Acknowledgements. Willowbrook Nurseries Inc. and The National Research Council, Industrial Research Assistance Program (IRAP) supported this project.

LITERATURE CITED

Chong, C. and **P. Purvis.** 1999. Nonchemical alternatives for container weed control. Comb. Proc. Intl. Plant Prop. Soc. 49:397-399.

Bark Versus Municipal Compost in Paper Mill Waste Substrates for Container Culture©

Calvin Chong
University of Guelph, Department. of Plant Agriculture-Vineland, Vineland Station, ON L0R 2E0, Canada

Paper mill biosolids (Tripepi et al., 1996) and municipal waste composts (Maynard, 1999) are increasingly being advocated for use in container nursery substrates. Previously, I used paper mill biosolids mixed with bark, peat, and/or sand (Chong, 1999).

Results of another study (Chong, 2002), herein summarized in part, compared the response of dogwood (*Cornus alba* 'Sibirica'), forsythia [*Forsythia* ×*intermedia* 'Lynwood' (syn. 'Lynwood Gold')], common ninebark (*Physocarpus opulifolius*), and weigela [*Weigela florida* 'Nana Variegata' (syn. 'Variegata Nana')] grown from liners through one season in #2 containers filled with one of 16 waste-derived substrates, classified into four groups. Each group had 0%, 20%, 40%, or 60% (by vol) paper mill biosolids in binary mixtures with municipal leaf and yard waste compost (PC group) or pine bark (PB group), and quaternary mixtures with compost, topsoil, and sand (PCTS group) or bark, topsoil, and sand (PBTS group). There was a control mix of bark, peat, and topsoil (80 : 15 : 5, by vol). Table 1 shows the chemical analyses of the unamended paper mill biosolids and waste compost. Sierra 17-6-10 (17.0N - 2.0P - 8.7K) controlled-release fertilizer with micronutrients was incorporated into each substrate (6 $kg \cdot m^{-3}$). Plants were arranged by species in separate randomized complete block designs with four replications of each treatment and four plants per plot. Each plant received 1 liter of trickle-irrigated water per container twice daily.

Regression analysis showed that all four species grew more in the compost-amended than in the bark-amended groups, regardless of the rates of paper mill biosolids (Fig. 1). Growth of forsythia, dogwood, and weigela increased with increasing rates of biosolids up to 60%. Growth of ninebark increased with rates of biosolids up to 30% where amended with compost (PC/PCTS) or up to 55% where amended with bark (PB/PBTS). While none of the weigela plants attained (marketable) size comparable to that of the control mix, top dry weights of the other species reached or exceeded their control counterparts in the compost-amended substrates over most rates of biosolids (Fig. 1).

The electrical conductivity [EC, a measure of the soluble salts level, expressed in terms of dS/m, using substrate and water (1:2, v/v) extracts] at potting were: PC 1.1-1.5; PCTS 0.8-0.9; PB 0.6-0.7; PBTS 0.5-0.9; control mix, 0.5. During the season, EC values maintained the same relative order among groups, while within groups, values generally increased with increasing rates of biosolids. Values averaged over the last two sampling dates (30 July and 26 Aug.) were positively correlated with

Table 1. Chemical analysis of unamended paper mill biosolids and municipal waste compost[z].

Variable	Recommended values	Paper mill biosolids	Municipal waste compost
pH	5.5-7.0	7.0	8.0
EC (dS/m)	<1.0	1.3	3.8
$N0_3$-N (ppm)	100-200	3	16
P (ppm)	6-9	7	2
K (ppm)	150-200	82	745
Ca (ppm)	200-300	100	106
Mg (ppm)	70-200	29	41
Na (ppm)	0-50	172	89
Cl (ppm)	0-50	77	831
Fe (ppm)	0.3-3.0	0.6	0.2
Mn (ppm)	0.3-3.0	2.7	0.1
Zn (ppm)	0.3-3.0	0.1	0.5
Cu (ppm)	<0.6	0	0.1

[z] Triplicate samples; pH and EC were measured in substrate and water (1 : 2, v/v) extracts; all nutrients were measured by saturated medium extraction (greenhouse) procedure.

Table 2. Physical properties of amended paper mill biosolids[z].

Substrate group[y]	Bulk density ($g \cdot cm^{-3}$)	Porosities	
		aeration (%)	water retention (%)
PC	0.42[z]	40	25
PB	0.33	43	19
PCTS	0.75	30	29
PBTS	0.60	30	25

[z] Triplicate samples averaged over rates of paper mill biosolids.

[y] Paper mill biosolids mixed with waste compost (PC), pine bark (PB), compost, topsoil, and sand (PCTS), or bark, topsoil, and sand (PBTS).

Figure 1. Response of four container-grown nursery shrubs to rates of paper mill biosolids in binary mixtures with municipal waste compost (PC group) or bark (PB group), and quaternary mixtures with compost, topsoil, and sand (PCTS group) or bark, topsoil, and sand (PBTS group). When the regressions of any two groups were not significantly different at $P \leq 0.05$, a common regression (solid line) was fitted. pr^2 represents the coefficient of determination after removing replication effects. The horizontal broken line represents top dry weight in the control mix.

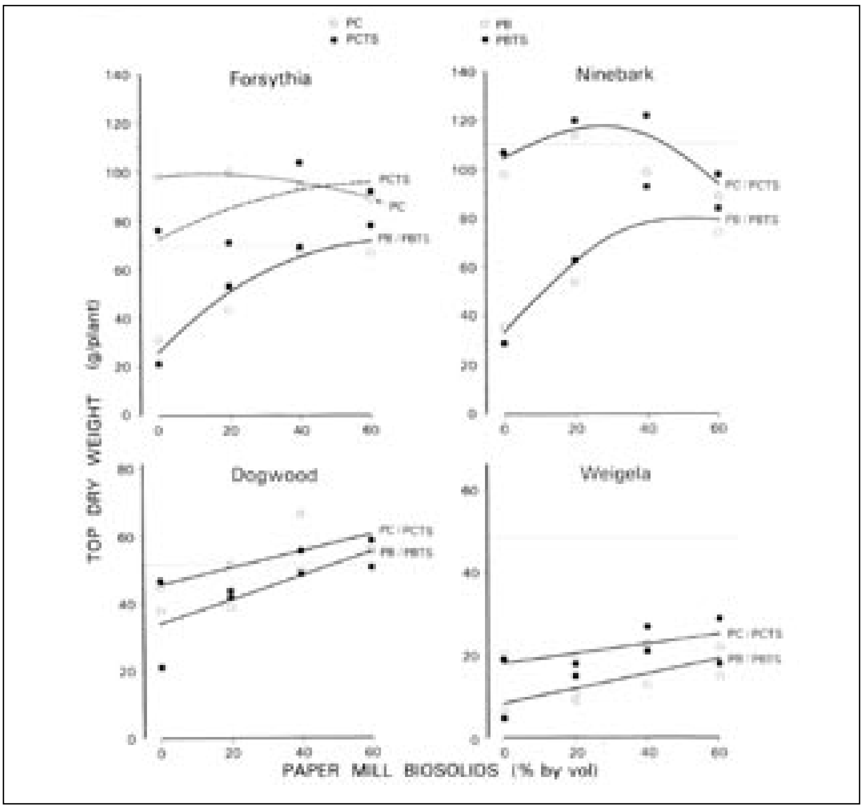
Equations:

Ninebark:
$$Y_{pc/pcts} = 103 + 1.1X - 0.020X^2$$
$$Y_{pb/pbts} = 32 + 1.9X - 0.018X^2$$
$$pr^2 = 0.86$$

Forsythia:
$$Y_{pc} = 98 + 0.10X - 0.042X^2$$
$$Y_{pcts} = 72 + 0.81X - 0.0070X^2$$
$$Y_{pb/pbts} = 26 + 1.4X - 0.011X^2$$
$$pr^2 = 0.87$$

Dogwood:
$$Y_{pc/pcts} = 45 + 0.25X$$
$$Y_{pb/pbts} = 33 + 0.38X$$
$$pr^2 = 0.63$$

Weigela:
$$Y_{pc/pcts} = 18 + 0.11X$$
$$Y_{pb/pbts} = 7.7 + 0.18X$$
$$pr^2 = 0.68$$



top dry weight of all four species (forsythia, r=0.73**; ninebark, r=0.43*; dogwood, r=0.65**; and weigela, r=0.48*; **, * $P \leq 0.01$ and 0.05, respectively). This result provided evidence that enhanced growth (Fig. 1), and/or increased foliar nutrient status in three (forsythia, ninebark, and weigela; data not shown) of the four species, were related to higher retention of nutrients (salts) in the compost-amended groups, especially as the rate of biosolids increased. Higher bulk densities and water retention capacities in the compost — versus the bark — amended groups (Table 2) may also have contributed. However, reason(s) for the poor growth of weigela in all treatments compared to the control mix is not clear.

Acknowledgement. This research was supported in part by Domtar Specialty Fine Papers.

LITERATURE CITED

Chong, C. 1999. Experiences with the utilization of wastes in nursery potting mixes and as field soil amendments. Can. J. Plant Sci., 79:139-148.

Chong, C. 2002. Paper mill waste mixed with compost and other ingredients as container nursery substrates. Compost Sci. Util. 11(1):16-26.

Maynard, A.A. 1998. Utilization of MSW compost in nursery stock production. Compost Sci. Util. 6:38-44.

Tripepi, R.R., M.W. George, A.G. Campbell, and **B. Shafii.** 1996. Evaluating pulp and paper sludge is a substitute for peat moss in container media. J. Environ. Hort. 14:91-96.

Mycorrhizal Fungi, and Organic and Inorganic Slow Release Fertilizers Influence Growth of Bush Morning Glory (*Ipomoea carnea* subsp. *fistulosa*)©

Lucila Amaya de Carpio, Fred T. Davies, Jr., and Michael A. Arnold
Department of Horticultural Sciences, Texas A&M University, College Station, Texas 77843-2133 U.S.A.

INTRODUCTION

This study investigated the utilization of arbuscular mycorrhiza fungi (AMF) to enhance the efficiency of slow-release organic and inorganic fertilizers during container production of bush morning glory (*Ipomoea carnea* subsp. *fistulosa*). Uniform rooted liners of *Ipomoea carnea* subsp. *fistulosa* were planted into 9.6-liter (2-gal) pots containing a pasteurized soilless medium [pine bark to sand (3 : 1, v/v)]. The mycorrhizal treatments consisted of two commercial AMF inocula: Bioterra Plus and Mycorise Pro, and a noninoculated control [NonAMF]. Fertilizer treatments included an organic slow-release fertilizer (SRF) (Nitrell; 5N-3P-4K) and an inorganic SRF (Osmocote; 18N-7P-10K). Nitrell was tested a three levels: 8.4 kg m^{-3} (14 lb per yd^3), 12 kg m^{-3} (20 lb per yd^3), and 16.8 kg m^{-3} (28 lb per yd^3), which were, respectively, 70%, 100%, and 140% of the manufacturer's recommended rate. Osmocote was tested at two levels: 3.5 kg m^{-3} (6 lb yd^{-3}) and 7.0 kg m^{-3} (12 lb per yd^3) which were, respectively, 50% and 100% of the recommend rate. With organic and inorganic SRF, both mycorrhizal inocula significantly enhanced the marketability, growth index, root, leaf, shoot, and total plant dry mass of bush morning glory. The greatest growth response occurred with the highest level of Osmocote colonized