Potential of composted biodegradable municipal waste in seedlings production

Želimir Vukobratović[1], Marija Vukobratović[1], Zdenko Lončarić[2], Renata Erhatić[1]

[1]College of Agriculture at Križevci, 48 260 Križevci, Croatia

[2]Faculty of Agriculture, J. J. Strossmayer University, 31 000 Osijek, Croatia

Presenting author email: zvukobratovic@vguk.hr

Presenting author address: Visoko gospodarsko učilište u Križevcima, M. Demerca 1, 48 260 Križevci, Croatia

Abstract

The experiment was conducted during 2013 in a randomized block design with three replications. The treatments were: a biodegradable composted municipal waste (BMW), BMW with a foliar nutrition of seedlings using a liquid fertilizer NPK 10:5:4 supplemented with trace elements (BMWT) and commercial substrate Klasmann (CS) as a control. Chemical analysis showed that the pH reaction of BMW compost was alkaline (pH = 7.82), containing 23.83% of organic carbon, with a good nitrogen content (1.98%) and a low content of phosphorus (P_2O_5=0.775%) and potassium (K_2O=1.18%). CN ratio was 14.91 and did not contain impermissible concentrations of heavy metals. In order to detect phytotoxcity, a germination test was performed using endive (*Cichorium endivia*

L.). Germination index was calculated according to Tiquia and Tam (1998). Plant growth parameters were measured 35 days after sowing, when the transplants approximately reached the commercial transplanting size, each experimental unit containing 45 plants. Based on preliminary research, it can be concluded that the compost from biodegradable municipal waste can be used in the production of seedlings, since there are no inhibitory effects on germination, seedling growth and development of endive as sensitive plant species. Compost from this waste will certainly be more frequently used in the production of seedlings of flowers than of vegetables, so the future research should be directed towards detecting their possible sensitivity.

Keywords: biodegradable municipal waste, compost, properties, endive, suitability

Introduction

The Law on sustainable waste management in the Republic of Croatia (Official Gazette 94/2013) specifies the maximum permissible weight of biodegradable municipal waste that can be disposed annually at the landfills. By 31st December 2016 this mass must be reduced to 50% of biodegradable municipal waste produced in 1997, and by 31st December 2020 to just 35%. Biodegradable waste includes mostly branches, grass, leaves, flowers and weeds, as well as remains of vegetables and fruits. Units of local government are obliged to secure a service of separate collection of biodegradable

municipal waste in their area in a high quality, stable and economically efficient way which is in accordance with the principles of sustainable development, environmental protection and waste management.

Disposal of biodegradable waste is possible in the following ways: composting (Belyaeva and Haynes, 2009; Gabhane et al., 2012.), digestion (Johari et al., 2012) or conversion into energy. The easiest and cheapest way is composting and therefore many of local governments choose exactly that procedure. This mode of disposal can produce compost which can be placed on the market to cover part of the costs incurred by separation, transportation and disposal. At the same time a significant contribution to the preservation of the environment is achieved, because the application of compost increases soil fertility, reduces the need for fertilizers, and reduces the exploitation of peat. Exploring the composted municipal solid waste as an organic soil additive when applied in field suggested that it can be used in agricultural production, improving soil physicochemical properties (Kuo et al., 2004; Tzortzais et al., 2012; Chrysargyris et al., 2013).

This compost can be used as a substrate for the cultivation of seedlings or for the production in greenhouses. Little information is available regarding the use of the composted municipal solid waste as a peat alternative for nursery production of horticultural crops and most studies have focused on ornamental potted plants, woody shrubs and trees (Fitzpatrick et al., 1998; Grigatti et al., 2007; Tian et al., 2012; Chrysargyris et al., 2013)

The quality of the substrate depends on its physical and biological properties, which have not been analysed in composted biodegradable municipal waste in Croatia until now. The aim of this study was to determine the suitability of composted biodegradable municipal waste in the production of seedlings.

Materials and methods

The experiment was conducted during 2013 in a randomized block design with three replications. The treatments were: a biodegradable composted municipal waste (BMW), BMW with a foliar nutrition of seedlings using a liquid fertilizer NPK 10:5:4 supplemented with trace elements (BMWT) and commercial substrate Klasmann (CS) as a control. BMW was produced under the program of separate collection and disposal of organic waste. Composting material is made from: waste from households and waste from public areas (parks), markets and cemeteries. Composting was done using the windrow system in compost heaps of pyramidal shape sized 1.5x2x2 m with machined mixing and wetting. The compost used in the experiment was aged one year.

Chemical analyses of compost: moisture content was determined using 5 g samples at 105 ^{o}C until constant weight, organic matter was determined for total solids at 550 ^{o}C for 4 h (AOAC, 2000), pH in water slurries 1:10 w/v and EC in water slurries 1:5 w/v (Tiquia i Tam, 2000). The following analyses were done in dry samples: total nitrogen was

measured using the Kjeldahl method, concentration of total P by spectrophotometric, K, Ca and Mg (from the basic solution of ash), K by flame photometry and Ca and Mg with atomic-absorption spectrometry. Content of micronutrients and heavy metals was analysed by aqua regia destruction of dry sample (Thompson, 2001.), and spectrometry was used to determine the concentration of individual elements – AAS for Fe, Mn, Zn, Cu, and ICP-OES for Ni, Cr, Cd, Pb and Hg.

In order to detect phytotoxcity, a germination test was performed using endive (*Cichorium endivia* L.). Containers with 160 holes were filled with a substrate, and each treatment was performed in three replicates. The number of germinated seeds was controlled daily. Fertilizing on treatment BMWT was conducted once a week over four weeks, using a liquid fertilizer NPK 10:5:4 supplemented with trace elements (B, Cu, Fe, Mn and Zn). Germination index was calculated according to Tiquia and Tam (1998). Plant growth parameters were measured 35 days after sowing, when the transplants approximately reached the commercial transplanting size, each experimental unit containing 45 plants. The above-ground parts of plants were separated from the roots and gently washed many times with tap water and then finally with deionized water. The following measurements were performed on transplants: seedling height (h), lives height (LH), seedling FM weight per plant (w), FM root weight (RW), number of leaves (n).

Chemical analyses of plant tissues: samples were dried at 70 ° C to constant weight, total nitrogen was measured using the Kjeldahl method, phosphorus was determined by

spectrophotometry using ammonium molybdate and potassium by flame photometry directly from the filtrate.

The results of analysis of manures and compost were statistically analysed by SAS PC applications for Windows (SAS Institute Inc., Cary, NC, USA).

Results and discussion

Results of chemical analysis of composted biodegradable municipal waste and total nutrients and trace elements contents are shown in Table 1 and Table 2 respectively.

Table 1: Chemical properties of composted biodegradable municipal waste

	moisture (%)	OM (%)	pH (1:10)	EC (dS m^{-1})	TKN	TOC	P_2O_5 (%)$_{dm}$	K_2O	Ca	Mg
BMW	36.90	41.22	7.82	1.61	1.98	23.83	0.775	1.18	3.82	0.73

[dm] dry matter

Table 2: Total nutrients and trace element contents in composted biodegradable municipal waste

	Fe	Mn	Zn	Cu	Cd	Pb	Ni	Cr	Hg

					(mg kg^{-1})				
BMW	1423	482	113	36.3	1.02	21.33	13	14.9	0.066
LV			200-300	60-100	1-2	100-150	50-60	60-100	1-2

LV = limit value for use of substrate for seedlings

Chemical analysis showed low water content, pH reaction was alkaline (pH = 7.82), containing 23.83% of organic carbon, with a good nitrogen content (1.98%) and a low content of total nutrients which was indicated also with low EC value (1.61 dS m-1). Although, according to many researchers (Tam and Tiquia 1994, Miller, 2001; Kuo et al., 2004, Herrera et al., 2008) pH and EC are the parameters which are the most frequent causes of inappropriateness of a substrate for container production, in this case these will not pose a problem. CN ratio is 14.91 and does not contain impermissible concentrations of heavy metals, according to the National Ordinance about the Protection of Agricultural Land from pollution (OG 32/10).

Index of emergence was very frequently used in literature as a parameter for determining the maturity of the compost. Index of emergence, in addition to the percentage of germination, also uses the length of the plant including the root (Tiquia 2003, Kotaro et al., 2005). The results (Table 3) show that the substrate had no effect on the germination percentage, while the value of the GI and the length of the roots were smaller in BMW

than in CS. Carmona et al (2012) obtained similar results, by exploring suitability of compost for the growth of seedlings of lettuce, tomato, pepper and melon.

Table 3: Mean percentage of germination, root length and germination index (GI) in endive (*Cichorium endivia* L.) seedling

Substrates	Germination (%)	Root length (mm)	GI (%)
BMW	80	32,0	75.09
CS	80	37,0	86.64

Largest average length of leaves, seedlings weight and number of leaves were achieved in CS and significantly lower values were observed in the compost from biodegradable municipal waste. Foliar fertilization had no effect on the mentioned properties (Table 4). Type of substrate had no statistically significant effect on the length of the plant. Similar results are displayed by the Carmona et al. (2012) and Tian et al. (2012), while Chrysargyris et al. (2013) reported that none plant was sprung up on municipal solid waste compost used as growing medium for melon seedlings production.

Table 4: Morphological properties of the endive seedling 35 days after sowing: seedling height (h), lives height (lh), seedling FM weight per plant (w), root FM weight (rw), number of leaves (n)

Substrates	h (cm)	lh (cm)	w (g)	rw (g)	n
BMW	18.97^{ns}	10.47 ^{B}	2.64 ^{B}	0.776 ^{B}	3.80^{ns}
BMWT	18.92	10.25 ^{B}	2.31 ^{B}	0.638 ^{A}	3.80
CS	19.49	11.95 ^{A}	2.87 ^{A}	0.682 ^{A}	4.07
LSDp=5%		0.809	0.072	0.055	
LSDp=1%		1.338	0.120	0.091	

^{AB} statistically significant difference of values in columns which doesn't contain same letter

Chemical analysis of the plant tissue (Table 5) indicates that there were significant differences in dry matter content of seedlings grown on a commercial substrate compared to seedlings grown on compost from biodegradable waste. Transplants from CS had a significantly smaller dry matter content than seedlings from BMW but higher than on BMWT. The nitrogen concentration (N %) in the leaves on BMWT was significantly higher than on the other two treatments, while root on CS had a significantly higher N % only than on BMW. The percentage of potassium in leaves on BMWT and BMW was significantly higher than on CS, while, in the roots, there was significantly more

potassium in seedlings on BMWT than on other substrates. Also BMW produced root with significantly higher potassium percentage than CS.

Table 5: Chemical properties of the endive seedling 35 days after sowing; dry matter seedling with root (DM)

substrates	DM	Leaves			Root		
	(%)	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)
BMW	11.81 ^{A}	1.10 ^{B}	0.19^{ns}	3.67 ^{B}	0.50 ^{B}	0.12^{ns}	1.35 ^{B}
BMWT	10.02 ^{C}	1.37 ^{A}	0.23	4.08 ^{A}	0.58 ^{AB}	0.16	1.49 ^{A}
CS	10.91 ^{B}	1.15 ^{B}	0.21	1.56 ^{C}	0.63 ^{A}	0.14	0.77 ^{C}
LSDp=5%	0.714	0.128		0.123	0.082		0.120
LSDp=1%	1,182	0.211		0.204	0.136		0.199

^{AB} statistically significant difference of values in columns which doesn't contain same letter

Conclusion

Based on the preliminary research, it can be concluded that the compost from biodegradable municipal waste can be used in the production of seedlings, since there is no inhibitory effects on germination, seedling growth and development of endive as

sensitive plant species. Compost from this waste will certainly be more frequently used in the production of seedlings of flowers than of vegetables, so the future research should be directed towards detecting their possible sensitivity.

References

Belyava, O.N., R.J. Haynes (2009): Chemical, microbial and physical properties of manufactured soils produced by co-composting municipal green waste with coal fly ash, Bioresource Technology 100: 5203-5209

Carmona, E., M.T. Moremo, M. Aviles, J. Ordovas (2012): Use of grape marc compost as substrate for vegetable seedlings. Scientia Horticulturae, 137:69-74

Chrysargyris, A., Saridakis, C., Tzortzakis, N. (2013): Use of Municipal Solid Wasre as Growing Medium Component for Melon Seedlings Production, Journal Plant Biology and Soil Health, 1 (2): 5

Fitzpatrick, G.E., Duke, E.R., Klock-Moore, K.A. (1998): Use of compost product for ornamental crop production: research and grower experiences. HortScience 33: 941-944

Gabhane, J., SPM Prince William, R. Bidyadhar, P. Bhilawe, D. Anand, AN. Vaidya, S.R. Wate (2012): Additives aided composting of green waste: Effect on organic matter degradation, compost maturity, and quality of the finished compost, Bioresource Technology 114: 382-388

Grigatti, M., Giorgioni, M.E., Ciavatta, C. (2007): Compost-based growing media: Influence on growth and nutrient use of bedding plants. Bioresource Technology 98: 3526-3534.

Herrera, F., Castillo, J.E., Chica, A.F., Lopez-Bellido, L. (2008): Use of municipal solid waste compost (MSWC) as a growing medium in the nursery production of tomato plants. Bioresource Technology 99: 287-296

Johari, A., S.I. Ahmed, H. Hashim, H. Alkali, M. Ramli (2012): Economic and environmental benefits of landfill gas from municipal solid waste in Malaysa, Renewable and Sustainable Energy Reviews, 16: 2907-2912

Kotaro, K., Nobuaki, M., Hiroyasu, T., Ichio, N. (2005): Evaluation of maturity of poultry manure compost by phospholipid fatty acids analysis. Biol. Fertil. Soils 41: 399-410.

Kuo, S., Ortiz-Escobar, M.E., Hue, N.V., Hummel, R.L. (2004): Composting and compost utilization for agronomic and container crops. Recent Res. Devel. Environmental Biology, 1:451-513.

Miller, M. (2001.): Fulfilling special needs of nurseries. BioCycle. 4: 55-59.

Tam, N.F.Y. and Tiquia, S.M. (1994.): Assessing toxicity of spent pig litter using a seed germination technique. Resources, Conservation and Recycling, 11: 261-274.

Thompson, W.H. (ed.) (2001.): Test Methods for the Examination of Composting and Compost. The United States Composting Council Research and Education Foundation. The United States Department of Agriculture.

Tian, Y., Sun, X., Li, S., Wang, H., Wang, L., Cao, J., Zhang, L. (2012): Biochar made from green waste as peat substitute in growth media for *Calathea rotundifola cv. Fasciata*. Sciencia Horticulturae, 143, 15-18

Tiquia, S.M., Tam N.F.Y. (1998): Elimination of phytotoxicity during co-composting of spent pig-manure sawdust litter and pig sludge, Bioresource Technology 65: 43-49.

Tiquia, S.M. (2003): Evaluation of organic matter and nutrient composition of partially decomposted and composted spent pig litter. Environmental Technology, 24: 97-

Tzortzakis, N., Gouma, S., Paterakis, C., Manios, T.(2012): Deployment of municipal solid wastes as a substitute growing medium component marigold and basil seedlings production. ScientificWorldJournal 201: 285874