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Reuse of waste materials as growing media for ornamental plants

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Abstract

The use of different waste materials: pine bark, coconut fibre and sewage sludge as substrates in the production of ornamental plants was studied, with an special interest on the suitability of coconut fibre as growing substrate for conifer plants. The plant species tested were *Pinus pinea*, *Cupressus arizonica* and *C. sempervirens* and the substrate mixtures were: (1) pine bark, (2) pine bark with 15% of sewage sludge compost, (3) pine bark with 30% of sewage sludge compost, (4) coconut fibre, (5) coconut fibre with 15% of sewage sludge compost and (6) coconut fibre with 30% of sewage sludge compost. Substrates were physically and chemically well characterized, and 75-cm plants were grown on them for one year. Plant and substrate status were periodically tested along the experiment. As biosolid recycling is the main objective of the present work, the mixtures with 30% of composted sewage sludge will be the most convenient substrate to use. For *C. sempervirens* and *C. arizonica*, a mixture between pine bark or coconut fibre and 30% of biosolid compost in volume gave the best results, but the lower cost of the pine bark than the coconut fibre substrate indicated the use of the PB + 30% CSS. For *P. pinea* the research of new combinations between waste products is recommended to attain better results.

Keywords: Pine bark; Coconut fibre; Sewage sludge compost; Chemical and physical characterization; *Pinus pinea*; *Cupressus sempervirens*; *Cupressus arizonica*

1. Introduction

Materials such as peat and natural soils are commonly used in Spain for the production of substrates for ornamental plants (Pagés and Matallana, 1984; Guerrero and Polo, 1990). But for over 25 years container production of ornamental trees, shrubs and perennial plants has depended almost entirely on quality soil less media derived from both organic and inorganic constituents. Waste products such as biosolids (Gouin, 1993; Ingelmo et al., 1998; Guerrero et al., 2002) and wood waste (Hicklenton et al., 2001; Chen et al., 2002) have been frequently used in nurseries, but the availability of other materials is attracting more attention. For example, coco fibres are increasingly used as substrate, because they have many characteristics in common with peat (Lennartsson, 1997). During the past few years has this material become commercially popular, and it is now being successfully used in different parts of the world as peat substitute for container-grown ornamental plants (Handreck, 1993; Stamps and Evans, 1997; Offord et al., 1998; Noguera et al., 2000; Abad et al., 2002). But, to our knowledge, no experiments had been conducted to shown the feasibility of this substrate for growing plants such as *Pinus pinea*, *Cupressus sempervirens* or *Cupressus arizonica*. Composted softwood bark and biosolid compost are both stable organic products containing essential plant nutrients, but for biosolids, changing economic, industrial and demographic conditions mean that both the physical and the chemical makeup of the compost shifts with time and source (Hicklenton et al., 2001). As the biosolid feedstock changes so does the quality of the compost. While slight variations in texture, particle size and mineral composition are of less consequence when the material is used as landscape mulch, these factors may be of significant importance when combined with other constituents in the limited volume of a plant container. Since

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successful container culture depends on producing a consistent finished plant, variability in the growing substrate can pose significant problems if it affects growth rate, nutrition or plant form and aesthetics.

The use of these materials provides environmental benefits as ecosystem damage caused by soil or peat extraction is avoided and the impact of residue accumulation is minimized (Raviv et al., 1986). There are also economic benefits, as the use of residues means lower costs than those of conventional materials (Ingelmo et al., 1998).

In previous studies Guerrero et al. (2002) had shown the feasibility of pine bark and sewage sludge mixtures as substitutes of peat in substrates formulation for growing *P. pinea* and *C. arizonica* plants. *P. pinea* dry weight showed no response to the addition of biosolids as substrate component, but on the other hand, *C. arizonica* dry weight increased significantly with the addition of the organic refuse. Differences in plant height were observed, but their commercial value was the same.

The objectives of this work were (1) to introduce coconut fibre as an alternative substrate for *P. pinea*, *C. arizonica* and *C. sempervirens* growth in container, and (2) to take a further step on the research of growing media for ornamental plants based on pine bark–biosolid mixtures, with an increasing percentage of biosolid in the mixture.

2. Methods

The study was carried out in a commercial nursery devoted to producing conifer plants located near Madrid (Spain), which tested the alternative substrates in real production conditions. According to the data provided by the nearest pluviometric observatory, the annual average precipitation is 451 mm, the annual average temperature 13.8 °C and the annual average potential evapotranspiration is 768 mm.

The irrigation water was classified as good quality water for irrigating pot plants by Waters et al. (1972).

The substrates tested are shown in Table 1, as well as their relative costs. The most expensive component was the coconut fibre, but it was introduced in this study as a request of the nursery, due to its similarities with peat and its increasing use as plant growing media in Spain.

The commercially valuable composted sewage sludge (CSS) was produced from a mixture of sawdust and anaerobically digested sewage sludge (volume ratio of 0.2:1) by the aerated-pile method.

The hydrophysical characteristics of the substrates tested were determined by using the method described by De Boodt and Verdonk (1972) and Bunt (1988) for measuring the water desorption curve of organic substrates. According to this method, Porosity_0 (% v/v) is the total pore space determined at 0-cm water suction, Airspace_{10} (% v/v) is the difference in volume between porosity and the moisture content at 10-cm suction, and $\text{Microporosity}_{100}$ is the moisture content (% v/v) at 100-cm suction. Two intervals of available water (AW) commonly used for horticultural purposes (De Boodt et al., 1974) were also determined. AW_{10-50} (% v/v) is the water released from the substrate when the suction increases from 10 to 50-cm, and AW_{50-100} (% v/v) is the water released from the substrate when the suction increase from 50 to 100-cm water tension.

Electrical conductivity (EC) and substrate pH were determined in the saturated paste extract with an Orion Conductivimeter and an Orion Research Ion Analyzer 920A pH-meter equipped with a pH-glass electrode, respectively, as well as the nutrient content by atomic absorption spectrometry (AA, Perkin Elmer 2800). Total concentration of heavy metals was determined after digestion with 3:1 (v/v) concentrated HCl–HNO_3 (aqua regia) by atomic absorption spectrometry. Total organic matter (TOM) was measured by the dry combustion method at 540 °C, oxidized organic matter (OMox) by the Walkley–Black method (1934) and N by Kjeldahl digestion (Bremmer and Mulvaney, 1982).

Three plant species were grown to evaluate the suitability of the substrates: *P. pinea*, *C. arizonica* and *C. sempervirens*. For each species, the experimental design consisted of six random blocks with 60 plants per substrate grown in 7-l capacity pots. Plants were previously grown in 3-l pots, and transplanted to 7-l pots when they achieved around 75-cm height. All experimental pots were irrigated by aspersion. Two samples were taken in the course of the experiment: the first, six months after transplanting (September 2000) and the second, 12 months after it (April 2001). In each sampling, plant height was determined and three plants per treatment and species were collected. Shoot and root were sepa-

Table 1
Composition of the substrates tested and relative cost

Substrate	Composition	Relative cost
PB + N	Pine bark + 1.5 $g\,l^{-1}$ slow release NPK fertilizer (16:8:12)	39
PB + 15% SSC	Pine bark + 15% (v/v) sewage sludge compost	33
PB + 30% SSC	Pine bark + 30% (v/v) sewage sludge compost	27
F	Coconut fibre	100
F + 15% SSC	Coconut fibre + 15% (v/v) sewage sludge compost	85
F + 30% SSC	Coconut fibre + 30% (v/v) sewage sludge compost	70