as a result of the severe N-immobilization that occurred in PTS. Longer N-immobilization evaluations are needed to monitor N losses in PTS over several months so that long term fertility management strategies can be determined. Also, future work needs to be conducted on nutrient leaching from PTS, which is a second potential reason for lower nutrient levels, in addition to the N-immobilization that we now know is occurring.

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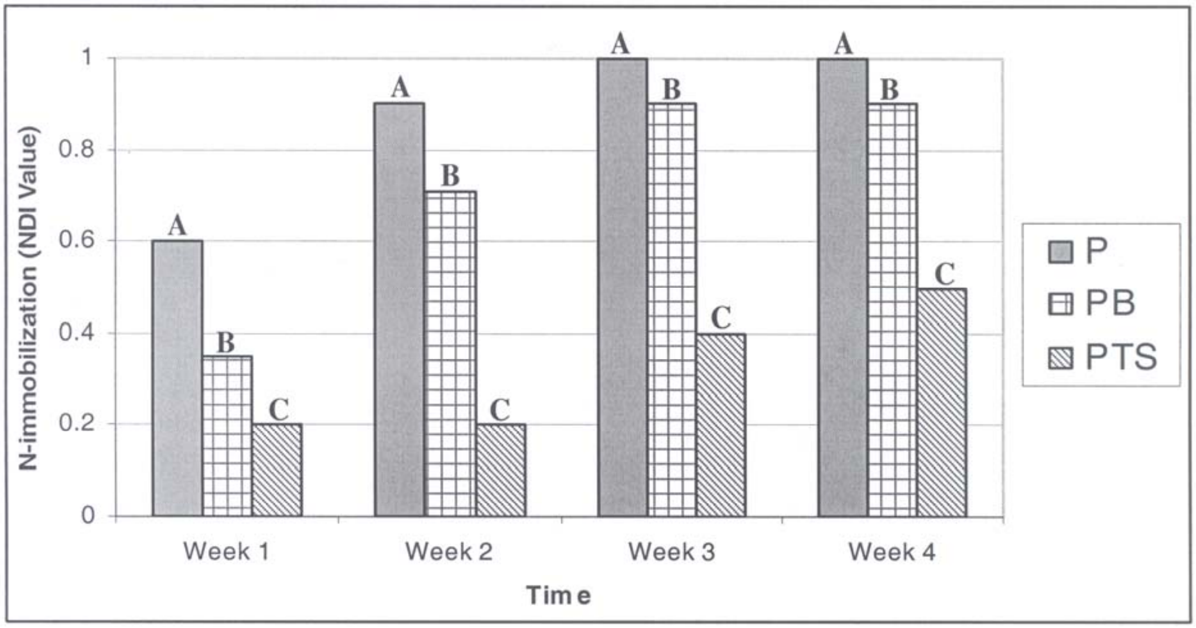

Figure 1. Nitrogen Drawdown Index (NDI) on peat (P), pine bark (PB), and pine tree substrate (PTS) when fertilized at 200 ppm N. NDI values range from 0-1, with 1 representing no N-immobilization, and 0 representing total (severe) N-immobilization.

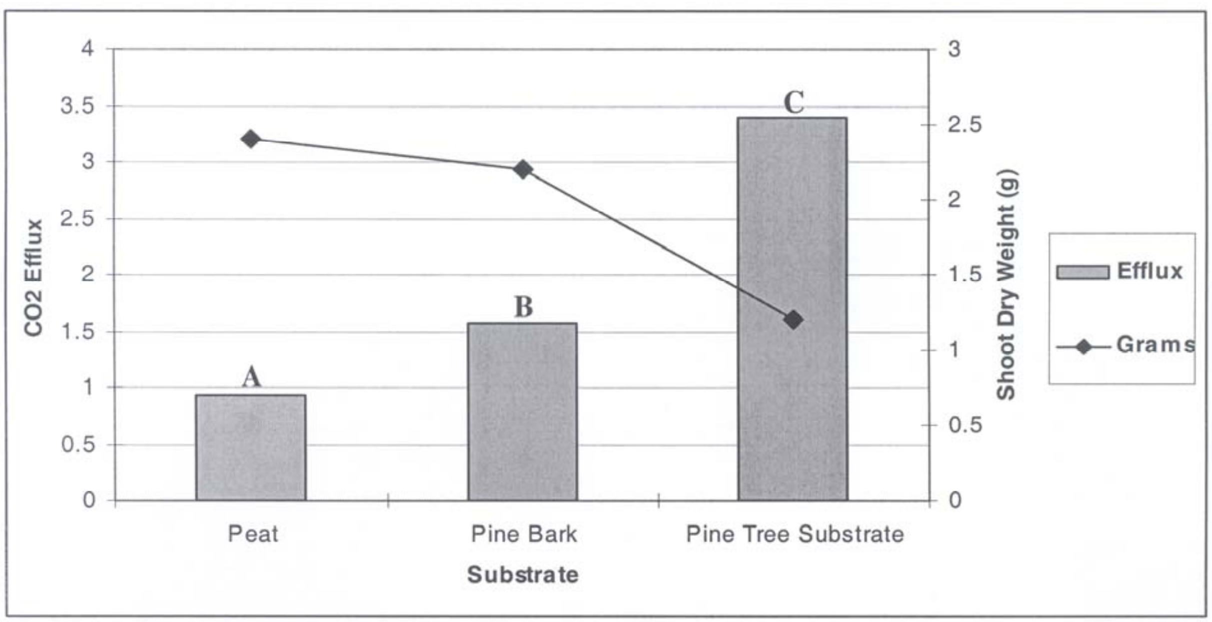

Figure 2. Substrate CO_2 efflux (measured at day 28) and shoot dry weight of marigolds grown for 28 days in peat (P), pine bark (PB), and pine tree substrate (PTS) when fertilized at 200 ppm N.