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Full Length Research Paper

The use of hazelnut husk and biosolid in substrate preparation for ornamental plants

Omer Hulusi DEDE*, Gulgun DEDE and Saim OZDEMIR

Department of Environmental Engineering, Engineering Faculty, Sakarya University, 54187 Sakarya, Turkey.

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Ornamental industry demanding large amounts of container substrate which is giving opportunity to recycle agricultural and urban organic waste materials. The study presents the physical and physico-chemical characterisation of hazelnut husk substrates supplemented with biosolid in different proportions (0, 25, 50 and 75%), comparing to the standard peat substrate. In addition, plants were planted into 10 L pots filled with the prepared substrates and cultivated in a glasshouse. On the basis of the research results, it was concluded that physical and physico-chemical properties of hazelnut husk substrates were in the range of optimum, except for the higher dose of biosolid (75%). Furthermore, it was also observed that biosolid mixture with hazelnut husk can be used in the cultivation of ornamental palm tree. The main factor affecting plant growth was higher substrate nitrogen value in higher dose of biosolid application, which is positively correlated with leaf N and plant dry weight. Based on substrate characteristics and plant growth, hazelnut husk and municipal biosolid can be recycle in the ornamental industry as a container substrate.

Key words: Hazelnut husk, substrate, biosolid, compost, peat, palm tree.

INTRODUCTION

Peat and natural soil have been widely used as growing media constituents for the production of ornamental potted plants in Turkey. Predominant potting components in most nurseries are natural sandy soil and animal manure. On one hand, rapid decomposition of animal manure in potting mix causes soil compaction and poor plant growth and this decreases the commercial value of the ornamental plants. On the other hand, too much soil increases weight and creates handling difficulties. For recovering soil compaction, some alternative materials that are being investigated are peat moss, expanded perlite and pumice. Native peat has some problems associated with quality, such as salinity and high pH (Çaycı et al., 1989), while imported peat is rather expensive. The cost of high quality peat for horticultural use together with the declining availability of peat in the near future makes it necessary to look for alternative materials. Moreover, in an effort to recycle and reclaim solid wastes, various organic residues generated by agriculture, livestock farming, forestry, industries and city centres have been successfully used as container media for ornamental plant production (Guerin et al., 2001).

Composted organic wastes are increasing value of growth commercial medium because organic matter and nutrients from organic wastes are recycled. The use of compost as a growth medium component has been considered to reduce fertilizer requirements, improve crop vigour and root growth, and increase the number of flowers per plant (Ingelmo et al., 1998; Garcia-Gomez et al., 2002). Combinations of different organic materials can reduce negative properties of single materials, such as, heterogeneity, salinity, low content of organic matter or low cation-exchange capacity; therefore, obtaining a sound and cheap substrate could be possible (Guerin et al., 2001; Marfa et al., 2002). According to Ingelmo et al. (1998), the cost of substrates supplemented with sewage sludges is lower by 20 to 40% as compared to peat based substrates.

Turkey produces around 500,000 metric tons of

*Corresponding author. E-mail: ohdede@sakarya.edu.tr. Tel: +90 264 2955649. Fax: +90 264 3460633.

Table 1. Physical properties of growing media.

Media	Bulk density (g.cm^{-3})	Particle density (g.cm^{-3})	Porosity (% v/v)	Microporosity (% v/v)	Air capacity (% v/v)	Water holding capacity (ml.L^{-1})
P	0.260^{c}	1.650^{d}	84.08^{b}	17^{e}	36.38^{ab}	592^{bc}
HH	0.205^{d}	1.633^{d}	87.41^{a}	20^{d}	36.91^{a}	697^{a}
HHB1	0.282^{c}	1.739^{c}	83.79^{b}	23^{c}	33.69^{b}	630^{b}
HHB2	0.420^{b}	1.793^{b}	76.55^{c}	28^{b}	22.40^{c}	563^{c}
HHB3	0.494^{a}	1.931^{a}	74.42^{d}	32^{a}	23.97^{c}	507^{d}
LSD	0.0424	0.0424	1.499	2.136	3.116	49.00
ANOVA	***	***	***	***	***	***
İdeal range[a]	<0.4	1.4-2.0	>85	-	20-30	600-1000

***, **, *: p<0.001, 0.01 and 0.05. Values followed by different letters are significantly different for p = 0.05. [a], Bunt (1988), Baran and Zyetin (2003).

Table 2. Chemical properties of growing media.

Media	pH	EC (µS.cm^{-1})	TOM (%)	Total nitrogen (%)	CN (%)	NO_3^-
P	6.83^{d}	355^{c}	79.94^{a}	0.62^{d}	26.70^{a}	7.41^{d}
HH	7.38^{a}	256^{d}	81.24^{a}	1.34^{c}	26.27^{a}	27.40^{c}
HHB1	7.16^{b}	423^{c}	68.11^{b}	1.41^{c}	18.65^{b}	32.20^{b}
HHB2	7.05^{c}	715^{b}	61.75^{c}	1.57^{b}	15.46^{c}	35.00^{b}
HHB3	7.06^{c}	826^{a}	58.81^{d}	1.74^{a}	11.30^{d}	40.30^{a}
LSD	0.09481	130.2	2.097	0.1199	1.090	4.490
ANOVA	**	***	***	***	***	***
Ideal range[a]	5.2-6.3	≤500	>80	-	15-20	100-199

***, **, *: p < 0.001, 0.01 and 0.05. Values followed by different letters are significantly different at p = 0.05. a: Bunt (1988), Baran and Zyetin (2003).

hazelnut annually and one third of that production generates husk. In general, hazelnut husk used to be considered as garbage; thus, was being burned uncontrolled without any beneficial use. In parallel, sewage sludge (biosolid) production in Turkey is increasing and it needs avenues of proper utilization. The landscape and nursery industries are prime candidates for using these products if only the materials meet high quality standards. The conversion of hazelnut husk and biosolid into value-added compost may have the potential to improve productivity of the ornamentals and to reduce environmental pollution. It is obvious that incorporation of composted organic materials into soil and nursery media provides environmental and economic benefits.

In this study, the objectives are: (1) to introduce locally or regionally available hazelnut husk and biosolid as an alternative substrate for container grown ornamentals, (2) to determine the suitability of hazelnut husk-biosolid mixtures for the plant growth and, (3) to improve waste-management practices of hazelnut husk and biosolids, thereby, to enhance environmental protection.

MATERIALS AND METHODS

Harvest residue of hazelnut husk was collected from local farms as air dried, and grounded in a crushing machine to obtain particule size of 0 to 10 mm. Sewage sludge was obtained from local municipal wastewater treatment plant in the city of Sakarya, Turkey.

The two materials were thoroughly mixed by volume of 100, 25:75, 50:50 and 75:25% as grounded hazelnut husk and sewage sludge. The initial moisture content of mixtures were aranged to 50% by adding water particularly in treatment containg higher hazelnuthusk, and composted in a 50 L black plastic bag for experimental use. Fermentation of the mixtures continued for 90 days while being turned over for aeration once a week. After composting, mixtures were allowed to mature for 5 months until it was used for substrate characterizarion and plant growth experiments. Commercial peat was also tested as control. Control pots were filled with 100% commercial soilless mixture consisting of 70% peat and 30% perlite.

Physical properties of the samples (Table 1) were determined by using the methods described by Verdonck and Gabriels (1992).Dry weight determination was performed at 105°C until the constant weight was achieved. Total organic matter in different substrates (Table 2) were determined by the dry combustion method at 540°C (Nelson and Sommers, 1982). Substrate pH and electrical conductivity (EC) were measured in saturated extracts. After water extraction, NO_3^--N content was measured colorimetrically on a spectrophotometer. Total concentration of heavy metals were determined after digestion with 4:1 (v/v) concentrated perchloric acid ($HClO_4$) and nitric acid (HNO_3) (aqua regia) by inductively coupled plasma (ICP) and optical emission spectroscopy (OES) (Shen et al., 2002). Nitrogen in substrates and plants were determined using the method by the Kjeldahl digestion (Bremmer and Mulvaney, 1982).The suitability of the hazelnut husk as a potential growing media was studied in a pot experiment using palm tree young plants (*Washingtonia robusta*). Palm tree shows

Table 3. Physical and chemical properties of biosolid.

Parameter	Value
Bulk density (g.cm^{-3})	0.698
Particle density (g.cm^{-3})	1.862
Porosity (% v/v)	61.45
Air capacity (%v/v)	36.71
Water holding capacity (ml.L^{-1})	269.8
pH	6.7
EC (µS.cm^{-1})	1826
TOM (%)	56.43
TN (%)	3.62
CN ratio (%)	14.35

vigorous plant growth when it is grown on high nitrogen and organic matter substrates in our experience (Ozdemir et al., 2004). Surface sterilized palm seeds were germinated in petri dishes in a germination cabinet. Seedlings with 1 cm shoot length were sown in 0.25 L pot filled with five different prepared media (10 replicates) (Table 2). 45 days after sowing, five plugs with same growing degree were transferred into 10 L plastic pot containing same substrate. Control mix and 100% hazelnut husk treatments were fertilized before planting with a slow-release fertilizer (15:9:9 + micronutrients) (Osmocote Plus, 3 to 4 months) at a rate of 1.5 kg.m^{-3} substrate. The pots were hand-watered as needed (2 to 3 times a week). The experiment was run in a plastic greenhouse, starting on 1 May 2004 until 30 November 2004 when the plant growth had stopped. At the end of the growing season, the following parameters were measured from each replicate: height and stem diameter 10 mm above the medium, fresh and dry weight. Elemental analysis of N in leaves was also used to evaluate plant nutrition from each replicate.

Measured data for the growing medium and plants were analyzed statistically using analysis of variance (F-test) and means of the treatments were compared by the Least Significant Difference (LSD) at $P = 0.05$.

RESULTS AND DISCUSSION

Some physical and chemical properties of the growing media are given in Tables 1 and 2. Bulk and particle density were slightly higher in commercial peat than in hazelnut husk because of the perlite in peat. Bulk and particle density was increased gradually with the increasing rate of biosolid addition to hazelnut husk. As expected, biosolid addition decreased the total porosity and water holding capacity because of high inorganic content of biosolid (Table 1), but these values were still in acceptable range as proposed by Bunt (1988). The physical properties of the peat and pure hazelnut husk were similar to (Table 1) and adequate for ornamental plants according to Bunt (1988). Mixtures of hazelnut husk and biosolid showed higher micro porosities than the peat or pure hazelnut husk, which indicates improved rewettability of substrates due to an increase in their water holding capacity and as well as resistance to drainage (Beardsell and Nichols 1982). Acceptable level of physical properties of hazelnut husk compost has also been noticed by Baran and Zeytin (2003).

Physical and chemical properties of biosolid were given in Tables 3 and 4. The heavy metal concentrations of biosolid were much lower than the limits recommended by both EU and US EPA regulations as indicated in Table 4. The addition of the biosolid slightly increased the electrical conductivity of the mixtures, but did not exceed the acceptable range for container substrates in the highest application rate (Table 2). The low EC level of hazelnut husk improved the EC of the mixture even in the highest biosolid application rate. pH was found to be around 7.0 in all mixtures (Table 2), which is normal for the container substrate (Abad et al., 2001). On one hand, increasing rates of biosolid addition to the mixtures decreased the total organic matter content, as evidences in previous studies suggested (Ingelmo et al., 1998; Hernandez-Apaolaza et al., 2005). On the other hand, the addition of biosolid increased the total nitrogen and NO_3^- content of the mixtures and the highest value corresponded to 25% hazelnut husk + 75% biosolid mixture (Table 2). Total nitrogen in pure hazelnut husk was also higher than the peat. The related literature suggest that the optimum C/N ratio for container substrate is generally considered to be around 25:1 to 15:1 (Rosen et al., 1993). In this study, C/N ratio of pure hazelnut husk was not as high as compared to the peat or bark compost due to the higher nitrogen content; furthermore, biosolid addition to hazelnut husk significantly reduced this parameter below the optimal values in 75% biosolid addition (Rosen et al., 1993; Ozores et al., 1998).

Effect of the different growing media on the growth and nitrogen state of palm leaves were given in Table 5. At the end of the growing season (after 7 months), the height of Washingtonia palm plants was found to be similar in all substrates, ranging from 49.62 cm in peat to 51.66 cm in hazelnut husk + biosolid (1:1 v/v). Although the difference in plant height was not significant, increasing rates of biosolid addition increased the stem diameter. The largest fresh and dry weights of plants were obtained in the following mixtures: hazelnut husk (50%) + biosolid (50%), and hazelnut husk (25%) + biosolid (75%) (Table 5). These results may be due to greater nutrient contribution by biosolid (Table 2). Similar results were found in container grown woody ornamentals with increasing proportions of biosolid in the substrates (Ozdemir et al., 2004; Hernandez-Apaolaza et al., 2005).

For container substrate, recommended rate of biosolid in mixture ranges was between 10 and 30% due to the contribution of soluble salts of biosolid. However, there are studies indicating good growth of several woody species in media with initial EC values exceeding 8 mS cm^{-1} (Hernandez-Apaolaza et al., 2005; Guerrero et al., 2002). When waste composts are added in the mixture, the initial EC is generally higher than optimum, but EC decreases during growth/culture since soluble salt leaches out. In this study, EC was slightly higher than optimum in 50 and 75% biosolid additions, but no adverse effect was observed in plant growth. This is

Table 4. Heavy metals values of biosolid and comparison with the EU standards.

Heavy metal	Values of heavy metals ($mg.kg^{-1}$)	EU standards* ($mg.kg^{-1}$)	US EPA** ($mg.kg^{-1}$)
Zn	1350	2500 - 4000	2800
Cu	16.2	1000 - 1750	1500
Cr	251	-	1200
Pb	32.5	750 - 1200	3000
Ni	75	300 - 400	420
Cd	2.4	20 - 40	39
Fe	13478	-	-

*Directive 86/278/EEC(1986); ** US EPA (1993) Part 503

Table 5. Effect of the different growing media on the growth and nitrogen state of palm tree leaves.

Media	Plant height (cm)	Stem diameter (cm)	Fresh weight (g/plant)	Dry weight (g/plant)	Leaf N content ($g.kg^{-1}$)
P	49.62	1.334^{b}	58.25^{c}	15.85^{b}	15.50^{b}
HH	49.78	1.349^{b}	63.36^{b}	17.48^{b}	16.24^{b}
HHB1	50.46	1.374^{b}	$61.56b^{c}$	17.05^{b}	16.41^{b}
HHB2	51.66	1.526^{a}	102.40^{a}	25.21^{a}	20.26^{a}
HHB3	51.54	1.522^{a}	102.30^{a}	24.35^{a}	21.20^{a}
LSD	-	0.05996	4.893	2.55	1.013
ANOVA	-	***	***	***	***

***, **, *: $p<0.001$, 0.01 and 0.05. Values followed by different letters are significantly different at $p = 0.05$.

probably because of the fact that EC of the mixture was reduced during growth period. Visual inspection showed that the plants treated with biosolid appeared to be darker green and had broader leaves than those treated with the Osmocote in commercial peat and pure hazelnut husk. In general, there were higher levels of nitrogen in plants amended with biosolid than in those treated with Osmocote, which might explain the darker green colour of the plants in the biosolid treatments (Table 5).

Conclusion

Due to their physical and chemical properties, substrates prepared from the hazelnut husk and biosolid can be considered as an alternative to peat and soil substitutes. Based on the results of this study, hazelnut husk appears to be a suitable alternative to peat for the formulation of substrates for the production of container-grown ornamental plants. The growth experiments showed that hazelnut husk required a nutrient-richer material mixture for better yields. For substrate properties and waste recycling, the mixtures with 1:1 hazelnut husk+biosolid might be one of the most convenient substrates to use. Using hazelnut husk and biosolid as alternative substrates to peat will contribute to resolving the problem of local waste management.

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