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Compost and vermicompost of horticultural waste as substrates for cutting rooting and growth of rosemary

Daicy Mendoza-Hernández, Fernando Fornes, Rosa M. Belda*

Instituto Agroforestal Mediterráneo, Universitat Politècnica de València, 46022 Valencia, Spain

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ABSTRACT

Peat replacement is an issue that receives much attention in the horticulturist agenda. Several organic materials have been suggested either as substrates or as substrate constituents. This study aims to determine how three such materials, one compost and two vermicomposts, affect the rooting of cuttings and plant growth of rosemary plants grown in pots. The compost (C) and vermicomposts (V1 and V2) were obtained from the same batch of tomato crop waste. Each material was mixed with peat at several proportions. Two experiments were carried out in nursery conditions. In the first, rosemary cuttings were grown in each mix and rooting was quantified. In the second experiment, rooted seedlings were grown in each mix to marketable size (six months after the seedling transplant). The physical, physico-chemical and chemical characteristics of the initial mixes and of the mixes at the end of the six-month experiment were determined. The physical properties of the substrates were within adequate ranges. pH was fairly alkaline, especially in C and salinity was particularly high in the C-based mixes. Soluble mineral contents in C were much higher than in V1, V2 or peat. Mixing with peat produced substrates with intermediate characteristics. Both vermicomposts outperformed compost and peat for rooting cuttings. The presence of hormone-like substances in the vermicomposts might be behind this effect. The vermicompost-based substrates gave acceptable results for growing plants, though none performed as well as the control. Nitrogen and potassium contents in cuttings and ready-for-sale plants were low and phosphorus content was very low compared to sufficiency ranges, which led to a recommendation to increase fertilization. At the end of the six-month experiment, the mix properties had changed, representing an improvement in the substrate quality that might be taken into consideration when transplanting the rosemary to the soil.

1. Introduction

In 2012 Spain exported ornamental plants worth €252 million and the export of trees and shrubs represented €24 million (FEPEX, 2011). Shrubs are produced as ornamental plants for gardening and landscaping both in commercial and governmental nurseries. The standard procedure involves propagation by cuttings in rooting trays which are later transplanted to larger pots, the plants being considered marketable when roots cover the substrate surface inside the pot. Most shrubs will eventually be transplanted to the soil (Handreck and Black, 2005).

The main substrates which nurseries use for shrub production are peat and, to a lesser extent, coconut coir dust. Peat replacement has been promoted in recent years in order to reduce the negative impact on peatlands, which are considered natural heritage and are included in conservation policies. Coir dust is a by-product of the coconut industry but it must be imported to Europe from Indonesia, The Philippines, India, Sri Lanka, Mexico or Brazil. In view of the above, peat and coir dust are being replaced in part by composts and vermicomposts (Abad et al., 2001; Farrell and Jones, 2010). Besides, their use in horticulture is a good way to reclaim organic wastes.

Composting and vermicomposting are procedures to detoxify and stabilize organic wastes. The rendered products, composts and vermicomposts, can be used as substrate or substrate constituents for soilless culture or to amend soils with organic matter. Vegetable crop residues have been successfully recycled through composting (Carrión et al., 2008) and vermicomposting (Srivastava et al., 2011) for horticultural purposes. Composting is an aerobic process which relies on high temperatures and thermophilic and mesophilic bacteria to sanitize, decompose and stabilize the organic material. Vermicomposting involves the use of worms.

* Corresponding author. Tel.: +34 963877000.
E-mail address: rmbelda@bvg.upv.es (R.M. Belda).

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It does not reach high temperatures and the organic material is decomposed by the soil and worm gut bacteria as well as the gut erosion of the material.

Consumers tend to prefer vermicompost to compost but the fact that the former does not allow for high temperatures is a drawback in terms of hygienization of the material (Tognetti et al., 2005). In this sense mixed procedures have been devised, in which the thermophilic phase of composting is followed by standard vermicomposting (Fornes et al., 2012; Yadav et al., 2012).

The original raw material is one of the most significant factors affecting the quality of composts and vermicomposts (Domínguez, 2004; Masaguer and Benito, 2007; Nogales et al., 2007). Nevertheless, most studies that compare composts and vermicomposts do not process the same raw material (Lazcano et al., 2008; Tognetti et al., 2005).

At the end of composting and vermicomposting, the organic matter is stabilized, however, its characteristics may still change during cultivation, which should be taken into account especially if the plants are to be transplanted to soil (Domeño et al., 2011).

One of the main drawbacks to the use of composts as substrate constituent relate to the high salinity of composts obtained from cattle manure or agricultural wastes and to the high heavy metal content of composts obtained from sewage sludge. Composts of agricultural origin (horticultural wastes or olive-mill wastes) tend to have large EC due to high K^+ content, rather than high Na^+ or Cl^- contents. High salinity can be successfully eliminated by leaching. However, the leachates need the appropriate management to avoid pollution (Fornes et al., 2010).

This study aimed first to compare the nursery performance of rosemary (*Rosmarinus officinalis* L.) in one compost and two vermicomposts (one obtained after the thermophilic phase of composting and the other by straight vermicomposting), the materials being produced simultaneously and from the same batch of horticultural waste. The study also aimed to determine the changes in the substrate when plants are ready to be transplanted to soil.

2. Materials and methods

2.1. Compost, vermicomposts and plant material

One compost (C) and two vermicomposts (V1 and V2) were assayed as substrate constituents for plant growth. Composting and the two vermicomposting treatments were carried out simultaneously at the same site, and the raw material for the three was prepared from the same original mix of chopped, air-dried tomato crop waste and ground almond shell in a proportion of 75:25 (v:v).

Composting was carried out using a combined system of Rutgers static pile with forced aeration and controlled temperature plus pile turning (twice during the first month). Two cubic meter piles of raw material were watered at the start of the process and during pile turning. The thermophile stage of composting, during which temperatures rose to 70 °C, ended on day 63. The piles were allowed to rest for another 117 days, at which time the compost was considered mature and stabilized to be used either as growing media, as growing media constituent for soilless horticulture or as soil amendment.

For V1 production, two pre-composted raw mix piles (63 days of thermophilic phase) were transferred to two beds to which *Eisenia andrei* and *Eisenia fetida* worms were added. The final worm population in the mix was approximately 25,000 individuals/m^3. The material was maintained at 25–30 °C and 70–80% humidity throughout the vermicomposting process, which lasted 198 days.

In order to produce vermicompost V2, *E. andrei* and *E. fetida* worms were added directly to 2 m^3 beds of raw material and subjected to the same conditions described for V1 during 261 days.

Cuttings of rosemary (*R. officinalis* L.), about 5 cm in length, obtained from lateral or terminal buds of mother plants, were used in the rooting experiment, and seedlings of rosemary of similar age and size with root ball were used in the pot experiment.

2.2. Experimental design

Treatments consisted of mixing C, V1 or V2 with commercial peat (Kekkilä Ornamental Plant Mix 410, Kekkilä Oy). The three assayed mixes were C:peat, V1:peat and V2:peat in the proportions: 100:0, 75:25, 50:50, 25:75 and 0:100 (control), which totaled 13 treatments.

For the rooting experiment three 72-cell plastic rooting trays (cell volume = 62 mL) were filled with each of the peat mixes and distributed in a random block design.

For the pot experiment, seedlings were transplanted in 550 mL square plastic pots which were filled with each of the peat mixes. Three replicates of five pots each containing a single plant were distributed in a random block design.

2.3. Plant growing conditions

The rooting experiment was conducted in a glasshouse at a commercial nursery (TENISPLANT, S.L.) located in Picassent, Spain. Before placing the cutting in the substrate, its basal zone – 1-cm from cut – was immersed in a commercial indolbutyric acid solution (Flower Hormonas Enraizantes, Codyesa). One cutting per cell was placed in the substrate. Cuttings were irrigated using a microsprinkler system (performance of 36 $L\,h^{-1}\,m^{-2}$) at a regime of 5 min once a day, resulting in 0.6 $L\,tray^{-1}\,day^{-1}$. Rooting and growth results were recorded three months after planting.

The pot experiment was conducted outdoors at the same commercial nursery. Plants were irrigated with sprinklers (performance of 25 $L\,h^{-1}\,m^{-2}$) at a regime of 15 min once a day. Fertilizers were applied by fertigation twice a week with an 8–1–10–1 ratio ($N–P_2O_5–K_2O–MgO$) at a rate of 1.5 $L\,m^{-3}$ of water. This experiment ended when the control plants reached commercial size (roots filled the pots).

The management of both experiments followed nursery standards. The water for irrigation in both experiments was chemically characterized as follows: pH 7.95, EC 180.6 mS/m, $N-NH_4^+$ non-detectable, $N-NO_3^-$ 23 mg/L, P non-detectable, K 8 mg/L, Ca 178 mg/L, Mg 39.4 mg/L, bicarbonates 220 mg/L, sulfates 345 mg/L and Na 64 mg/L.

2.4. Physical characterization of the substrates

Bulk density (D_B) and water capacity (V_{water}) were determined using loosely packed cores and methods from EN 13041 (2011). For this study, steel cylinders measuring 40 mm in height and 82.3 mm internal diameter (210 mL) were used. Shrinkage was calculated as the percentage of bulk volume lost after drying the material contained in the cylinder at 105 °C.

Particle density (D_P) was indirectly estimated from the organic matter content (OM) and the mineral matter content (MM) by applying the equation:

$$D_P(\mathrm{kg\ m^{-3}}) = \frac{100}{\%\mathrm{OM}/1550 + \%\mathrm{MM}/2650}$$

where 1550 $kg\,m^{-3}$ is the organic matter mean density and 2650 $kg\,m^{-3}$ is the mineral matter mean density. Total pore space (P_T) is the percentage of volume of the material that can be filled with water. Air capacity (V_{air}) is the difference – in percentage by volume – between the total pore space and the moisture content at a suction of −1 kPa (EN 13041, 2011).