Scientia Horticulturae 172 (2014) 155–160

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Evaluation of green/pruning wastes compost and vermicompost, slumgum compost and their mixes as growing media for horticultural production

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ARTICLE INFO

Article history:
Received 30 July 2013
Received in revised form 17 March 2014
Accepted 27 March 2014
Available online 4 May 2014

Keywords:
Physico-chemical properties
Residues
Peat substitute
Production essays
Sustainable plant production

ABSTRACT

Three composts were used as plant growing media: green and pruning wastes compost (GPC) and vermicompost (GPV) and slumgum compost (SLC). Their main physico-chemical and biological characteristics were studied and nine growth substrates were prepared in order to establish production essays for rosemary, Leyland cypress, lettuce, onion, petunia, and pansy. GPC compost and GPV vermicompost had excellent physico-chemical characteristics, allowing them to be considered good substrates. The high E.C. and the low GI values for SLC means that it should not be used in high proportions. However, the high concentration of N could permit its use in suitable fertilizers, especially in Leyland cypress. Rosemary, lettuce and onion were seen the more sensitive species to high dosage of compost. Leyland cypress, petunia and pansies recorded good growth rates with high GPC dosage. Finally, GPV, at a proportion of 25% of the substrate, could be a good sustainable practice for plant production.

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1. Introduction

The E.U. accounts for almost half of the world's production of ornamental plants, which is mostly carried out in containers. The production value of this sector is estimated at € 6379 million, Germany, France, U.K. and the Netherlands being the main producer countries. Increasingly, horticultural seedlings are also produced in containers due to market demands and the many production advantages, including greater production per surface unit, faster plant growth and higher plant quality. Spain is one of the main producers of horticultural seedlings and there are currently 456 companies that produce more than 3152 million seedlings of horticultural species annually (Eurostat, 2012).

Peat is the amendment most widely used in commercial potting substrates for ornamental plants and horticultural seedling production, but this involves the exploitation of non-renewable resources and the degradation of highly valuable peatland ecosystems. In many countries several restrictions have been established for the use of this material owing to environmental concerns and indeed peat has become a somewhat scarce and expensive potting substrates (Lazcano et al., 2009). In Spain alone, 229,188 tons of peat were consumed in 2010 (IGME, 2010). Thus, the search for alternative substrates is crucial.

Compost, as a product of thermophilic processes of organic waste degradation, and vermicompost, as a mesophilic biodegradation product resulting from interactions between earthworms and microorganisms, are both humus-like materials that could act as suitable substitutes of peat (Arancon et al., 2004). Generally after vermicomposting the organic material is reduced to a more uniform size, which gives the final substrate a characteristic earthy appearance while the material from composting normally has a more heterogeneous appearance (Tiquia, 2010). Lazcano et al. (2009) consider that the biological properties of compost and vermicompost could elicit quite different effects in plant growth and morphology. Many studies have attempted to assess the potential of different organic wastes as growing media (Zheljazkov et al., 2009). Some of them only afford good results when they are properly composted: biosolids, sewage sludge, green wastes, pruning residues, olive-mill wastes, etc. (Zaller, 2007). Owing to the high variability of the parameters that characterize the different

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http://dx.doi.org/10.1016/j.scienta.2014.03.048
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composts (pH, electrical conductivity and nutrient content) it is essential to know their physical, chemical and biological properties when they are used as a substrate (Benito et al., 2005).

In this study two different residues were used as plant growing media: green and pruning wastes and slumgum. The annual production of green residue (woody material from pruning, leaves and grass) in the cities of developed countries is more than 20,000 tons per year (e.g., Madrid, Spain) and, as indicated by Kumar et al. (2010) green residues makes up 22–30% of the total municipal solid waste by weight in countries such as Taiwan.

Slumgum is an organic waste from beekeeping enterprises. It appears in the beeswax-rendering process from old scraped honeycombs, which are eliminated every three or four years. Currently, there is no direct use for this material and neither it recycled (Morales-Corts et al., 2010). In countries such as India, the production of this waste is 15,333 tons per year (FAOSTAT, 2012). This waste is dark (brown-black) in color and is mainly composed of brood cocoons, moths and larvae of *Galleria melonella* L., dead bees, excrement, pollen, propolis, and small proportions of non-extractable wax.

Studies carried out by Benito et al. (2005) have addressed the behavior of *Cupressus sempervirens* L. using substrates containing pruning residue compost, obtaining good production results. These authors indicated that more studies with different ornamental species should be performed. No studies about slumgum compost have been cited in literature. Only those carried out by Morales-Corts et al. (2010) using slumgum, without composting, in lettuce and pepper seedling production have been reported.

The aim of the present work was to study the effect of grass and pruning residue compost (GPC) and vermicompost (GPV) and slumgum compost (SLC) at different rates of application as growing media for different ornamental and horticultural crops (*Rosmarinus officinalis*, *Cupressocyparis leylandii*, *Lactuca sativa*, *Allium cepa*, *Petunia* x *hybrida* and *Viola tricolor)*, in order to define the correct mixtures and dosages for the commercial production of these plants.

2. Materials and methods

2.1. Materials

The green and pruning residues came from gardens in the province of Salamanca and were collected by the "Arca" Company, located in the city of Salamanca (Spain). Most of the material corresponded to the leaves and stems of *Cupressaceae* species and grass clippings. Some of these wastes were composted in piles at the factory (GPC). The composting process was carried out using aerated-piles of 15 m by 1 m (sides) and 1.5 m in height. The piles were turned twice per week over eight weeks and once a week during the rest of the bio-oxidative process. Pile moisture was controlled weekly. The composting process lasted 180 days. Another part of the green and pruning wastes was vermicomposted over six months adding *Eisenia foetida* (GPV) in raised soil beds that were constructed in non-controlled green house. Each bed measured 3 m × 1 m × 0.43 m. The slumgum used for composting came from the "Apícolas Fernández" beekeeping company, located close to Salamanca (Spain). The composting process of slumgum (SLC) was carried out in a thermo-composter with 360 l capacity (Florabest, Germany) over six months at the Crop Production Laboratory. The final compost (GPC, GPV and SLC) was passed through a 10 mm sieve.

For crop production essays, nine growth substrates were prepared by mixing commercial peat (P) with different proportions of GPC, GPV and SLC. The main characteristics of the peat, were: pH 6.7, 390 mg L^{-1} N, 130 mg L^{-1} P_2O_5, 305 mg L^{-1} K_2O, 90% OM, 1.15 dS m^{-1} EC (Gramoflor GmbH & Co. KG, Vechta, Germany).

2.2. Physico-chemical and biological characterization of compost and vermicompost

The various parameters were studied following the methods indicated by Aendekerk et al. (2000). Twenty subsamples per compost (SLC, GPC and GPV) were randomically collected, to obtain a composite sample (2.5 kg). Five replications of the composts were analyzed and the means for each of the following parameters were calculated: electrical conductivity (EC) in saturated paste; pH: compost/water, 1/2.5; total organic matter (OM): combustion method at 540 °C (Nelson and Sommers, 1996); bulk density (BD) (Blake and Hartge, 1986); real density (RD) (Klute, 1986); total pore space (TPS) (Wever and Kipp, 1998); moisture content (H): samples were dried at 75° for 24 h; cationic exchange capacity (CEC): ammonium acetate method; total nitrogen (N): Kjeldahl method; total carbon (C) and sulphur (S): with a LECO CNS-2000 device; C-to-N ratio; phosphorus (P): Bray method; potassium (K): ammonium acetate method; total magnesium (Mg), calcium (Ca), iron (Fe), copper (Cu), zinc (Zn), boron (B), manganese (Mn), chromium (Cr), lead (Pb), mercury (Hg), nickel (Ni) and cadmium (Cd): inductively coupled plasma atomic emission spectroscopy (ICP Perkin Elmer Elan 6000 and ICP Yobin Ivon II).

The biological characterization of the composts and substrates was carried out in lettuce and watercress germination bioassays (GI) with aqueous extracts at a ratio of 1:5 (w/v) using the methodology described by Varnero et al. (2007). Five replicates per sample were analyzed. In order to point out the significance of the differences among compost and substrates GI, an ANOVA analysis was carried out. When significant differences ($P < 0.05$) were observed, Duncan's multiple range test ($P < 0.05$) was implemented. The SPSS 17.0 program was used for the calculations.

2.3. Production essays

Nine growth substrates were prepared by mixing peat with different proportions of GPC, GPV and SLC. A peat control was included. T1: 90%P + 10%SLC, T2: 90%P + 10%GPC, T3: 90%P + 10%GPV, T4: 80%P + 15%GPC + 5%SLC, T5: 75%P + 25%GPC, T6: 75%P + 25%GPV, T7: 50%P + 50%GPC, T8: 35%P + 50%GPC + 15%GPV and T9: 100%P.

Crops of *Rosmarinus officinalis* (rosemary), *Cupressocyparis leylandii* (Leyland cypress), *Lactuca sativa* (lettuce), *Allium cepa* (onion), *Petunia* x *hybrida* (petunia), and *Viola tricolor* (pansy) were established in pots using a randomized arrangement with twenty-eight plants of each species and treatment. Pot size was 15 cm diameter and 10 cm height, except for rosemary and Leyland cypress, for 30 cm diameter and 25 cm high pots were used. Lettuce, onion, and petunia were grown for two months (March and April), pansy (September and October), whereas rosemary and Leyland cypress were cultivated for ten months (February–November). Plants were watered by means of a subirrigation system when needed and neither pesticides nor fertilizers were applied before or during the study. The assays were carried out in a greenhouse over two consecutive years (2010 and 2011).

The common parameters evaluated in all species were the chlorophyll level of leaves (SPAD-502, MINOLTA) and root and shoot dry weight. Plants were dried in an oven (P-Selecta-210) at 60 °C for 48 h, and the shoot and root parts were separated and weighed in a precision balance (A&D-ER-120A). For Rosemary and Leyland cypress, plant height and diameter (digital calliper with a sensitivity of 0.01 mm) were also recorded. In the case of lettuce and onion, the germination ratio and the number of leaves were

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