along for several years with each part foliating in spring and defoliating in autumn. I wondered if the albinism might be caused by inbreeding. Where these masses of plants spread by sucker growths, the clump could very well be all one clone. I spoke to several plant physiologists about this and asked if this might be true. In their opinions, there was no doubt that it was.

Aesculus parviflora var. *serotina*. This variety differs from the species in a number of ways. It grows about twice as tall, flowers during the first half of August while the typical form blossoms in mid-July, and is also more prolific. Two or three seeds are often found in a capsule, while the species usually has one.

Aesculus parviflora can be propagated by root cuttings or root suckers can be collected from the bases of existing plants.

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SPENT MUSHROOM COMPOST AND PAPERMILL SLUDGE AS SOIL AMENDMENTS FOR CONTAINERIZED NURSERY CROPS

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Abstract. Two sources of mushroom compost were evaluated as soil amendments with bark: (1) unweathered (UMC) in proportions of 25, 50, 75 and 100% by volume, and (2) weathered (WMC) in proportions of 25, 50 and 75%. There was also a 100% bark control treatment. Both red osier dogwood (*Cornus stolonifera* [syn. *C. sericea*]) and forsythia (*Forsythia* × *intermedia* 'Lynwood') grew well in all media. While plant height was little affected by the amount of mushroom compost in the media, top dry weight of the two species was increased in proportion to the amount of both UMC and WMC. Regardless of the media treatment, there was no apparent symptoms of nutrient toxicity or deficiency.

Of four types of papermill sludge (primary, secondary, mixture of primary and secondary from Ontario Paper Co., and a mixture of primary and secondary from Fraser Paper Co.) added at 33% by volume to bark, secondary sludge which has the highest N content provided the best growth of spiraea (*Spiraea* × *bumalda*); however, foliage of plants was dark blue-green in color reflecting high N. Unacceptably poor growth occurred in Fraser-amended media because of low N.

INTRODUCTION

During the past 20 years, there has been considerable interest in the use of various organic and woody waste by-products in agriculture (4,6,10). The type and availability of these products varies widely in different locations. In southern Ontario, the availability of large quantities of spent mushroom compost and papermill sludge at little or no cost make these by-products attractive for use as inexpensive growing media additives in nursery container culture.

Mushroom compost has been used as soil amendment for various crops including vegetables (11) and greenhouse crops (8). Papermill sludge is also being evaluated for use on various crops (5,7) and one company, after years of research, has marketed a growing medium (Grow Rich) derived primarily from this type of waste (1). Compost derived from papermill wood waste and poultry manure was used as an organic amendment of a container growing mix (6).

Such waste products seem to be promising alternatives for improving the physical properties of container mixes and also the nutrient resources. However, there are several potential disadvantages to plants encountered from the application of such waste products: accumulation of total salts in the media, specific toxicities due to particular nutrients, and variation in response due to species (6, 8, 11).

As part of a research program which focuses on the adaptation of nursery crops to container culture, this study was conducted to determine the influence of mushroom compost and papermill sludge as soil amendments for use in container crop culture.

MATERIALS AND METHODS

Mushroom Compost. In 1986, two sources of spent mushroom compost, previously used in the cultivation of the commercial mushroom, *Agaricus brunnescens,* were evaluated. The first was a weathered mushroom compost (WMC), which had been discarded on an open field and exposed to weathering for two years. The second was an unweathered mushroom compost (UMC) obtained from the cropping area of the Horticultural Research Institute of Ontario mushroom programme and used soon thereafter without exposure to weathering.

Media treatments potted in 6-l (2 gal. trade size) nursery containers consisted of: 25, 50, 75, and 100% by volume of WMC mixed with 75, 50, 25, and 0% of bark; 25, 50, and 75% UMC also mixed with bark; 100% bark (control). Selected physical characteristics of these media are shown in Table 1. A treatment with 100% UMC was not included since it was believed that excessive salts (1,226 mhos $\times 10^{-5}$) in this treatment at planting time would be detrimental.

In mid-May, rooted hardwood cuttings of dogwood (*Cornus stolonifera*) or forsythia (*Forsythia × intermedia* 'Lynwood') were planted in each medium treatment. For each species, containers were spaced 45 cm × 45 cm arranged in a randomized complete

Table 1. Characteristics of media amended with weathered (WMC) and unweathered (UMC) mushroom compost.

Source	% Compost	Soluble salts (mhos × 10^{-5}) Planting	Harvest	pH Planting	Harvest	Shrinkage (cm)
Bark (control)	0	3	62	4.2	6.4	1.31
WMC	25	17	66	6.0	6.8	1.81
	50	39	67	6.5	6.9	2.23
	75	62	70	6.8	7.1	2.43
	100	83	72	7.0	7.1	2.20
UMC	25	35	82	6.2	6.7	1.92
	50	63	94	6.6	6.9	2.72
	75	1030	101	7.9	7.0	3.24

block design outside in a container nursery with four replications of each treatment. There were five plants in each treatment unit. Plants were fertilized 2 to 3 times per week with 20-20-20 and watered as needed. In mid-August samples of leaves were taken for analysis of N, P, K, Ca, Mg, Fe, Mn, Zn, and B. In mid-September, media shrinkage determined by depth from the container rim (Table 1), plant height, and top dry weight were determined. The pH and total soluble salts were determined from a 1:2 soil:water (by volume) extract of all media at planting time and also at harvest (Table 1).

Papermill Sludge. In 1985, four types of papermill sludge, each added at 33% by volume to bark, were evaluated: a primary sludge; a secondary sludge; and a mixture of 20% of primary and 80% secondary sludges from the Ontario Paper Co.; a mixture of primary and secondary sludges from the Fraser Paper Co. Using spiraea (*Spiraea* × *bumalda*) as test species, selected media characteristics (Table 2), experimental design, and growth measurements were as described above. Leaf samples taken from mature leaves in the centre of the current season's growth in early October were analyzed for N, P, and K.

Table 2. Characteristics of media amended with different types of papermill sludge.

Type	% Sludge	Soluble salts (mhos × 10^{-5}) Planting	Harvest	pH Planting	Harvest	Shrinkage (cm)
Bark Control	0	10	41	5.8	5.3	2.5
Primary	33	29	38	6.2	5.8	4.7
Secondary	33	108	43	7.4	5.0	5.6
Ontario Mixture	33	29	13	6.9	5.3	4.3
Fraser Mixture	33	30	50	7.4	6.0	6.3

RESULTS AND DISCUSSION

Mushroom Compost. Both dogwood and forsythia grew vigorously during the season in all media treatments. While plant height was little affected by the amount of mushroom compost in the medium (data not shown), top dry weight of the two species increased significantly with increases in the proportion of both sources of mushroom compost (Fig. 1).

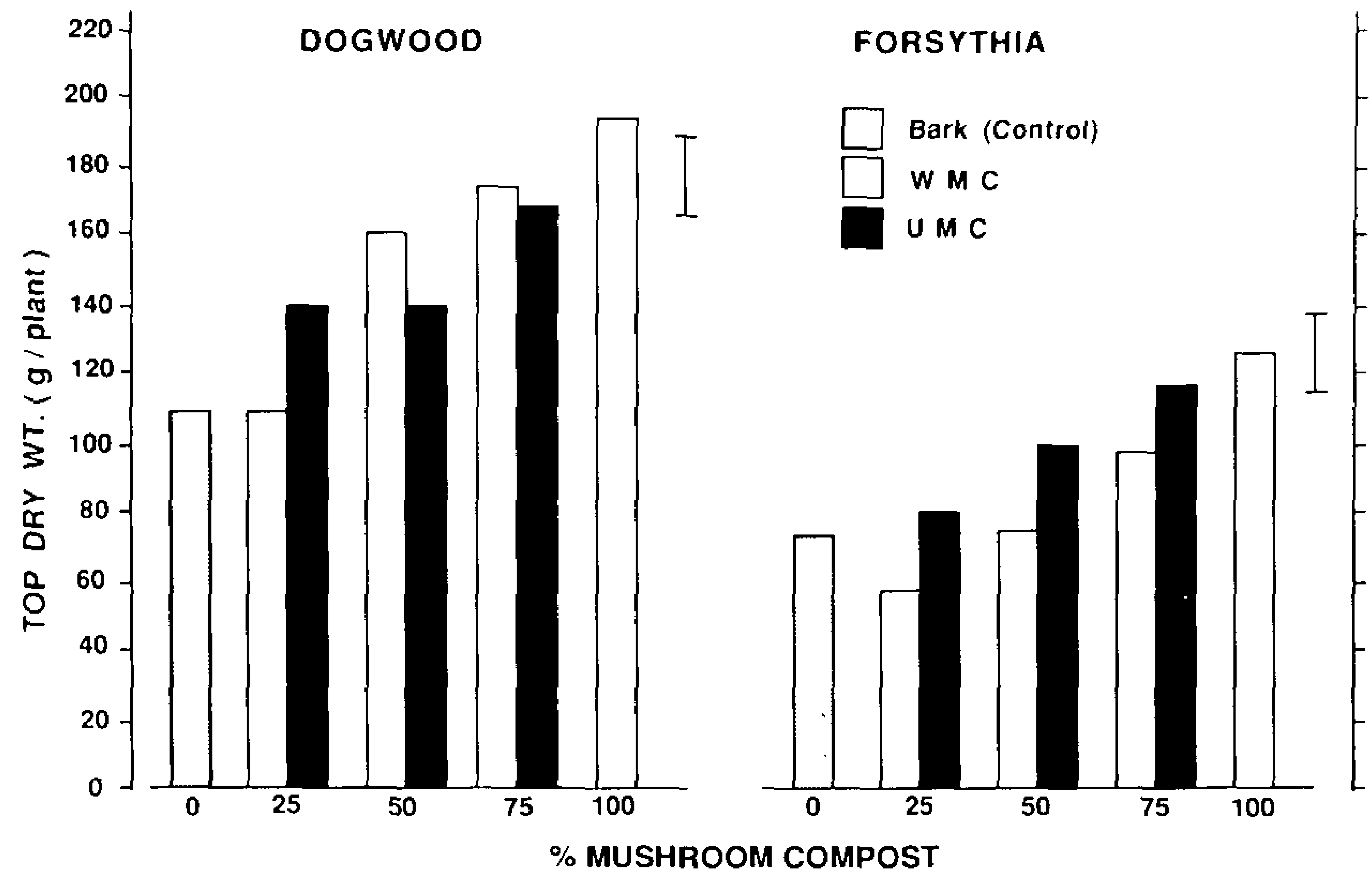

Figure 1. Top dry weight of dogwood and forsythia grown in media amended with weathered (WMC) and unweathered (UMC) mushroom compost. Vertical bars represent LSD at 1% level.

Table 3. Nutrient analysis in leaves of dogwood grown in media amended with weathered (WMC) and unweathered (UMC) mushroom compost.

		Percent dry wt					ppm			
Source	Compost	N	P	K	Ca	Mg	Fe	Mn	Zn	B
Bark (Control)	0%	2.17	0.58	1.27	2.12	0.33	55	22	27	27
WMC	25%	2.42	0.76	1.27	2.74	0.35	72	33	28	25
	50	2.36	0.77	1.23	2.60	0.34	58	24	26	24
	75	2.45	0.81	1.31	2.50	0.33	57	33	35	28
	100	2.74	0.78	1.33	2.59	0.33	55	30	27	29
UMC	25%	2.25	0.68	1.23	2.40	0.33	42	20	27	25
	50	2.32	0.68	1.17	2.22	0.32	50	23	25	25
	75	2.25	0.67	1.18	2.41	0.31	63	34	26	25
LSD (5% level)		NS[z]	0.10	NS	0.35	NS	NS	9	NS	NS

[z] Not significantly different.

Regardless of the medium treatment, there was no apparent symptoms due to specific nutrient toxicity or deficiency. Leaf analysis for dogwood indicated only small to moderate increases in leaf P, Ca, Mn, and(or) Zn in some or all treatments with compost (Table 3); there was no effect of mushroom compost on leaf N, K, Mg, Fe, and B. Similar results were observed in forsythia (data not shown).

Soluble salt levels and pH of the two sources of mushroom compost increased with increasing proportions of compost, with values generally higher in the UMC than in the WMC (Table 1). While pH tended to rise over time, values for soluble salts showed the reverse trend. Except for the elevated value of 1,030 mhos $\times 10^{-5}$ at planting time and perhaps the value of 101 mhos $\times 10^{-5}$ in the 75% UMC treatment at harvest, all other values for soluble salts (Table 1) were not considered high enough to cause plant injury. This evidence suggests that salts were leached away rapidly by irrigation before manifestation of any detrimental effect. Also, the species used in the study may be quite tolerant to high salt levels. It is noteworthy that in a related observation trial, several plants of each of the two species in 100% UMC grew as well, if not better, than plants in the treatments described above. Another species, *Prunus × cistena*, also grew well in 100% UMC.

Rathier (8) indicated that mushroom compost in amounts up to 33% by volume can be useful as a partial substitute for topsoil or for peat moss in greenhouse crop production. According to the experience of flower growers, using a growing medium with more than 15% by volume of freshly spent mushroom compost can cause problems (2). Interestingly, in the present study, the increasing shrinkage and accumulation of excess total salts in media with high proportions of both UMC and WMC were not detrimental to growth but in fact were associated with increased dry matter yield. It was expected that treatments with high proportions of UMC would result in poor growth due to excessive salts. However, the increased growth (i.e. dry matter yield) with these treatments suggests that woody nursery stock may be more tolerant of high salts than herbaceous crops.

Presently in Ontario, several commercial nurseries routinely add weathered mushroom compost to container growing mix to culture nursery crops. To save in handling costs and time, it would be desirable to use mushroom compost for growing-on after little or no exposure to weathering and (or) leaching. However, until definitive research in the future indicates otherwise, dangers of high salt levels should be reduced by composting, leaching, and (or) by taking soil tests to determine when the material is suitable for use (8). Unweathered material should be used with care or avoided at this time.

Papermill Sludge. Best growth of spiraea in terms of height or top dry weight yield occurred in the secondary-amended medium (Table 4), although foliage of plants in this treatment had a dark blue-green sheen. In contrast, unacceptably poor growth occurred in Fraser-amended media. This appears to be related at least in part to excessive and low quantities of nitrogen present in the secondary and the Fraser mixture, respectively (Table 5). However analytical data of leaf N (Table 4) did not relate with this observation.

Table 4. Growth and leaf N, P, K content of spiraea grown in media amended with different types of papermill sludge.

Type	Sludge	Height (cm)	Top dry wt (g/plant)	Percent dry weight N	P	K
Bark (control)	0%	30.3	18.1	2.49	0.23	2.19
Primary	33	28.6	13.1	2.48	0.22	2.23
Secondary	33	35.3	39.2	2.55	0.22	1.95
Ontario mixture	33	30.8	22.5	2.58	0.22	2.04
Fraser mixture	33	22.8	5.1	2.91	0.22	1.91
LSD (1% level)		3.1	7.2	0.32	NS[z]	0.28

[z] *Not significantly different.*

Table 5. Initial N, P, and K content in representative samples of papermill sludge.

Type	Percent dry wt N	P	K
Primary	0.50	—[z]	0.24
Secondary	3.50	—	0.25
Ontario mixture	1.50	0.17	0.25
Fraser mixture	0.20	0.12	0.02

[z] Data not available.

Leaf analysis also indicated little or no differences in leaf N and K among the various types of sludges and did not reveal any imbalances in these major nutrients (Table 4). Increased growth with the secondary sludge may have diluted any increase in uptake or masked nutrient imbalances. Shrinkage was higher in all sludge-amended media than in the bark control (Table 2), but there was no apparent relationship between shrinkage and plant growth.

Further investigations are required to determine the influence of different proportions of each sludge in the media, the role of both macro- and micro-nutrients, and the effect of fertilizers added to types such as the Fraser mixture that is low in nitrogen.

Acknowledgements. Financial support from Ontario Paper Co. and Fraser Paper Co. is acknowledged. The plant material used in this study was supplied by Downham's Nursery, Strathroy, Ontario. The technical assistance of Bob Hamersma is appreciated.

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