Amending Pine Bark with Swine Lagoon Compost: Is Poo the Answer?

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INTRODUCTION

Pine bark for use in the nursery industry is in short supply and at times not completely aged due to timber processing mills moving overseas (Lu, et al., 2006). Growers are working to overcome these shortages, high prices, and quality issues by using other products (such as wood) or amending pine bark to stretch their supplies (Worley et al., 2008). Calcined clays can be used as an 8% (by volume) amendment to pine bark to increase buffering and water holding capacity as well as to reduce nutrient leaching in bark based substrates (Owen, et al., 2007). Utilizing composted turkey litter as an amendment (at 4, 8, 12, 16% by volume) to pine bark increased available water but decreased air space (Tyler, et al., 1993). Both Owens et al. (2007) and Tyler et al. (1993) emphasize the need to evaluate both the physical and chemical properties of an amendment to pine bark before adoption by the containerized plant production industries (nurseries and greenhouses). Therefore, before implementing a new substrate mix into an operation, impacts on plant growth, nutrient availability within the substrate, and changes to fertility programs must be considered. With many alternative substrates available, growers are

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looking for the most locally available substrate with the least increase in cost, and the ready availability of swine lagoon waste is an attractive option.

In North Carolina, production of hogs comprises $26,419,703 of North Carolina's $420,145,646 farm cash receipts (USDA, 2015). Incubation studies showed pelletized processed swine lagoon solids were an adequate source of phosphorus, but some plants, such as row crops, would require supplemental application of nitrogen (Duffera et al, 1999A). It has also been reported that the shoot dry weights of bermudagrass (*Cynodon dactylon* L. Pers.), sweet corn (*Zea mays* L. var. silver queen), sorghum (*Sorghum bicolor* L. var. DK-54), and field bean (*Phaseolus vulgaris* L. var. blue lake) in the Ap horizon of a Norfolk sandy loam soil mixed with processed swine lagoon solid were similar or superior to growth with a conventional inorganic fertilizer (Duffera et al., 1999B). The application of vermicomposted swine lagoon waste at 20% has been shown to increase plant dry weight in *Hibiscus moscheutos* L. 'Luna Blush' as much as 58% compared to 100% pine bark in a greenhouse setting (McGinnis et al., 2009). However, little research has evaluated the growth of herbaceous perennials in containerized plant production with SLC as the only source of nutrients. Therefore, the objective of this study was to evaluate the impact of increasing amounts of swine lagoon compost to pine bark on plant growth.

MATERIALS AND METHODS

A study was designed as a randomized complete block with five replications to evaluate the impacts on plant growth of pine bark amended with varying rates (10,20,40,60, and 80% by volume) of swine lagoon compost (pH 5.6) (n=25). Swine lagoon waste was dredged from a lagoon in Garland, NC (Murphy Brown, LLC, Warsaw, NC) and dewatered using a polymer (PT1051, PolyTec Inc., Mooresville, NC) and a geotextile bag (TITANTube OS425/OS425A, Flint Industries, Metter, GA). The waste/polymer mix was pumped into the bags where the water filtered out and was pumped back into the lagoon. The bagged waste was allowed to drain for two years before use, resulting in swine lagoon compost (SLC). Once removed from the bag, the SLC was spread on plastic to dry with heat and forced air for a week, and then ground to 2mm using a grist mill grinder (Molina Corona, Landers, Mora & Cia, LTDA., Medellin, Colombia).

On 3 June 2015 seedling liners of *Musa velutina* H.Wendl & Drude, grown in 10.16 cm containers, were potted into 3.8 L (1 gal) (Classic 500, Nursery Supplies, Inc., Chambersburg, PA) containers filled with pine bark (PB) amended with one of five increasing ratios of swine lagoon compost (SLC): 10:90, 20:80, 40:60, 60:40, and 80:20 SLC:PB (v/v). The plants were grown in a greenhouse (26° C day/ 18° C night temperature) with 50% shade (XLS Revolux Climate Screen, LivingShade, Hornsby NSW Australia), and natural irradiance and photoperiod. Plants were irrigated twice a day using low-volume spray stakes (PC Spray Stake, Netafim, Ltd., Tel Aviv, Israel). No supplemental fertilizer or lime was added.

Leaching fractions (LF = volume leached ÷ volume applied) were measured every two weeks (17 June, 25 June, 10 July) and irrigation volume was adjusted to maintain a 0.2 LF for each substrate. Irrigation water contained an average of 0.83 $mg \cdot L^{-1}$ N, 0.21 $mg \cdot L^{-1}$ P, and 3.44 $mg \cdot L^{-1}$ K with a pH of 7.83. Additionally, substrate solution was collected every two weeks (10 June, 25 June, 14 July) using the pour-through nutrient extraction method (Wright, 1986). Substrate solution electrical conductivity (EC) and pH were determined via a combination EC/pH meter (HI 8424, Hannah Instruments, Ann Arbor, MI).

Total porosity (TP), airspace (AS), container capacity (CC), and bulk density (BD) analyses were conducted in the Horticultural Substrates Laboratory, Department of Horticultural Science, N.C. State Univ., Raleigh, NC. Substrate physical properties were determined initially at potting. Three replications of each substrate were packed into 347.5 cm3 cylindrical aluminum 23 rings

(7.6 cm dia, 7.6 cm ht) and they were used to determine TP, AS, CC, and BD according to procedures outlined in Tyler et al. (1993).

After 6 weeks, shoots were removed and roots were washed free of substrate. Shoot and root dry weights (dried at 60° C for 4 days) were determined and used for growth comparisons. The data were subjected to analysis of variance and regression analyses where appropriate ($P \leq 0.05$).

RESULTS

TP and AS decreased linearly with increasing amount of SLC added to PB, while BD increased linearly with increasing amount of SLC (Table 1). CC had a quadratic response to amount of SLC and was highest with 40% SLC added to PB. Substrates greater than 60:40 SLC:PB had AS that was below the recommended range (Yeager et al., 2007). Additionally, substrates with greater than 40% SLC (40:60 SLC:PB) had bulk density above the recommended range (Yeager et al., 2007).

The amount of SLC added to PB affected pH for each of the three sample dates (10 June P= 0.0001, 25 June P= 0.0001, and 14 July P= 0.01) (Figure 1). On 10 June 2015 the substrate solution pH readings ranged from 5.9 to 6.6, while on 14 July 2015 it ranged from 4.8 to 5.8. Higher amounts of SLC did not always result in higher substrate solution pH. Two weeks after potting (10 June 2015), pH of the substrate solution increased quadratically as SLC in the substrate increased with a maximum at 60% by volume. Four weeks after potting (25 June 2015), there was again a quadratic response in pH to increasing SLC with the highest pH found again in the 60:40 SLC:PB substrate solution. At six weeks after potting (14 July 2015), there was again a quadratic response in substrate solution pH, but with a maximum at 10% SLC. All substrates maintained acceptable pH levels throughout the study (Yeager, et al., 2007).

The substrate solution EC was also impacted by the amount of SLC added to PB at each sample date (10 June *P*= 0.0001, 25 June *P*= 0.001, and 14 July *P*= 0.001) (Fig. 2). At each sample date, EC levels increased quadratically as SLC in the substrate increased with the maximum EC found in the 40:60 SLC:PB substrate. While EC levels for substrates with less than 40% decreased over time, all substrates with greater than 10% SLC maintained unacceptably high EC levels (Yeager, et al., 2007)

Musa velutina shoot and root growth were also both impacted by the amount of SLC added to PB (shoot *P*= 0.0004 and root *P*= 0.0008) with both root and shoot growth decreasing quadratically as SLC amount increased from 10 to 80% (Fig. 3). There was substantial growth reduction, particularly in roots, at rates of SLC greater than 20%. Additionally, roots of plants grown in 10:90 SLC:PB were nearly twice the size of those in the 20:80 SLC:PB substrate. Shoot growth showed reduction in dry weight at 20:80 SLC:PB and greater reduction at 40:60 SLC:PB.

DISCUSSION

PB substrate amended with SLC at all volumes (10, 20, 40, 60, and 80%) had TP and CC within the recommended ranges. However, when PB was amended with more than 60% SLC had AS that was below the recommended range and PB amended with greater than 40% SLC had BD above the recommended range.

Substrates with greater than 10% SLC (10:90 SLC:PB) produced smaller shoots and roots of *Musa velutina*, in contradiction to results seen by McGinnis et al. (2009) with *Hibiscus moscheutos* L. 'Luna Blush', where shoot growth dry weight was consistently greater in pine bark amended with 20% (by volume) vermicomposted swine waste. Tyler and Warren (2000) also saw increase in shoot growth of *Rudbeckia fulgida* Aiton 'Goldsturm' when pine bark was amended with 8% (by volume) composted turkey litter. Root growth was likely reduced by high substrate solution EC which damaged roots. Burned root tips were observed (visual observation). All rates of SLC maintained acceptable substrate solution pH throughout the 6 week study.

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Table 1. Effect of swine lagoon compost (SLC) additions to pine bark (PB) on total porosity (TP), container capacity (CC), air space (AS), and bulk density (BD) initially at time of potting on 3 June, 2015.

	TP	CC	AS	BD
SLC:PB (v/v)[z]	% vol.			g/cc
10:90	84.05	52.39	31.65	0.19
20:80	74.51	54.75	19.76	0.20
40:60	77.88	64.16	13.72	0.28
60:40	74.90	63.48	11.41	0.32
80:20	55.05	49.11	5.95	0.44
ANOVA[y]	0.0016	<.0001	0.0030	<.0001
Linear[x]	0.0013	NS	0.0002	<.0001
Quadratic[w]	NS	<.0001	NS	0.0107
BMP Guidelines[v]	50-85	45-65	10-30	0.19-0.24

[z]The substrate consisted of: 10:90, 20:80, 40:60, 60:40, and 80:20 SLC:PB.
[y]Analysis of variance (ANOVA) effect of substrate ($P \leq 0.05$).
[x]Analysis of linear regression. NS=not significant, *P*-value given otherwise.
[w] Analysis of quadratic regression. NS=not significant, *P*-value given otherwise.
[v]BMP = Best Management Practices recommended ranges (in percentages) for substrates used in general containerized nursery production (Yeager et al., 2000).

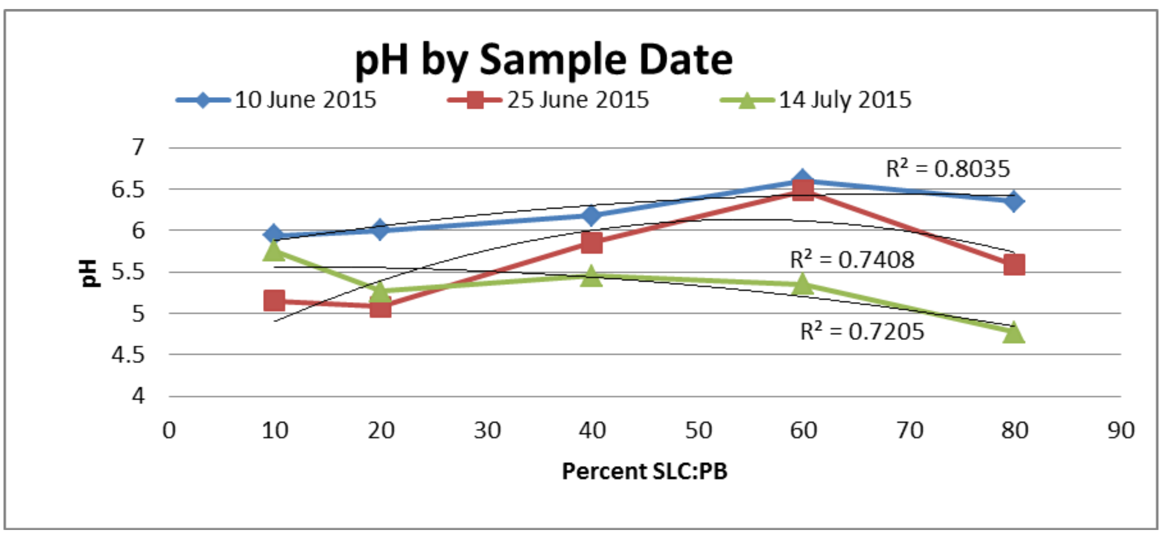

Figure 1. Effect of increasing amounts (10, 20, 40, 60, and 80% by volume) of composted swine lagoon solids added to pine bark on a substrate solution pH.

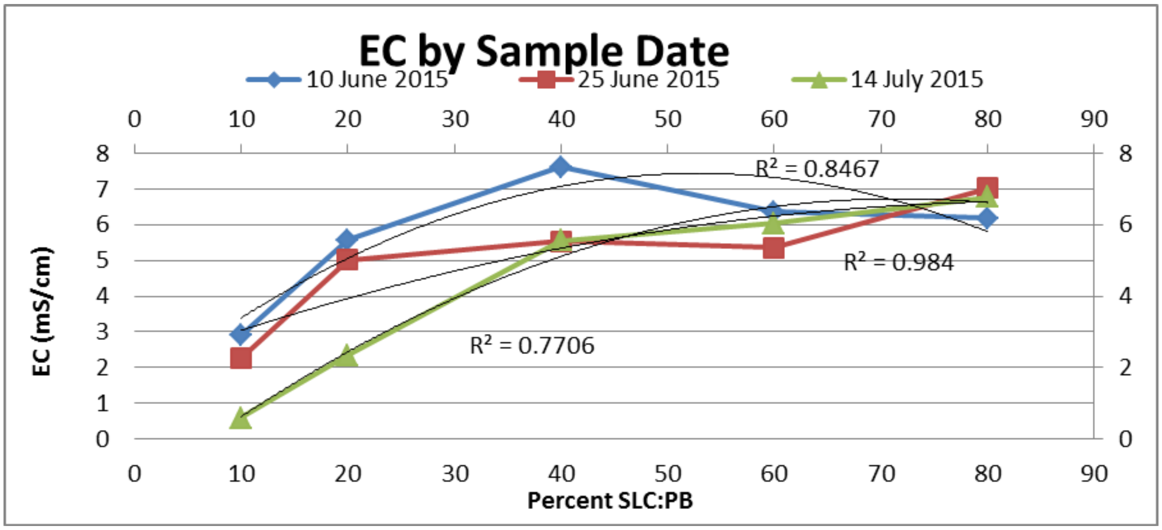

Figure 2. Effect of increasing amounts (10, 20, 40, 60, and 80% by volume) of composted swine lagoon solids added to pine bark on a substrate solution electrical conductivity (EC).

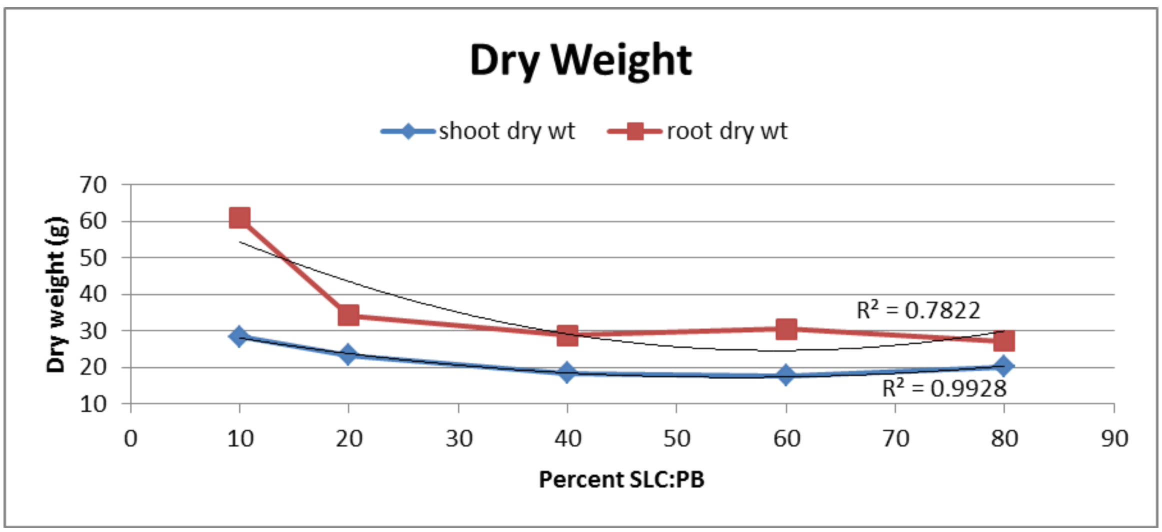

Figure 3. Effect of increasing amounts (10, 20, 40, 60, and 80% by volume) of swine lagoon compost (SLC) added to pine bark (PB) on root and shoot dry weights of *Musa velutina* using regression analyses ($P \leq 0.05$).