Evaluation of invasive Acacia species compost as alternative horticultural organic substrates

LUÍS MIGUEL BRITO[1], MÁRIO REIS[2], ISABEL MOURÃO[1], JOÃO COUTINHO[3]

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Abstract

The physical and chemical characteristics of composts of invasive Acacia longifolia and Acacia melanoxylon shrubs were evaluated to identify compost limitations as a substrate component. The bulk density was <0.4 g cm^{-3} and the total pore space was >85% of the total volume. Air capacity, the easily available water and buffering capacity were also within acceptable recommended values for horticultural substrates. With increased composting time the physical characteristics of the composts improved, but the same was not true for chemical characteristics. It is recommended to use these Acacia composts in mixtures with peat which increases the content of organic matter and the C/N ratio, and decreases the pH and the electrical conductivity, of the final substrates.

Introduction

Pine bark and peat moss have traditionally been used as nursery and greenhouse substrates but there has been increasing environmental concerns against the use of peat as a growing media (Jayasinghe et al., 2010) and pine bark is increasingly costly. Invasive Acacia spp. such as Acacia longifolia and Acacia melanoxylon are highly available and after composting could be considered as an appreciable low cost component for plant substrates. Composts may have physico-chemical properties that make them suitable as peat substitutes, and the combination of peat and compost in growing media may be synergistic as peat often enhances aeration and water retention and compost improves the fertilizing capacity of a substrate. The aims of this work were: (1) to evaluate the main physical and chemical properties of Acacia composts as organic amendments and (2) to ascertain the potential use of these composts as an alternative to widely used substrate components such as peat and pine bark, for organic horticultural substrate production.

Material and methods

Two commercial scale conical composting piles (> 100 m^3, 3 m high) consisted of Acacia longifolia (60% v) and Acacia melanoxylon (40 % v) were established in Mira, Portugal (40º25' N 8º44' W). Acacia shrubs were harvested using a high speed grinder , shredded and screened to provide a particle size of <4 cm. Pile A was turned by front-end loader on day 28, 56, 84, 147 and 263 after pile construction and Pile B was turned only on day 28, 147 and 263. Composts with 147 and 420 days were analysed for physical and chemical characteristics. Bulk density (dry material), texture analysis, total porosity and water retention capacity were estimated using the methods of de Boodt et al. (1974), and volume shrinkage according to Martinez (1992). The pH and EC values were determined according to Gabriels and Verdonck (1991) in the aqueous extract 1:2 (v/v). The cation exchange capacity (CEC) was evaluated by the method of Harada and Inoko (1979). The OM content was calculated by the loss of mass on ignition at 450 ºC for 6 h and the TKN content was determined by Kjeldahl method. The total phosphorus (P) content was measured using molecular absorption after digestion with H_2SO_4. The potassium (K) content was measured by flame photometry and calcium (Ca) and magnesium (Mg) by atomic absorption spectrometry, after nitric-perchloric acid digestion. Contents of NH_4^+–N and NO_3^-–N in 2M KCl extracts (1/5 m/v) were obtained by molecular absorption. Statistical analysis was carried out using SPSS 17.0 for Windows (SPSS Inc.). Analysis of variance (ANOVA) was performed with two factors (type of compost and composting time) by the general linear model SPSS procedure, and a probability level of α=0.05 was applied to determine statistical significance between treatment means.

[1]Centro de Investigação de Montanha (CIMO), Escola Superior Agrária, Instituto Politécnico de Viana do Castelo, Refóios, 4990-706 Ponte de Lima. Portugal. E-mail: miguelbrito@esa.ipvc.pt

[2] Faculdade de Ciências e Tecnologia de Gambelas, Universidade do Algarve, 8005-139 Faro. Portugal. E-mail: mreis@ualg.pt

[3] C Química, DeBA, EC Vida e Ambiente, Universidade de Trás-os-Montes e Alto Douro, ap 1013, 5001-911 Vila Real. Portugal. E-mail: j_coutin@utad.pt

Results

The bulk density and real density increased between 147 and 420 days of composting (Table 1) due to OM degradation and the reduction in particle size which took place during composting (Fig. 1). However, the bulk density was always below the maximum of 0.4 g cm^{-3} recommended for use as growing media for ornamental potted plant production by Abad et al. (2001) and the real density of the composts, was within the recommended range (1.4 to 2.0 g cm^{-3}). Total pore space (TPS) of final composts was above 85% of the total volume of the substrate as recommended by Verdonck and Gabriëls (1992). The volume shrinkage of Acacia composts (22 – 26%) was below the limit value considered acceptable for most substrates (Abad et al., 2001).

Table 1. Physical characteristics of Acacia compost with 147 and 420 days of composting with higher (A) and lower (B) turning frequency (n=12).

Parameter	Pile	Day 147	Day 420
		Mean ± *SD	Mean ± *SD
Bulk density (g cm^{-3})	A	0.13±0.01 b	0.24±0.02 a
	B	0.12±0.01 b	0.26±0.02 a
Real density (g cm^{-3})	A	1.67±0.03 c	1.78±0.07 b
	B	1.74±0.05 b.c	1.96±0.08 a
Total pore space (% v/v)	A	92.0±0.8 a	86.5±1.5 b
	B	92.9±0.5 a	86.6±1.5 b
Volume shrinkage (%)	A	24.0±3.1 a	23.1±2.7 a
	B	25.7±3.0 a	21.7±6.6 a

*SD = Standard deviation
Mean values followed by different letters are statically different (P <0.05)

After 147 days of composting there were more particles >5 mm in compost B compared to compost A, and more particles <2 mm in compost A compared to B (Fig. 1). The coarser material of pile B was explained by lower turning frequency in this pile compared with pile A. Turning contributed to an increased degradation of the organic feedstock material, resulting in a smaller particle size in compost A.

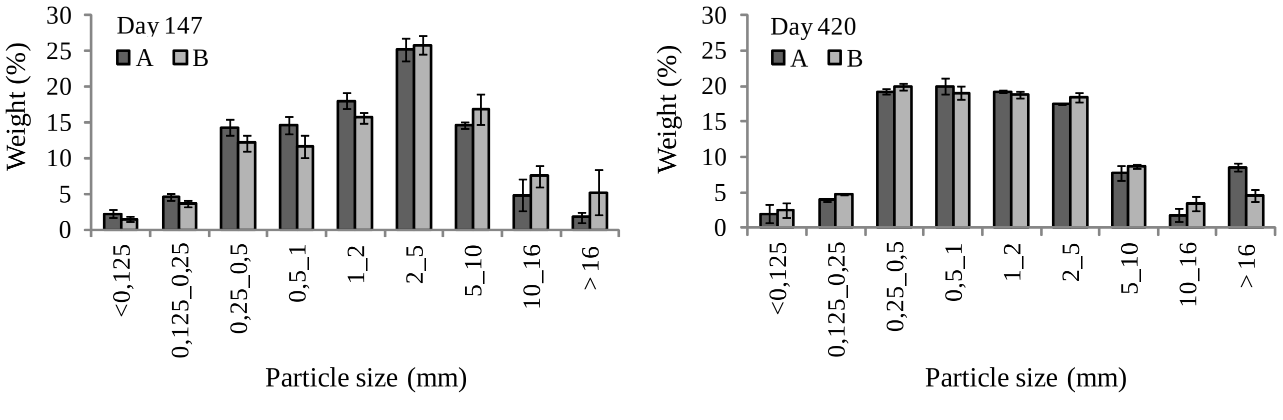
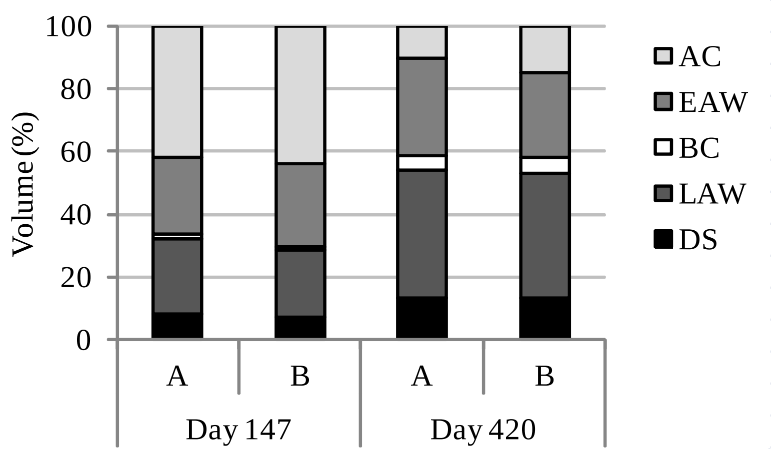


Figure 1. Particle size distribution of Acacia composts with 147 and 420 days of composting with higher (A) and lower (B) turning frequency.

The easily available water (EAW) of composts with 147 days was 24 and 26% and final compost EAW was 31% and 27%, respectively for the compost A and B (Fig.2). Therefore, EAW was above the minimum value of 20% recommended by de Boot & Verdonck (1972). Composts with 147 days buffering capacity (1.3-1.6%) was below the recommended limit of 4%, but rose to values of 5% in both final composts. The total water-holding capacity (TWHC) increased from 49%-50% to 72%-76% between 147 and 420 days of composting. Therefore, final compost TWHC was above the minimum recommended values of 60 % (Abad et al., 2001) and 55% (Noguera et al., 2003) for substrates and close to those reported for peat (Jayasinghe et al. 2010).



AC – Air capacity; EAW – Easily available water; BC – buffering capacity;
LAW – Less available water; DS – Dry solids.

Figure 2. Air capacity, water availability, and dry solids (% v/v) of Acacia composts with 147 and 420 days of composting with higher (A) and lower (B) turning frequency.

The pH was alkaline (7.2 – 7.7) in both composts and dates and above pH values set by Abad et al. (2001) for commercial substrates (5,3-6.5) or established as optimal values (5.2-7.0) for the growth of most greenhouse crops (Herrera et al., 2008). The EC of Acacia composts with 147 days (0.7 – 0.8 dS m^{-1}) increased to 1.0 – 1.2 dS m^{-1} at the end of composting (Table 2), probably as a result of ammonia nitrification. The total N content of final composts A and B was 12.0 and 13.5 g kg^{-1}, respectively. The content of NO_4^+-N was 61 mg kg^{-1} DM in compost A and 120 mg kg^{-1} in compost B. The ratio NO_3^--N/ NO_4^+-N was <1 at the end of the composting period suggesting that the composts were matured (Larney and Hao, 2007) which is a requirement for the use of composts on substrate composition. At the end of composting period the content of phosphorus (P) was similar in both composts (0.8 g kg^{-1} DM) while potassium (K) was 6.6 to 6.1 g kg^{-1} DM for compost A and B, respectively. Calcium (Ca) was the nutrient with higher levels, 27.2 and 32.6 g kg^{-1} in composts A and B respectively. The content of magnesium (Mg) was 2.1 and 2.4 g kg^{-1} DM while the iron content (Fe) was 2.6 and 2.8 g kg^{-1} DM, respectively for compost A and B.

Discussion

Acacia composts were well matured and showed good physical characteristics as partial substitutes for peat, e.g. porosity, air capacity and easily available water within the recommended values for substrates, as well as reduced volume shrinkage and low bulk density. However, these composts showed high values of pH and EC and reduced of OM and C/N ratio that can limit the percentage by which these composts can substitute peat in final substrates. With increasing composting period from 147 to 420 days, the physical properties of the composts improved, but the same did not happen in relation to the chemical characteristics. In further studies, we will evaluate the response of germination, emergence and plant growth in mixtures with increasing rates of Acacia composts in replace of pine bark compost on commercial substrates.

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