Cotton and Other Low to No Bark Alternatives: Getting Past Biomass Crops Assistance Program©

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INTRODUCTION

Bark has been a major component of container substrate since the 1960s. In recent years with the continuous rise in energy prices, the demand for bark as a clean fuel has increased. In 2010 the nursery industry faced a new threat to pine bark availability due to a proposed rule for USDA's Farm Security Administrations Biomass Crops Assistance Program (BCAP). Although pine bark supplies used for container potting substrates were not intended to be included in this program to utilize wood-mill-based residuals, it was not exempted and placed nursery pine bark supplies in jeopardy. One of the most popular areas of university research in recent years has been focused on evaluating alternatives and supplements to pine bark potting substrates since the quantity of timber harvested in the United States has decreased since 1986. Farm Security Administrations Biomass Crops Assistance Program accelerated the quest for new substitutes for commercial growing horticultural crops.

Use of composted materials to replace pine bark in a substrate is not a new idea. Many research studies have investigated the use of industrial and agriculture wastes as substitutes for bark. A comprehensive literature search would yield a very long list. Many alternatives show promise; however, cost, regional availability, and a limited supply of uniform and consistent quality reduce their widespread use.

Cotton is a major agronomic crop in the southeastern United States. In production of no-till cotton, stalks and residue remaining after harvest are very woody and do not easily decompose. This mulch may persist for several seasons and eventually the accumulation interferes with planting and application of fertilizer and herbicides, therefore some of this material must be removed from the field. North Carolina has experienced a tremendous growth in the hog industry, with an increase from 2.7 million hogs in 1990 to over 10 million hogs in this decade, producing over 4,000 tons of hog manure per day. Hog waste has been traditionally managed by open air lagoons and spray-fields. As a result of the documented environmental impacts by hog lagoons and spray-fields, a phase-out plan of anaerobic lagoons and spray-fields has been mandated in North Carolina. Combining these two materials into composted nursery substrate component would appear to be a simple solution to a complex problem. The end product produces an odorless, dark, pine-bark-like substrate. This research study set out to answer the questions: can we use this material to amend pine bark to grow a high quality plant? The use of recycled waste in container production would provide the nursery industry with a reproducible, consistent substrate amendment of unlimited supply. It is not incumbent on the nursery industry to solve the world's waste disposal problems. However, if recycled waste is a valuable substrate amendment then it becomes a win/win situation. Therefore, our objective was to evaluate the physical, chemical, and subsequent growth effects of addition of composted cotton-swine waste (CCSW) to ratios of pine bark.

METHODS AND MATERIALS

To accomplish this objective a study was conducted on a gravel pad at North Carolina State University with pine bark amended with four rates [0%, 15%, 30%, and 45% (by volume)] of cotton stalk/swine compost (CCSW). No micronutrients or dolomitic limestone amendments were added. For comparison to a commercial substrate, 8 pine bark : 1 sand (v/v) was amended on a cubic-yard basis with 2.0 lbs dolomitic limestone and 1.5 lbs MicroMax micronutrient fertilizer. All plants were topdressed with 5 g N per container with a commercial controlled-release fertilizer (Harrell's 17-5-10, 5- to 6-month controlled-release fertilizer).

Uniform rooted cuttings of *Cotoneaster* ×*suecicus* 'Skogholm' were potted into 1-gal. containers on 15 April. Irrigation volume to maintain a 0.2 leaching fraction (LF = irrigation volume leached ÷ irrigation volume applied) was applied via overhead irrigation daily. Leaching fraction for each treatment was determined weekly and adjusted accordingly. After 19 weeks (25 Aug.) tops and roots of all plants were harvested for dry weight determination. Roots were washed with a high-pressure water stream to remove substrate. All plant materials were dried for 5 days at 62 °C (144 °F). After drying, cotoneaster leaves were ground and analyzed for mineral nutrient concentration (N, P, K, Ca, Mg, S, B, Cu, Fe, Mn, Zn, and Na).

An additional 14 containers of each of the pine bark : CCSW substrate combinations were filled at treatment initiation. These fallow containers received similar cultural practices as those with plants. After 9 weeks, particle size distribution along with the physical properties of each pine bark : compost substrate combination were determined for seven fallow containers. Physical properties consisted of total porosity, air space, container capacity, available water, unavailable water, and bulk density. All physical properties analyses were conducted at the Horticultural Substrates Laboratory, Department of Horticultural Science, North Carolina State University. To determine how these properties may change over time, the same analyzes were conducted at the end of the study (19 weeks) for the remaining fallow containers.

To determine the chemical properties of each pine bark : CCSW substrate combination, the substrate solution was extracted from each container via the pour-through nutrient extraction method at 15, 45, 75, 105, and 135 days after treatment initiation (DAI). Electrical conductivity and pH were determined on each sample. The substrate solutions collected at 15, 75, and 135 DAI were analyzed for mineral nutrient concentration (N, P, K, Ca, Mg, S, B, Cu, Fe, Mn, Zn, and Na). All variables were tested for differences using analysis of variance procedures and regression analysis, where appropriate. The control substrate (8 pine bark : 1 sand, v/v) was separated from the CCSW amended substrates via Dunnett's test, $P = 0.05$. Due to page limits and space only growth data and physical properties will be presented.

RESULTS AND DISCUSSION

Top dry weight of cotoneaster increased linearly with increasing rate of CCSW, whereas root dry weight increased quadratically with increasing CCSW (Table 1). In addition, top dry weight of cotoneaster grown in 15%, 30%, and 45% CCSW was significantly greater than cotoneaster grown in (8 pine bark : 1 sand, v/v).

Electrical conductivity (EC) increased with increasing rate of CCSW at all sample times except 75 DAI indicating that CCSW was acting like a slow-release fertilizer (data not shown). This increase in EC was also probably responsible for the increase in top growth with increasing rate of CCSW. The highest EC was 2.81 $dS{\cdot}m^{-1}$ recorded at 15 DAI. During the growing season, an EC range of 0.5 $dS{\cdot}m$ to 2.0 $dS{\cdot}m^{-1}$ is considered appropriate assuming the EC is representative of all essential elements being present.

Table 1. Effect of pine bark substrates amended with cotton stalk/swine compost (CCSW) on top and root dry weight of Skogholm cotoneaster.

CCSW % by volume	Top dry weight (g)	Root dry weight (g)
0	88.0	19.0
15	107.4*[z]	17.8
30	107.3*	18.2
45	121.0*	23.4*
8 : 1[y]	95.3	19.1
Significance[x]		
Linear	***	*
Quadratic	NS	**

[Z*] Significantly different from the control substrate [8:1 pine bark:sand (by vol.)] based on mean separation by Dunnett's test, $P = 0.05$.

[y] 8 : 1 pine bark:sand substrate by vol. The control substrate data not included in regression analysis.

[x]NS, *, **, *** nonsignificant or $P = 0.05$, $P = 0.01$

Total porosity, container capacity, available water, and unavailable water increased with increasing rate of CCSW (Table 2). In addition, all substrates amended with CCSW had greater total porosity and less available water compared to the pine bark : sand, (8 : 1, v/v) control. In contrast, air space and bulk density decreased with increasing rate of CCSW. Air space was greater and bulk density was less in CCSW-amended substrates compared to the control. Air space is critical in substrates for root metabolism and growth; low air space reduces root adsorption capacities. A 20% to 30% air space is preferable for nursery size containers. Thus, the 0% CCSW was very high at 63 DAI and barely inside the range at 135 DAI. In contrast, pine bark : sand was on the low end of the range at both 63 and 135 DAI. Air space values for 15%, 30%, and 45% amended substrate fell between 0% CCSW and the control. Most organic-based substrates including pine bark decrease in air space during production conditions with high irrigation application and fertilizer application.

Table 2. Effect of pine bark substrates amended with cotton stalk/swine compost (CCSW) on physical properties at 63 and 135 days after treatment initiation.

	Total porosity		Air space		Container capacity		Available water		Unavailable water		Bulk density	
	Days after treatment initiation											
Volume (%)	63	135	63	135	63	135	63	135	63	135	63	135
	% vol										$g \cdot cm^{-3}$	
0	84 *[z]	85*	33*	30*	52	55	22*	22*	29*	33*	0.26*	0.24*
15	84*	86*	29*	28*	55	58	24*	25*	30*	32*	0.25*	0.24*
30	85*	87*	29*	27*	56	60	24*	26*	32*	34*	0.23*	0.21*
45	86*	87*	24	25*	62*	62*	29	27*	33*	36*	0.23*	0.21*
8:1[y]	77	80	23	21	54.0	59	28	29	26	29	0.43	0.44
Significance[x] Linear												
*** ***	***	***	***	***	***	***	***	***	***	***		
Quadratic	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[Z]Significantly different from the control substrate [8 : 1 pine bark : sand (by volume)] based on mean separation by Dunnett's test, $P = 0.05$.

[y]8 : 1 pine bark:sand substrate by vol. The control substrate data not included in regression analysis.

[x]NS, *** nonsignificant or $P = 0.001$ respectively.

As air space decreases in substrates during a growing season, a reciprocal increase in container capacity usually occurs. Except for 45% CCSW, which remain unchanged, these substrates increased 3% to 5% in container capacity from 63 to 135 DAI, which was associated with the decline in AS. However, container capacity values remained within normal ranges.

At 63 DAI, 0%, 15%, and 30% CCSW had lower available water compared to the control. At 135 DAI, all CCSW amended substrates had lower available water than the control.

Bulk density decreased linearly with increasing rate of CCSW (Table 2). All CCSW substrates were significantly lower than the control substrate. Changes in bulk density reflect the stability of substrate components. The bulk density of all CCSW-amended substrate decreased 4% to 9% from 63 to 135 DAI indicating the particles were decomposing and reducing the volume of the substrate, whereas the 8 pine bark : 1 sand substrate changes very little from 63 to 135 DAI.

SUMMARY

In summary, composted cotton swine waste used as a supplemental component addition to pine bark has the potential to stretch bark supplies, increase plant growth, replace limestone and micro-nutrients additions, and recycle a waste material.