USE OF COMPOSTED MANURE AS SUBSTRATE FOR LETTUCE AND CUCUMBER SEEDLINGS

Marija Vukobratović[1], Zdenko Lončarić[2], Želimir Vukobratović[1], Mirjana Mužić[1]

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

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

Presenting author email: mvukobratovic@vguk.hr and address:

Visoko gospodarsko učilište u Križevcima, M. Demerca 1, 48 260 Križevci

Abstract

Manure from cattle (fresh, FCM and semi-mature, SCM), horse (HM), swine (SM) and poultry (PM) production was composted and tested as a medium for container-grown crops. Analysis of physical and chemical characteristics was conducted, and the biological test of facilities for growing transplants was conducted by sowing lettuce (*Letuca sativa* L.) and cucumber (*Cucumis sativus* L.). Composted manure mixed with white peat in a ratio of 1:1 was used for preparation of potting medium (v/v).

The physical properties of the compost were mainly satisfying, except porosity which was too low, while the chemical properties were not satisfying since pH and EC were too high. The addition of white peat should reduce the pH and EC of the composted manure. Lettuce is a more sensitive plant species than cucumber. No plants sprung up on the compost from horse and chicken manure (pH above 8, and the EC over 5 $dS \cdot cm^{-1}$). Regardless of the plant species, the plants grown in compost obtained from swine manure had the maximum height, and consequently maximum mass and total leaf area. These values were slightly lower on the compost of cow manure.

The compost produced from swine manure is suitable for the production of seedlings of both species, less sensitive and very sensitive. Compost from cow manure can also be used as a substitute for a portion of peat, while the same proportion of composts from horse and chicken manure are not suitable without being previously mixed with other materials.

Keywords: compost, physical properties, chemical properties, substrate, lettuce, cucumber

Introduction

Peat is a scarce and largely non-renewable natural resource, and peat exploitation is now banned in many counties. Therefore, many researches have been conducted on materials that could replace peat in potting medium. One possibility is to use composted biodegradable organic material (wastes of urban, agro-industrial or agricultural origin). According to Kuo et al. (2004) the most common composts today are derived from animal manures, municipal waste, yard debris or trimmings, and biosolid (sewage sludge).

Compost produced from manure is one of the possible solutions to this problem, because it satisfies most of the requirements that a good substrate should meet. Unfortunately, with all advantages, the compost may also have some disadvantages such as: too high pH, too high content of soluble salts for sensitive plants, immobilized nitrogen, and it may be phytotoxic for the seedlings, if it is immature. A weak plant growth may be caused by the presence of many phytotoxic compounds in the volatile fresh compost material. Phytotoxicity can be caused by high concentrations of NH_3 and NH_4^+-N (Wang et al., 2004), the phenolic compounds and low molecular organic acids such as acetic, propionic, butyric (Epstein, 1997), high salt concentrations (Contreras-Ramos et al., 2004) and high EC (Sanchez-Monedero et al., 2004), in particular a water-soluble heavy metals Cu and Zn (Tiquia and Tam, 1998) and the high pH (Atiyeh et al., 2000). Many other researchers were also involved in this problem (Tam andTiquia1994, Bernal et al., 1998, Lau and Wong, 2001; Kotaro et al., 2005; Grigatti et al., 2007, Ribeiro et al., 2007).

Production of seedlings is mainly related to container production. The root systems of container-grown plants are restricted to small capacity of media that must act as a reservoir for nutrients, water and oxygen (Kuo et al., 2004), which is why good growing medium is essential to the production of high quality plants. It is important that there are adequate physical and chemical properties, and the total porosity and water capacity are the most important physical properties. Growing media chemical properties of importance to container plant growth include pH and soluble salts content (EC). Many studies based on the morpho-physiological response of plants have focused on factors that limit the use of compost as a substrate (Bragg et al., 1993; Atiyeh et al., 2001; Carmona et al., 2012)

Croatia does not have its own deposits of peat, so there are no scientific or practical experiences related to this issue. The aim of this study was to determine the suitability of different composted manures in the production of lettuce and cucumber seedlings.

Materials and methods

For the purposes of this research the following five types of manure were composted: fresh cattle manure (FCM), semi-mature cattle (SCM), horse (HM), swine (SM) and poultry manure (PM). Manure from four different farms in north-western part of Croatia

was used in the composting process. Piles of manure were formed in a pyramid shape, with dimensions 2x2x1m, a pile of chicken manure with 2x3x1m. Compost piles were periodically manually mixed, once per week. Manures were composted during 9-months period. Samples were taken from the center of each pile immediately after mixing in the amount of about 5 kg and divided into two sub-samples. Part of the sample was stored in polyethylene bags, tightly sealed and kept in a refrigerator at 5^0C (Zhu, 2007) and the rest of the samples were dried in an oven at 75±2°C for 48 hours or until constant weight according to the method TMECC (Test Methods for the Examination of Composting and Compost, Thompson, 2001) 03.09-A had been achieved, homogenized, ground, sifted through a sieve of 1mm (Zhu, 2007) and kept in paper bags in a desiccator.

Bulk density, porosity, free airspace (FAS) and water-holding capacity (WHC) were analyzed in samples containing 45-60% water, thus the samples were wetted or dried in the air for one to two days before testing, with the occasional rotation and grinding according to the method TMECCA 01.03-A (Thompson, 2001).

The following analyses were performed in fresh samples: in water slurries pH 1:10 w/v and electrical conductivity (EC) 1:10 w/v (Tiquiai Tam, 2000) and total N (ISO, 1995). The following analyses were performed in dry samples: concentration of total P (by spectrophotometric vanado molybdophosphoric acid method, Vajnberger, 1966), K, Ca and Mg (from the basic solution of ash, K by flame photometry and Ca and Mg with

atomic-absorption spectrometry). Chemical analyses of fresh samples were performed in the 48 hours.

A germination test on plates was performed using lettuce (*Letuca sativa* L.) and cucumber (*Cucumis sativus* L.) in order to detect phytotoxicity. Just composted manure mixed with white peat in a ratio of 1:1 (v/v) (Levy and Taylor, 2003; Carmona et al., 2012) was used for preparation of growing medium in order to improve physical and chemical properties of the substrate. Containers are filled with the prepared substrates in four replications, and the sowing of lettuce was conducted at a depth of 0.5 cm and of cucumbers to a depth of 1 cm (Zmora-Nahum et al., 2007). Plant growth parameters were measured 35 days after sowing, when the transplants reached the commercial transplanting size. The following measurements were performed on the transplants: seedling height (h), dry weight per plant (w), leaf surface (s).

The results of analyses of manures and compost were statistically analyzed by SASPC application for Windows (SAS Institute Inc., Cary, NC, USA).

Results and discussion

Good physical properties of the composts, especially porosity and good ratio of air and water are very important when compost is used as a growing medium for vegetable transplants (Kuo et al, 2004; Carmona et al., 2012). Although the physical properties

(Table 1), were significantly different depending on the type of manure, they were mainly satisfying, except PS that should be between 75 and 85% (Fonteno cit. by Kuo, 2004). Grigatti et al. (2007) suggest that the mixing of peat with compost increases the WHC so WHC of compost was less than HM, SM and PM (<35%) probably improved with the addition of the peat. However, this verification was not performed.

Table 1: Physical properties: bulk density (ρ), pore space (PS), free airspace (FAS), water-holding capacity (WHC); fresh cow manure (FCM), semi-mature cow manure (SCM), horse manure (HM), swine manure (SM), poultry manure (PM)

substrate	ρ ($g \cdot cm^{-3}$)	PS (%)	FAS (%)	WHC (%)
FCM	0,162 a	61,76 a	22,10 a	39,65 b
SCM	0,191 a	60,30 a	21,85 a	38,45 b
HM	0,234 b	57,13 a	26,77 b	30,13 a
SM	0,190 a	66,18 b	34,69 c	31,48 ab
PM	0,231 b	71,01 b	39,89 d	31,12 a

The contents of total elements (Table 2) are of the same order of magnitude as those in compost of manure (Bernal et al, 1998; Kotaro et al., 2005; Raviv et al., 2005) while pH and EC are too high (Table 3). pH near 9 indicates that the processes of transformation of NH_4-N to NO_3-N have not yet completed and that the pH could be a limiting factor in the

production of seedlings. Miller (2001) states that the EC of 5 dS/m is upper limit of the substrate in container production. Almost all composts have a pH of about 9 and EC above the recommended limit so, if not previously mixed with other materials, they may have a phytotoxic effect on seedlings, especially on sensitive and very sensitive cultures. Compost from SM is an exception, because it is closest to neutral pH and has the lowest EC. The addition of white peat reduces the pH and EC of composted manure. In the FCM and PM pH is still too high (>8) as is EC in HM and PM (>5).

Table 2: Chemical properties: total N, P, K, Ca and Mg; fresh cow manure (FCM), semi-mature cow manure (SCM), horse manure (HM), swine manure (SM), poultry manure (PM)

substrate	N ($g \cdot kg^{-1}$)	P ($g \cdot kg^{-1}$)	K ($g \cdot kg^{-1}$)	Ca ($mg \cdot kg^{-1}$)	Mg ($mg \cdot kg^{-1}$)
FCM	13,68 b	13,30 b	7,63 c	162,5 ab	255,6 c
SCM	10,72 a	10,66 a	6,03 b	156,5 a	251,4 c
HM	14,57 b	10,77 a	9,50 d	227,3 c	329,7 d
SM	18,57 c	42,06 d	1,37 a	648,4 d	195,9 b
PM	27,32 d	20,34 c	5,73 b	175,0 b	107,1 a

Table 3: Chemical properties: pH, electrical conductivity (EC) in composts and substrates, fresh cow manure (FCM), semi-mature cow manure (SCM), horse manure (HM), swine manure (SM), poultry manure (PM)

	pH		EC (dS/m)	
substrate	compost	compost:peat (1:1)	compost	compost:peat (1:1)
FCM	9,16 bc	8,32 a	4,79 c	3,01 c
SCM	9,26 bc	7,68 b	4,06 b	3,42 c
HM	9,48 c	7,71 a	6,88 d	5,05 b
SM	7,73 a	6,13 c	3,04 a	2,27 d
PM	8,81 b	8,47 a	9,74 e	5,87 a

The results of measurements of seedlings confirm our assumptions. Highest seedlings, with the greatest weight and leaf area were grown on a substrate obtained by mixing of compost of pig manure and white peat (Table 4), while the lowest values were obtained in the compost of HM and SM. Salads is much more sensitive plants than cucumber and did not spring up on these composts.

Table 4: Morphological properties of lettuce seedlings 35 days after sowing: seedling height (h), dry weight per plant (w), leaf surface (s); fresh cow manure (FCM), semi-

mature cow manure (SCM), horse manure (HM), swine manure (SM), poultry manure (PM)

	Lettuce			Cucumber		
substrates	h (cm)	w (g)	s (cm^2)	h (cm)	w (g)	s (cm^2)
FCM	4,70 b	0,151 b	45,39 b	10,33 b	0,322 b	32,58 b
SCM	3,69 b	0,098 b	27,51 b	9,12 bc	0,272 b	26,61 bc
HM	0,00 c	0,000 c	0,00 c	3,79 d	0,143 c	15,83 c
SM	10,70 a	0,985 a	230,43 a	15,43 a	0,549 a	70,58 a
PM	0,00 c	0,000 c	0,00 c	6,13 cd	0,112 c	12,69 c

Conclusion

Based on the results, we can conclude that the compost produced from swine manure is suitable for the production of seedlings of both species, less sensitive and very sensitive. Compost from cow manure can also be used as a substitute for one share of peat, while in the same proportion composts from horse and chicken manure are not suitable. In future studies should determine the optimal proportions of the compost and peat.

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