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The Usability of Sewage Sludge Municipal Solid Waste Compost and Spent Mushroom Compost as Growing Media on the Growth of *Euphorbia Pulcherrima*

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Abstract: The usability of composted sewage sludge, municipal solid waste compost, and spent mushroom compost in different ratios with native peat and perlite as a growing medium for *Euphorbia pulcherrima* were investigated. In the greenhouse experiment, *Euphorbia pulcherrima* were grown in pots containing mixtures of peat and perlite (4:1 v/v). Peat was replaced by organic wastes at the rates of 25 and 50 %. Some physical and chemical properties of the growing media, and horticultural parameters, nutrient elements and heavy metal composition of *Euphorbia Pulcherrima* were determined. The effects of different growing media on plant growth, horticultural parameters and mineral status of *Euphorbia pulcherrima* were found significant. Plant growth was enhanced and several important horticultural parameters, such as dry weight, plant height, leaf number, leaf area bract area and visual performance were improved in plants grown on media containing '1 sewage sludge+3 peat+1 perlite' and '1 spent mushroom compost+3 peat+1 perlite'. Both plant and media analysis showed that 25 % volume of peat was successfully replaced by composted sewage sludge and spent mushroom compost while not diminishing the quality of *Euphorbia pulcherrima*. The mixtures of 25 % composted sewage sludge + peat and perlite was found to be most suitable media based on the physical media parameters. Plant nutrient and heavy metal contents of *Euphorbia pulcherrima* were increased by using composted sewage sludge and municipal solid waste compost, but no detrimental effects were observed on plant growth.

Keywords: Organic wastes, growing media, *Euphorbia pulcherrima*, quality parameters

1. INTRODUCTION

Most ornamental plants produced in containers are grown in media without any mineral soil. Peat is commonly used as a growing medium in ornamental plant production. Increasing demand and rising costs for peat as potting medium in ornamentals have led to search for high-quality, low costs substrates, i.e., organic waste materials such as bark, spent mushroom compost, grape march, municipal solid waste compost and sewage sludge, etc. These organic materials have been introduced as an alternative to peat substrate in potting media after proper composting (Raviv et al., 1986; Chen et al., 1988). Also, these various organic materials have been used for inexpensive and locally available alternative substrates for container crops (Criley and Watanabe, 1974).

Compost from many different origins, like sewage sludge, municipal solid waste have been assayed as substrates, good results often being obtained by mixing with peat (Atiyeh et al., 2001). Raviv et al. (1986) reported that combination of sewage sludge and municipal solid waste compost with other residual materials were worth investigation because negative properties of single materials, such as heterogeneity, high salinity, low content of organic matter, low cation exchange capacity or high content of contaminants can be minimized thus obtaining a sound and cheap substrate.

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While the physical and chemical properties and management required for peat, farmyard manure used in potting media are generally known, something is still unknown for sewage sludge, municipal solid waste compost and spent mushroom compost. These materials contain elements and salts which may be potentially phytotoxic to plant growth (Krauss et al., 1987) and high compost salinity can also be detrimental (Brito, 1990).

The aim of the present work was to determine the effect of sewage sludge, municipal solid waste compost and spent mushroom compost as a peat substitute on the growth of poinsettia plant and to determine any limitation to their use.

2. MATERIALS AND METHODS

2.1. Growing Media

The substrates used as partial substitutes for peat (PT) were as follows:

- Sewage sludge (SS) thermal-stabilized and pelleted, supplied from waste water treatment plant, Kemer -Antalya
- Municipal solid waste compost (MSWC), fully matured, and supplied from solid waste composting plant, Kemer –Antalya
- Spent mushroom compost (SMC) supplied from common mushroom production area of Korkuteli, Antalya, and naturally rain-washed and digested in an open area for 6 months.

Before planting, SS, MSWC and SMC were leached through to avoid salinity damage (4 volume of water per volume of material). Then all materials were air dried, screened through 2 mm and steam pasteurized before filling to pots. Composition of potting media is shown in Table 1.

2.2. Growth Conditions

The experiment was conducted in a controlled-environment greenhouse. Poinsettia plants (*Euphorbia Pulcherrima*) were grown from cuttings rooted by using IBA in a propagation bed consisting of perlite. Rooted cuttings were transplanted on September 1 to plastic pots (16 cm wide and 15 cm deep) containing growing media which were designed in a randomized plot design with 5 replications. All treatments were watered as needed (when 10 % of plants showed the first symptoms of water stress) with deionized water. Irrigation waters were applied in excess, so that leaching with 25 to 30 % of the irrigation waters took place after each application. Basic N-P-K fertilization (175 mg kg^{-1} N, 50 mg kg^{-1} P and 150 mg kg^{-1} K) was applied to all pots. Plants were grown using standard commercial practices after potting in a greenhouse under natural day length conditions; and the experiment was ended on December 15.

2.3. Horticultural Parameters

After cultivation, plant height (measured from the pot rim to the top of plant) and width of all poinsettia plants were determined. Recently matured green leaves were collected from treatments for nutrient and heavy metal analysis. Shoots (remaining leaves, stems and bracts) were harvested at the soil line for dry weight determination. Leaf and bract numbers, total area of leaves and bracts (flowers), dry weights of plants were determined. Total area of all leaves and bracts were measured by using planimeter. Green leaves of poinsettia sampled for mineral analysis were washed with distilled water and dried in a forced air oven at 65-70 ºC for 48 hours. Dry weights were recorded and ground with a hummer-mill for chemical analysis. N was determined by Kjeldahl method. Elemental analysis of the leaves was performed by digestion with HNO_3+$HClO_4$. In wet ashed plant samples, P was determined by spectrophotometrically, and K, Ca, Mg, Fe, Cu, Zn, Mn, Cd, Pb and Ni were determined by atomic absorption spectrophotometry.

2.4. Growing media Analysis

The physical properties (bulk and particle densities, total porosity and air capacity) of the materials were determined according to methods of De Boodt et al. (1973). Electrical conductivity (EC_{25}), pH and water soluble NO_3-N, P and K were determined in a water-soluble extract 1:10

(w/v). Organic matter content was determined by loss on ignition at 430 ºC for 24 h (Navarro et al. 1993). The NO_3-N content of media and also the extractable concentrations of P and K were determined by standart methods (MAFF, 1986). Total nitrogen was determined by Kjeldahl method. Total P was determined by spectrophotometrically and total concentrations of K, Ca, Mg, Fe, Zn, Cu, Mn, Cd, Pb and Ni were measured in media using an atomic absorption spectrophotometer following digestion with a mixture of hydrochloric and nitric acids (3:1 v/v).

The statistical significance of results obtained was assessed by ANOVA test.

3. RESULTS AND DISCUSSION

3.1. Physical and chemical characteristics of the growing media

The main physical and chemical characteristics of the substrates prepared are shown in Table 2. Bulk density and particle density of all the growing media were in adequate levels for an ideal substrate (Abad et al., 2001). The highest bulk density was found in Medium 3 and the highest particle density was found in Medium 5 in which 50 % of peat was replaced by SS and MSWC respectively. All organic wastes used as partial substitutes for peat decreased total porosity and air capacity values. Both total porosity and air capacity of Medium 1 and Medium 2 were in ideal levels.

pH values in the water solution extracts ranged 6.92 to 8.15, the control being the lowest. Electrical conductivities of media were increased by SS, MSWC and SMC used as the partial substitutes for peat. However, electrical conductivity values of all media were found in acceptable levels which were recommended by Dudka et al (1998) as in the range of 0.5-3 dS m^{-1}. Total organic matter was higher than 700 g kg^{-1} in all growing media.

Nutrient contents of the growing media in water soluble extracts have shown variation. In growing media, originated from organic materials, recommended optimum levels for NO_3-N, P and K were 80-139 mg kg^{-1}, 110-179 mg kg^{-1} and 140-219 mg kg^{-1} respectively (Kirven 1986). As these values take into consideration, it is shown that water soluble P and K contents of all media were low. Nitrate content of Medium 2, Medium 3 were found in sufficient levels but NO_3-N levels in the other media were found low. Water soluble NO_3-N, P and K contents in all growing media were increased by the substrates used as partial substitutes for peat.

There were large differences in concentrations of total plant nutrients and heavy metals (Table 3). Replacement of peat by SS and MSWC particularly increased N, P, Mg, Fe, Mn, Zn, Cu, Cd, Pb and Ni levels. Heavy metal concentration of SMC applied media were lower than SS and MSWC applied media. Total element concentrations of media which 50 % of peat was replaced by organic wastes were generally higher than the first replacement level (25 %) of peat. Higher mineral values were found in the sludge-treated media. Although heavy metal contents of SS and MSWC added media were higher than that of the control, the concentrations of regulated trace elements in the media were below the regulatory limits established by EPA (Table 3).

3.2. Poinsettia plant development

The various horticultural parameters measured at the end of experiment are presented in Table 4. Plant dry weight, plant height, numbers of leaves and bracts, total leaf area and total bract area of plants grown in Medium 2 and Medium 6 were higher than that of the others. These results may possibly be due to the great contribution of nutrients by organic wastes (Table 3). Generally, all horticultural parameters of Poinsettia plants grown in Medium 4 were similar to control. Researchers studying sewage sludge and municipal solid waste compost (Ingelmo et al. 1998) in potting mixes for ornamental plants reported that dry weights of plants were increased by waste compost added media. However, plants grown in media that 50 % of peat replaced by organic wastes (Medium 3 and Medium 5) resulted relatively lesser amounts of dry weight, plant height, leaf and bract numbers and leaf and bract areas (Table 4). The reason of this fact can be attributed to depressed physical conditions in organic wastes added media, and higher pH, EC and nutrient contents of wastes, and possibly phytotoxic organic compounds in wastes as described by previous studies (Krauss et al., 1987; Chong et al., 1991).

According to findings and general appearance of plants (colour, brilliance, filling up to pot etc.), it was observed that the best results were both found in Medium 2 and Medium 6 in which peat was replaced by SS and SMC at 25 % rate.

3.3. Plant nutrients and heavy metal contents

Concentrations of N, P, K, Ca, Mg, Fe, Mn, Zn, Cu, Cd, Pb and Ni in plant material grown in media, and also critical nutrient levels of poinsettia (Pennn. State Univ, 2003) are presented in Table 5. According to these limits, nutrient status of plants was generally ranged in normal and high levels. Significant differences in the nutrient concentrations except Ca and in the heavy metal concentrations were observed in the poinsettia plants. The highest N, P, Mg, Fe, Zn, Mn, Cu, Cd, Pb and Ni concentrations were determined in plants grown in SS added media. The highest K contents were observed in plants grown in MSW compost added media, possibly due to the high total K concentration of this material (Table 3). Although all plants were treated with basic fertilization, media- containing organic wastes may have supported slow release of nutrients between irrigations during the growing period and thus resulted in higher mineral contents.

As would be expected, concentrations of metals in peat medium were small and representative of background levels. The concentration of Cd in plant material grown in control medium and SMC added media were small and below the detection limit of analytical apparatus. It is reported that phytotoxic threshold values of Cu, Zn, Cd, Pb and Ni in plant tissue were 20 mg kg^{-1} and 200 mg kg^{-1}, 8 mg kg^{-1}, 35 mg $kg^{-1}$and 11 mg kg^{-1} respectively (Davis and Carlton-Smith, 1980). As would be expected, concentrations of heavy metals in SS and MSWC added media were higher. Cd and Ni contents of Poinsettia showed that the amounts were significantly below the phytotoxic threshold levels. But Pb contents of plants grown in Medium 2 and Medium 3; and Zn, Cu and Pb contents of plants grown in Medium 3 were exceeded critical concentrations. Although concentration of total Pb in Medium 2 was particularly large and plant tissue content exceeded the phytotoxic threshold, there was no observation that plant growth was affected detrimentally. Similar findings were reported by Smith (1992). But in Medium 3 in which 50 % of peat replaced by SS, and total Zn, Cu and Pb concentrations were exceeded critical limits, the horticultural parameters of poinsettia plant were depressed in this medium (Table 5). However, other studies have shown no phytotoxicity problems in agricultural crops supplied with composted sewage sludge due to low availability of metals (Chu and Wong, 1987).

4. CONCLUSIONS

Plants grown in potting media consisting of 1 SS + 3 peat + 1 perlite and 1 SMC + 3 peat + 1 perlite mixtures showed the best results in all horticultural parameters measured. Physical and chemical properties of media in which 50 % of peat was replaced by SS and MSWC were depressed; and plants grown in these media showed an inhibited plant growth as compared with control. All horticultural parameters of poinsettia plants grown in Medium 4 were similar to control. Thus the media which 25 % of peat was replaced by SS and SMC resulted commercially acceptable plants at the end of study. Use of SS and SMC as a growing medium provides an inexpensive peat substitute, as well as a solution for environmental problems of waste disposal. But selection of organic wastes with low levels of contamination is important where these materials are to be used as a recycled compost material.

5. ACKNOWLEDGEMENTS

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6. Literature Cited

[1] Abad, M., Noguera, P., Bures, S., 2001. National inventory of organic wastes for use as growing medium for ornamental potted plant production ; case study in Spain. Biore. Technology, 77, 197-200.

[2] Atiyeh, R.M., Edwards, C.A., Subler, S., Metzger, J.D., 2001. Pig manure vermicompost as a component of a horticultural bedding plant medium: effects on physiochemical properties and plant growth. Biores. Technol, 78, 11-20.

[3] Brito, L.M.C.M., 1990. An analysis of the use of composted sewage sludge and municipal waste as soil amendments on the growth and mineral content of lettuce (Lactuva sative L). Thesis, University of Reading, U.K.

[4] Chen, Y., Inbar, Y., Hadar, Y., 1988. Composted agricultural wastes as potting media for ornamental plants. Soil Science, 145(4): 298-303.

[5] Chong, C., Rinker, D.L., Cline, R.A., 1991. A comparision of five mushroom composts for container culture of ornamental shrubs. Science and Cultivation of Edible Fungi, Meher (Ed), Belkama, Rotterdam.

[6] Chu, L.M., Wong, M.H., 1987. Heavy metal content of vegetable crops treated with refused compost and sewage sludge. Plant and Soil, 103. 191-197.

[7] Criley, R.A., Watanabe, T., 1974. Response of chrysanthemum in four soilless media. Hortscience, 9, 385-387.

[8] Davis, R.D., Carlton-Smith, C.H., 1980. Crops as indicators of the significance of contamination of soils by heavy metals. Water Research Centre, Technical Report TR140, WRd Medmenham, Marlow.

[9] De Boodt, M., Verdonck, O., Cappaert, I., 1973. Method for measuring the water release curve of organic substrates. Proceeding Symp. Artificial Media in Horticulture, 2054-2062.

[10] Dutka, S., Das, K.C., Miller, W.P., 1998. Blends of composted biosolids and bottom ash as potting media to grow ornamentals. Composting in the Southeast, The University of Georgia, Proceedings of the 1998 Conference, September 9-11 Athens, Georgia.

[11] EPA (US Environmental Protection Agency), 1995. A guide to biosolids risk assessments for the EPA Part 503 rule. Office of wastewater management, EPA, 932-B-93-005.

[12] Ingelmo, F., Canet, R., Ibanez, M.A., Pomares, F., Garcia, J., 1998. Use of MSW compost, dried sewage sludge and other wastes as partial substitutes for peat and soil. Biosource Technology, 63, 123-129.

[13] Kirven, D.M., 1986. An industry viewpoint: Horticultural testing is your language confusing. Proc. of Symposium. Interpretation of extraction and nutrient determination procedures for organic potting substrates, 215-217.

[14] Krauss, P., Blessing, R., Korherr, U., 1987. Heavy metals in compost from municipal refuse-strategies to reduce their content to acceptable levels. In: Compost: Production, quality and use. (de Bertoldi, M., Ferranti, M.P., L'Hermite, P., Zucconi, F. Eds). Elsvier Applied Science, London, 254-265.

[15] MAFF, Ministry of Agriculture, Fisheries and Food,, 1986. The analysis of agricultural materials. RB427, HMSO, London.

[16] Navarro, A.F., Cegarra, J., Roig, A., Garcia, D., 1993. Relationships between organic matter and carbon contents of organic wastes. Biores. Technol., 44, 203-207.

[17] Penn. State University Agricultural Analytical Services Laboratory , 2003. Interpretive nutrient levels for plant analysis. Available: hhtp://www.aasl.psu.edu/plant_nutrients.htm [2003, July 31].

[18] Raviv, M., Chen, Y., Inbar, Y., 1986. Peat and peat substitutes as growth media for container-grown plants. In: Developments in plant and soil sciences: The role of organic matter in modern agriculture, eds Y. Chen & Y. Avnimelech. Martinus Nijhoff Publish, Dordrecht, 257-287.

[19] Smith, S.R. 1992. Sewage sludge and refuse compost as peat alternatives for conditioning impoverished soils: Effects on the growth response and mineral status of Petunia grandiflora. J. of Hort. Science, 67(5):703-716.

Table 1. Composition of the growing media

Potting Media	Composition[1] (v/v)	Partial substitutes of substrate for peat (%)
1	4 Peat + 1 Perlite (Control treatment)	-
2	1 SS + 3 Peat + 1 Perlite	25
3	2 SS + 2 Peat + 1 Perlite	50
4	1 MSWC + 3 Peat + 1 Perlite	25
5	2 MSWC + 2 Peat + 1 Perlite	50
6	1 SMC + 3 Peat + 1 Perlite	25
7	2 SMC + 2 Peat + 1 Perlite	50

[1]: MSWC: Municipal solid waste compost; SS: Sewage sludge; SMC: Spent mushroom compost

Table 2. Physical and chemical properties of growing media at the beginning of growth

Media	Bulk Density ($g\ cm^{-3}$)	Particle Density ($g\ cm^{-3}$)	Total Porosity (%)	Air Capacity (%)	pH-H_2O (1:10 w/v)	Electrical conductivity ($dS\ m^{-1}$)	Organic Matter ($g\ kg^{-1}$)	NO_3-N	P	K
								Water soluble ($mg\ kg^{-1}$)		
1	0.101 [1]	1.63	93	22.7	6.92	0.79	788	28	1.56	14
2	0.226	1.74	87	21.6	6.96	1.17	740	88	66	21
3	0.357	1.88	81	16.6	7.01	1.74	710	126	74	24
4	0.178	1.77	81	20.0	7.19	1.86	711	33	22	31
5	0.266	2.074	78	16.6	7.25	1.97	722	39	24	38
6	0.121	1.55	84	19.4	7.96	2.11	757	66	44	19
7	0.185	1.64	79	18.6	8.15	2.77	732	74	51	24
Anova[2]	**	*	*	**	*	**	ns	**	*	*
Ideal Substrate[3]	< 0.40	1.4-2	>85	20-30	-	-	-	-	-	-

[1]: indicated values are means of five determinations; [2]: *: $P<0,05$, **: $P<0,01$, ns: no significance; [3]: Recommended physical properties of an ideal substrate (Abad et al., 2001).

Table 3. Total element concentrations of growing media at the beginning of growth

Media	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	Cd	Pb	Ni
	(%)					($mg\ kg^{-1}$)						
1	0.67 [1]	0.81	0.21	0.39	0.24	114	48	22	11	<0.05	7	1.3
2	1.72	1.66	0.17	0.66	0.41	232	166	290	110	0.92	75	24
3	1.88	1.88	0.12	0.74	0.53	288	219	310	166	1.77	146	56
4	0.87	0.99	0.15	0.41	0.14	144	179	177	88	1.25	49	21
5	0.74	1.07	0.17	0.49	0.17	167	213	196	99	1.88	77	39

6	1.68	1.17	0.21	0.44	0.34	111	135	51	21	<0.05	8	2.1
7	1.77	1.35	0.24	0.51	0.41	125	151	71	32	<0.05	11	3.6
Anova[2]	**	**	ns	ns	*	*	**	**	**	**	**	**
EPA Limits[3]	-	-	-	-	-	-	-	2800	1500	39	840	420

[1]: indicated values are means of five determinations; [2]: *: P<0,05, **: P<0,01, ns: no significance; [3] EPA Limits: Maximum concentrations in an exceptional quality sludge (US EPA,1995).

Table 4. Horticultural parameters for Poinsettia at the end of the experiment, as influenced by media composition

Media	Dry weight (g)	Plant Height (cm)	Plant Width (cm)	No. of leaves	No. of bracts	Total leaf area (cm^2)	Total bract area (cm^2)
1	8.9 [1]	20.8	40.3	39	41	1714	652
2	10.3	24.5	46.7	66	71	2214	996
3	7.6	18.8	41.4	38	44	1425	602
4	8.9	20.6	39.3	40	41	1745	645
5	8.1	16.5	36.0	44	43	1322	622
6	10.2	23.4	44.7	64	67	2154	988
7	8.1	18.5	43.2	44	55	1615	614
Anova[2]	*	*	ns	*	*	**	*

[1]: indicated values are means of five determinations; [2]: *: P<0,05, **: P<0,01, ns: no significance

Table 5. Analysis of nutrient elements and heavy metals concentrations in the leaf tissue of Poinsettia at the end of experiment, as influenced by media composition

Media	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	Cd	Pb	Ni
	%					mg kg^{-1}						
1	3.22 [1]	0.39	2.77	0.79	0.39	103	51	33	9	< 0.05	3	0.5
2	4.48	0.67	2.96	o.81	0.48	217	144	177	18	1.14	66	3.7
3	4.96	0.79	3.07	0.86	0.27	288	216	319	38	2.36	91	4.2
4	3.37	0.40	3.65	0.98	0.27	155	82	88	14	0.66	28	1.7
5	3.65	0.44	3.77	0.89	0.24	185	88	134	18	0.77	32	1.9
6	4.15	0.51	3.15	0.77	0.37	154	79	64	8	< 0.05	4	0.7
7	4.24	0.64	3.44	0.81	0.46	166	81	80	11	< 0.05	5	0.8
Anova[2]	**	*	*	ns	*	**	**	**	**	**	**	*
CC[3]	3.5-4.0	0.15-0.30	1.0-1.5	0.5-1.0	0.2-0.3	50-100	40-60	20-25	1-2	-	-	-

[1]: indicated values are means of five determinations; [2]: *: P<0,05, **: P<0,01, ns: no significance [3] CC(Critical concentrations): Low and normal nutrient levels of poinsettia plant proposed by Penn. State University (2003).