From Forest Nursery Notes, Summer 2008

149. Evaluation of municipal solid waste compost as a growing media component for potted plant production. Cendon, Y., Moldes, A., and Barral, M. T. Acta Horticulturae 779:591-597. 2008.

Evaluation of Municipal Solid Waste Compost as a Growing Media Component for Potted Plant Production

Y. Cendón, A. Moldes and M.T. Barral
Departamento de Edafología y Química Agrícola
Facultad de Farmacia, Universidad de Santiago
Santiago de Compostela
Spain

Keywords: compost, substrates, growing media, municipal solid waste

Abstract

Increasing limitations to peat exploitation make it necessary to look for alternative organic materials as constituents of plant substrates. In this work, two municipal solid waste (MSW) composts were evaluated as growing media components for potted plant production, in comparison with *Sphagnum* peat (P) and composted pine bark (CPB). MSW composts showed higher electrical conductivity and pH values, as well as higher cation exchange capacity and nutrient supply potential than P and CPB. Physical properties of the substrates were generally within the recommended ranges for production of ornamental plants, although water capacity at -10 cm suction was slightly low. Substrates were prepared by combining the compost with P or CPB in different proportions (25, 50 and 75% by volume). Plant tolerance to the mixtures was evaluated by means of the cress (*Lepidium sativum* L.) germination test and the spring barley (*Hordeum vulgare* L.) growth test. Poor germination and growth were only observed in substrates with 75% compost, whereas substrates with 25% compost produced higher cress germination and better spring barley growth than P or CPB alone. The MSW composts evaluated can be used in the preparation of substrates, as partial substitutes for peat or composted pine bark, provided that they are not employed in proportions higher than 50%. Using MSW compost for substrate preparation would be economically attractive and would help to conserve finite peat resources.

INTRODUCTION

Soil-less substrates are used in horticulture as well as in the production of ornamental plants in pots. *Sphagnum* peat has been the most widely used growing media constituent, due to its high physical and chemical stability and low degradation rate. Nevertheless, the cost of high quality peat, together with the declining availability of this low-renewable resource, due to environmental pressures, has made it necessary to look for alternative materials. In Europe, efforts are being made to reduce the usage of peat in potting substrates and to increasingly use composts and recycled materials instead. Composts used in growing media should have a high degree of maturity, and adequate physical and chemical properties, such as particle size, porosity, water-holding capacity, air capacity, electrical conductivity and pH. Composting biodegradable MSW produces compost that is commonly used as a soil amendment. MSW compost has also been successfully used in the preparation of growing media (Ingelmo et al., 1998; Castillo et al., 2004). However several factors hinder the use of MSW compost as a constituent of growing media, namely the unpleasant odour, the variability in different batches, deficient quality control and high content of foreign matter. The raw materials as well as the composting process characteristics may influence MSW quality, and therefore the performance of each type of MSW compost should be tested.

The aim of the present work was to evaluate the use of compost made from aerobic and anaerobic transformation of the biodegradable fraction of MSW, in the preparation of substrates for plants in pots, as a peat and composted pine bark substitute, and to determine any limitation to its use.

MATERIALS AND METHODS

Composts were evaluated from two industrial plants which receive previously separated household organic waste. Compost AC manufactured through aerobic transformation was kindly supplied by FCCC, Lousame (Spain). Compost BC, produced through anaerobic wet fermentation followed by an aerobic curing step to stabilize the incomplete digested residue, was kindly supplied by Albada, A Coruña (Spain). Commercial *Sphagnum* peat was supplied by Miksskaar AS (Estonia). Composted pine bark was obtained from a local producer.

Physicochemical Characterization

The physicochemical parameters of different substrates were characterized following the Spanish UNE-EN version of European CEN standards for the analysis of growing media and soil improvers (Table 1). Effective cationic exchange capacity (ECEC) was evaluated as the sum of K, Na, Ca, Mg and Al, after extraction with 1 M NH_4Cl for 14 h. Analyses were carried out in duplicate or triplicate and means are given.

Biological Tests

Substrates were prepared by combining compost with *Sphagnum* peat (P) or composted pine bark (CPB) in different proportions (25%, 50% and 75% v/v). Plant tolerance to the mixtures was evaluated by means of the cress (*Lepidium sativum* L.) test and the spring barley (*Hordeum vulgare* L.) test, following German standards for compost analysis (FCQAO, 1994). The plants remained in the greenhouse for 7 days in the cress test or 10 days in the barley test, at 20ºC with a luminous strength of 2150 lux for 12 h d^{-1} photoperiod. Plants were cut off exactly between the root and stalk at harvesting. The plants were then dried at 105ºC and the shoot dry weight was recorded. Biological tests were carried out in triplicate.

RESULTS AND DISCUSSION

Chemical Properties

Table 2 shows the most relevant chemical parameters of MSW composts, compared with peat and composted pine bark. MSW composts had an alkaline pH, whereas peat showed a strongly acidic pH. Only composted pine bark showed a pH value in the recommended range for substrates (5.3–6.5). Electrical conductivity in 1:10 extracts (EC) of MSW composts was higher than EC values in peat or CPB. Several EC ranges have been proposed as limiting values for plant growth. Gajdos (1997) indicated that EC could be an adverse factor when it exceeded 1–3 dS m^{-1}. Lemaire et al. (1985) reported that EC values above 3.5 dS $m^{-1}$are often too high to support vigorous plant growth in containers.) EC in the MSW composts studied exceeded 2.0 dS m^{-1} recommended for healthy, vigorous plant growth (Wright, 1986), but peat and CPB had EC values under these limiting values. EC has been shown to be an important factor when compost is used as a substrate for horticultural plants and especially seedlings (Sánchez-Monedero et al., 1997). Composts often require leaching or mixing with nutrient-poor material in order to become suitable substrates with better physicochemical properties for container grown vegetables and flowers. Good results have been obtained with composts of different origin by mixing with peat (Nappi and Barbieris, 1993; Sánchez-Monedero et al., 1997; Atiyeh et al., 2001).

Organic matter (OM) contents were lower in MSW than in P or CPB. OM values of MSW composts were well under the 80% OM proposed by Noguera et al. (2003) as an optimum value for substrates, but exceeded the minimum content of 25% OM requested by Spanish legislation for compost. On the other hand, N contents were higher in MSW composts than in P or CPB, rendering C: N ratios 15–16 that are indicative of mature compost. Rosen et al. (1993) have indicated that C: N ratios between 15:1 and 20:1 are ideal for ready-to-use municipal solid waste compost. Ingelmo et al. (1998) obtained optimal results for *Cupressus sempervirens* growth using different substrates with biosolids as a component and with C: N ratios around 25:1.

Effective ca
20 cmol kg^{-1} recor
very low values.
composts (data nc
plants were estima
aqua regia. (Table
substrates include:
(40–199 ppm N-N
Nutrients in the
necessary for opt
nutrient suppliers.
was in the nitrate
BC was in the am
CAT extracts.
Heavy met
legislation for con
be attributed to th
to the recent imple
expect heavy meta

Physical Propert
Although
content at -10 cr
Verdonck (1972)
an ideal substrate
density (<0.4 g cr
et al. (2001) also
and optimum wa
properties were
volume at -10 cm
(2001), even in
amounts to avoid

Biological Prope
Biologica
Working with fix
cress growth in A
(P), whereas the
growth in compo
BC/CPB mixture
and CPB, respect
The resu
reached >100%
of the yield of pe
composted pine
were higher tha
severely restricte
can be prepared
Similar r
growth and deve
the potting med
standard substra
percentage of co
and growth rate
decrease in grow

Effective cation exchange capacity values in MSW composts were higher than the 20 cmol kg^{-1} recommended as a minimum value for substrates, whereas P and CPB had very low values. Calcium predominated in the cation exchange complex of MSW composts (data not shown). Nutrients (P, K, Mg and Fe) that are readily absorbed by plants were estimated in water and CAT extracts, and total nutrients were extracted in *aqua regia*. (Table 3). According to Noguera et al. (1997) chemical properties required for substrates include: high cation exchange capacity (>20 meq/100 g), high nutrient content (40–199 ppm N-NO_3, 3–10 ppm P, 60–249 ppm K, 80–200 ppm Ca and 30–70 ppm Mg). Nutrients in the MSW composts fall within these ranges, providing the nutrients necessary for optimal plant growth, whereas P and CPB were almost ineffective as nutrient suppliers. Most of the mineral nitrogen in the aerobically treated compost AC was in the nitrate form whereas most of the mineral nitrogen in anaerobic treated compost BC was in the ammonium form. Mineral N in P and CPB were low both in water and in CAT extracts.

Heavy metal concentrations were lower than the limit values accepted in Spanish legislation for composts, with the exception of Cu in AC compost (Table 4). This fact can be attributed to the unsatisfactory separation of wastes at the source, which in turn is due to the recent implementation of this solid waste management system. Therefore one could expect heavy metals in MSW compost to decrease in the near future.

Physical Properties

Although total porosity was lower in MSW composts than in P or CPB, water content at -10 cm suction was similar in all the media. According to De Boodt and Verdonck (1972) and Verdonck and Gabriëls (1988) the optimum physical properties for an ideal substrate for plant growth are: high water-holding capacity (20–30%), low bulk density (<0.4 g cm^{-3}), high porosity (>85% v/v), fine texture and a stable structure. Abad et al. (2001) also include a particle density of 1400–2000 kg m^{-3}, air space 20–30% (v/v) and optimum water holding capacity of 55–70% at -10 cm water tension. Physical properties were generally within the recommended ranges (Table 2), except for water volume at -10 cm which was slightly lower than the ideal range proposed by Abad et al. (2001), even in peat. This means that water should be applied frequently and in small amounts to avoid leaching.

Biological Properties

Biological assays give a comprehensive judgement on compost quality (Table 5). Working with fixed proportions of 25, 50 and 75% of MSW compost in the substrates, cress growth in AC/P mixtures represented 151, 90 and 15% of the cress growth in peat (P), whereas the results using AC/CPB mixtures were 141, 140 and 67% of the cress growth in composted pine bark (CPB). On the other hand, cress growth in BC/P and in BC/CPB mixtures was 155, 115 and 0%, and 152, 60 and 0%, of the cress growth in P and CPB, respectively.

The results of the barley test indicate that mixtures with 25% MSW compost reached >100% of the yield of peat, whereas mixtures with 50% compost reached >44% of the yield of peat. Lower yield values were observed in mixtures of MSW compost with composted pine bark (CPB) in comparison with the yields obtained in CPB alone, which were higher than those obtained with 100% peat. The growth of spring barley was severely restricted in substrates with 75% MSW compost. Therefore adequate substrates can be prepared by mixing MSW compost up to 50% with peat or CPB.

Similar results have been obtained by Castillo et al. (2004) who observed that growth and development of tomato seedlings with various fractions of MSW compost in the potting medium were generally equal or superior to plant growth in containers with standard substrates, if the mixes contained 30 percent or less MSW compost. As the percentage of compost in the potting mix increased above 30%, reports of phytotoxicity and growth rate suppression also increased (Ribeiro et al., 2000; Castillo et al., 2004). The decrease in growth rate was attributed to high soluble salt concentration, boron toxicity, poor aeration, compost immaturity and heavy metal toxicity (Shiralipour et al., 1992). García-Gómez et al. (2002) and Ribeiro et al. (2000) have reported that the use of 100% compost as a growing medium had detrimental effects on the vegetative growth of containerized plants, mainly associated with high salt concentration, poor physical properties and phytotoxicity. In the MSW composts studied, the high EC of the MSW composts seems to be the main limiting factor for plant germination and plant growth, although other factors cannot be excluded. Lamanna et al. (1991) evaluated compost-based media as alternatives to peat in pot ornamentals; the cultivation trials gave evidence that in most cases plants obtained using a peat-compost mixture were of a better quality than those cultivated in peat or compost alone. For most of the employed species the quantity of peat can be reduced to 1/3 of the total, obtaining a substrate with optimal physical characteristics. Additionally, there is evidence in the literature which shows that, unlike peat, composts possess plant regulators and properties which suppress soil-borne plant pathogens (Atiyeh et al., 2001).

CONCLUSIONS

It can be concluded that the MSW composts evaluated may be used in the preparation of substrates as partial substitutes for peat or composted pine bark. Mixing peat or composted pine bark will reduce the electrical conductivity of MSW composts while benefiting from the high nutrient content of MSW composts. MSW compost proportions should not exceed 50% by volume of the mixtures. In any case, this depends on the species to be cultivated. Use of MSW compost as a partial peat substitute would reduce ecosystem damage caused by peat extraction and waste accumulation. There are also economic benefits, as the use of residues means lower costs than those of conventional materials.

ACKNOWLEDGEMENTS

This study was supported by the Ministry of Science and Technology of Spain (Project AGL 2003–08958). The authors gratefully acknowledge the analytical assistance of Eva Otero.

Literature Cited

Abad, M., Noguera, P. and Burés, S. 2001. National inventory of organic wastes for use as growing media for ornamental potted plant production: case study in Spain. Bioresour. Technol. 77:197–200.

Atiyeh, R.M., Edwards, C.A., Subler, S. and Metzger, J.D. 2001. Pig manure vermin-compost as a component of a horticultural bedding plant medium: effects on physicochemical properties and plant growth. Bioresour. Technol. 78:11–20.

Castillo, J.E., Herrera, F., López-Bellido, R.J., López-Bellido, F.J., López-Bellido, L. and Fernández, E.J. 2004. Municipal solid waste (MSW) compost as tomato transplant medium. Compost Sci. and Util. 2(1):86–92.

De Boodt, M. and Verdonck, O. 1972. The physical properties of the substrates in horticulture. Acta Hort. 26:37–44.

Federal Compost Quality Assurance Organization (FCQAQ) 1994. Methods book for the analysis of compost. Abfall Now e. V. Publishing House, Stuttgart, Germany.

Gajdos, R. 1997. Effects of two composts and seven commercial cultivation media on germination and yield. Compost Sci. and Util. 5:16–37.

García-Gómez, A., Bernal, P. and Roig, A. 2002. Growth of ornamental plants in two composts prepared from agroindustrial wastes. Bioresour. Technol. 83:81–87.

Ingelmo, F., Canet, R., Ibáñez, M.A., Pomares, F. and García, J. 1998. Use of MSW compost, dried sewage sludge and other wastes as partial substitutes for peat and soil. Bioresour. Technol. 63:123–129.

Lamanna, D., Castelnuovo, M. and D'Angelo, G. 1991. Compost-based media as alternative to peat on ten pot ornamentals. Acta Hort. 294:125–129.

Lemaire, F., Dartigues, A. and Rivière, L.-M. 1985. Properties of substrate made with

spent mushroom

Nappi, P. and Barbe

biological aspect

Noguera, P., Abad,

particle size on

medium. Commu

Ribeiro, H.M., Vas

geranium with a

Rosen, C.J., Halbach

waste componen

Sánchez-Monedero,

Antón, A. 1997.

Compost Sci. an

Shiralipour, A., Mc

composts: a revi

Verdonck, O. and

221:19–23.

Wright, R.D. 1986.

Tables

Table 1. UNE-EN-m

Method (year of pul
13040 (2001)
13041 (2001)
13037 (2001)
13038 (2001)
13049 (2001)
13654–1 (2002)
13652 (2002)
13651 (2002)
13650 (2001)

spent mushroom compost. Acta Hort. 172:13–29.
Nappi, P. and Barberis, R. 1993. Compost as growing medium: chemical, physical and biological aspects. Acta Hort. 342:249–256.
Noguera, P., Abad, M., Puchades, R., Maquieira, A. and Noguera, V. 2003. Influence of particle size on physical and chemical properties of coconut corrí dust as a container medium. Commun. Soil Sci. Plant Anal. 34:593–605.
Ribeiro, H.M., Vasconcelos, E. and Dos Santos, J.Q. 2000. Fertilisation of potted geranium with a municipal solid waste compost. Bioresour. Technol. 73:247–249.
Rosen, C.J., Halbach, T.R. and Swanson, T.R. 1993. Horticultural uses of municipal solid waste components. HortTechnol. 3:167–173.
Sánchez-Monedero, M.A., Roig, A., Cegarra, J., Bernal, M.P., Noguera, P., Abad, M. and Antón, A. 1997. Composts as media constituents for vegetable transplant production. Compost Sci. and Util. 12(2):161–168.
Shiralipour, A., McConnell, D.B. and Smith, D.B. 1992. Uses and benefits of MSW composts: a review and an assessment. Biomass and Bioenergy 3:267–279.
Verdonck, O. and Gabriëls, R. 1988. Substrate requirements for plants. Acta Hort. 221:19–23.
Wright, R.D. 1986. Pour through nutrient extraction procedure. HortScience 21:227–229.

Tables

Table 1. UNE-EN-methods employed in the analysis of substrates.

Method (year of publication)	Parameters
13040 (2001)	Dry matter, water content, compacted bulk density
13041 (2001)	Dry bulk density, air volume and water capacity at -10 cm, total air space
13037 (2001)	pH
13038 (2001)	Electrical conductivity
13049 (2001)	Organic matter and ash content
13654–1 (2002)	N-modified Kjeldahl method
13652 (2002)	Nutrient extraction in water
13651 (2002)	Nutrient extraction in calcium chloride/DTPA (CAT)
13650 (2001)	Elements soluble in *aqua regia*

Table 2. General physicochemical parameters of municipal solid waste composts (AC and BC), *peat* (P) and composted pine bark (CPB) used in this study.

	AC	BC	P	CPB
Moisture (%)	43	30	50	65
pH	8.2	8.4	3.89	6.2
EC (dS m^{-1})	2.42	2.29	0.02	0.37
OM (%)	40	49	99	98
Compacted Bulk Dens. (g L^{-1})	531	417	154	88
Dry bulk density (g L^{-1})	364	341	108	186
Particle density (kg m^{-3})	2066	1972	1558	1563
Total pore space (%)	82	83	93	88
Water Volume at -10 cm (%)	48	48	49	42
Air Volume (%)	34	35	44	46

Table 3. Nutrients extracted in water, Cl_2Ca and $HCl+HNO_3$ (aqua regia). All units are in mg L^{-1}.

	Parameter	AC	BC	P	CPB
H_2O	NH_4-N	8.9	375.8	5.6	2.1
	NO_3-N	35.6	17.9	7.4	2.8
	P	24.9	8.2	0.5	0.4
	K	848	630	2.5	3.3
	Ca	288	253	1.5	0.7
	Mg	53.3	54.9	0.2	0.1
	Fe	51.4	36.23	0.57	0.21
$CaCl_2$	NH_4-N	6.3	618.1	25.0	3.5
	NO_3-N	26.7	35.9	3.7	3.8
	P	200.8	194.7	0.11	0.1
	K	1760.5	1594.4	6.3	22.3
	Mg	465.6	447.9	24.7	13.2
	Fe	458.6	308.2	10.7	2.8
Aqua regia	P	5456	2247	31.7	12.9
	K	2529	877	30.6	77.8

Table 4. Heavy metal
limits in the Spanis

HM (mg kg^{-1})	AC
Zn	1045
Cu	728
Pb	179
Cr	54
Ni	70
Cd	2.8
Hg	0.58

[a]Spanish Ministry of Agricu
131 June 2[th], 1998.

Table 5. Yield (shoot f
P or CPB, in compa

Biological test	
Cress test	A
	B
Spring barley test	A
	B

Table 4. Heavy metal (HM) concentrations in the substrates compared with regulated limits in the Spanish normative for compost.

HM ($mg\ kg^{-1}$)	AC	BC	P	CPB	Regulated limits[a]
Zn	1045	608.5	8.36	69.9	1100
Cu	728	325	0.92	4.5	450
Pb	179	187.9	1.5	13.9	300
Cr	54	80.2	0.69	6.8	400
Ni	70	56.7	0.74	12.3	120
Cd	2.8	3.5	0.1	2.3	10.0
Hg	0.58	0.60	0.003	0.11	7.0

[a]Spanish Ministry of Agriculture. Ministerial Order of May 28[th], on Fertilizers and related materials, B.O.E 131 June 2[th], 1998.

Table 5. Yield (shoot fresh weight) of cress and spring barley in AC or BC mixtures with P or CPB, in comparison with yields in P or CPB alone (100%).

		P			CPB		
Biological test	Compost	25%	50%	75%	25%	50%	75%
Cress test	AC	151	90	15	141	140	67
	BC	155	115	0	152	60	0
Spring barley test	AC	118	91	36	78	68	18
	BC	110	44	0	86	67	14