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Use of Spent Mushroom Substrate and Manure Compost for Honeydew Melon Seedlings

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Abstract This experiment was conducted to investigate the possibility of mixing spent mushroom substrate (SMS) with manure composts for honeydew melon (*Cucumis melo* L. *inodorus*) seedling production in organic agriculture. The treatments evaluated were 100 % SMS, mixtures of SMS, and chicken manure compost, mixtures of SMS and cattle manure compost in different ratios: 80, 60, 40, and 20 %. The experiment was arranged in a randomized complete block design with three replications under greenhouse conditions. Some physical and chemical characteristics of growing media were determined. Germination rate, morphological growth, survival rate, and nutrient uptake of seedlings were also measured. The results indicated that the addition of manure composts to SMS-based growing media produced a decrease in pH values, air capacity, an increase in electrical conductivity, total water holding capacity, and a difference in nutrient concentrations. Eighty percent SMS can be used in mixtures with manure composts for honeydew melon seedling production. However, SMS at the rate of 40 % gave the most suitable condition for honeydew melon seedling performance.

Keywords Growing medium · Honeydew melon · Manure compost · Spent mushroom substrate (SMS)

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Introduction

Seedling production has a very important role in agricultural production. It provides vigorous, disease-free plants for the following production stages. To enhance the quality of seedlings, use of an appropriate substrate is essential. A good substrate must supply secure anchorage, suffice as a source for nutrients and water, permit oxygen dispersion to the roots, and permit gaseous exchange between the inside and outside of the root (Urrestarazu and others 2008).

Spent mushroom substrates (SMS) and manure composts are organic materials which are considered friendly to the environment. SMS, leftover after harvesting mushrooms, is always discarded in considerable amounts. About 5 kg of SMS are generated from a kilogram of mushrooms (Semple and others 2001) and this amount will cause environmental concerns if it is not disposed of properly (Rajput and others 2009). SMS contains a high value of nutrients that is generally harmless to plants (Fasidi and others 2008). Thus, SMS was considered as a component for horticultural substrate. Moreover, its use is also a suitable way to reduce environmental pollution. Previous studies have used SMS in agricultural production. For example, SMS was used as a source of organic matter and available nutrients to soil (Steffen and others 1994). Because of its physical presence on the soil surface and the activity of phytotoxic substances, SMS is successfully applied as a surface mulch for weed control (Tsaoir and Mansfield 2000; Ozores-Hampton and others 2001). Danny and Sanchez (2002) reported that SMS was used as a medium in agriculture, it improves soil structure and as a matrix for bioremediation of contaminated soils. Iwase and others (2000) reported that adding SMS to soil helps increase the yields of tomato and lettuce. Medina and others (2009) determined that increasing the volume of SMS in the media, pH and EC values, and macronutrient concentration increased, while water holding capacity (WHC) of the substrate decreased. Using SMS substrate as a growing substrate has a positive effect on the yield and quality of different vegetables and horticultural crops (Medina and others 2009; Polat and others 2009). However, the major constraints when using a high volume of fresh SMS are its high salinity and pH values (Maher and others 2000; Jordan and others 2008). Thus, processing of SMS and choosing other materials to mix together are very important. Manure compost was superior to conventional synthetic fertilizer and raw dairy manure in building soil nitrogen levels and reducing nutrient losses to ground and surface water (Hepperly and others 2009). Manure compost is widely used in organic farming as an affordable source of fertilizer (Inbar and others 1993). Wong and others (1999) observed that manure composts improve physical properties (increased porosity and hydraulic conductivity and decreased bulk density) of soil. Although there are previous studies using SMS and manure compost in agricultural production, few studies have used SMS and manure composts as a growing media in seedling production, especially in organic agriculture (Segarra and others 2007; Eklind and others 2001; Ribeiro and others 2007; Restrepo and others 2013; Wong 1985; Jayasinghe and others 2010a, b). Therefore, the study was conducted to examine the physical and chemical characteristics of substrates of SMS mixed with chicken manure compost (ChMC) and cattle manure compost (CaMC) in different proportions, and their effects on the nutrient uptake and growth responses of honeydew melon (*Cucumis melo* L. *inodorus*) seedlings. The main objective is to determine the best substrate mixture for honeydew melon seedling production in organic agriculture.

Materials and Methods

Characteristics of Materials

The experiment used the honeydew melon F1 hybrid variety Huigu from Known You Seed Company Ltd, Kaohsiung, Taiwan. ChMC was produced from chicken manure and sawdust of mango. CaMC was produced from cattle manure and sawdust of mango. They were bought from Chung Hsing collective farm, Neipu, Pingtung, Taiwan. SMS composed of rice straw, chicken manure, calcium sulfate, and inorganic nutrients was obtained from the Enoki mushroom (*Flammulina velutipes*) production unit, Jiuru Township, Pingtung County, Taiwan. It was pasteurized at 45 °C for 48 h with an oven to prevent pest and pathogen growth. All three materials (ChMC, CaMC, and SMS) were allowed in organic agricultural production (FAO 2006). Physical and chemical properties of ChMC, CaMC, and SMS are shown in Table 1.

Table 1 Physical and chemical properties of ChMC, CaMC, and SMS used in the experiment

Particulars	ChMC	CaMC	SMS
Aeration porosity (%)	18.56	18.71	36.47
Bulk density (g cm^{-3})	0.389	0.378	0.308
Total porosity (%)	79.13	82.01	89.73
Water holding capacity (WHC) (%)	61.98	63.12	53.26
pH	7.10	7.17	7.65
Electrical conductivity (EC) (dS m^{-1})	5.82	5.56	3.50
N (g kg^{-1})	0.938	0.796	0.218
P (g kg^{-1})	16.04	6.62	11.49
K (g kg^{-1})	21.86	20.07	13.85
Ca (g kg^{-1})	25.58	27.76	33.45
Mg (g kg^{-1})	6.45	6.04	7.79
Cu (mg kg^{-1})	0.030	0.198	0.227
Fe (mg kg^{-1})	37.08	643.34	146.37
Mn (mg kg^{-1})	68.86	354.73	241.81
Zn (mg kg^{-1})	26.67	273.82	142.52

ChMC chicken manure compost, *CaMC* cattle manure compost, *SMS* spent mushroom substrate

Experimental Design

The nursery experiment was conducted from October 17, 2013 to November 15, 2013 in greenhouse conditions at National Pingtung University of Science and Technology, Taiwan. SMS was mixed in different proportions (20, 40, 60, and 80 %) with CaMC or ChMC. The treatments included: (T1) 20 % SMS + 80 % ChMC; (T2) 40 % SMS + 60 % ChMC; (T3) 60 % SMS + 40 % ChMC; (T4) 80 % SMS + 20 % ChMC; (T5) 20 % SMS + 80 % CaMC; (T6) 40 % SMS + 60 % CaMC; (T7) 60 % SMS + 40 % CaMC; (T8) 80 % SMS + 20 % CaMC; (T9) 100 % SMS was also tested as control (P).

The experiment was established in a complete random block design with nine treatments and three replications. Each replication was conducted in a tray with 20 pots, one seed per pot. The plants were irrigated equally for all treatments in accordance with their water demand with distilled water during the growing period. No treatments were provided additional fertilizer.

Analytical Methods

Aeration porosity, bulk density, total porosity, and WHC were determined according to the methods of Raviv and others (2002). Each substrate was put into a pot (300 ml) fitted at the bottom. The samples were water-saturated for 24 h, and then allowed to drain for 60 min and the amount of drainage water recorded. Samples were weighed before and after drying in an oven at 105 °C for 24 h. Aeration porosity (%volume) = (drainage/volume) × 100; bulk density (g cm^{-3}) = dry weight/volume; the total porosity (%volume) = {(wet weight − dry weight + drainage)/volume} × 100; WHC (%volume) = [(wet weight − dry weight)/volume × 100. Electrolyte conductivity (EC) and pH were determined according to the methods of Cavins and others (2000) by using a pH meter (UltraBasic-UB10; Denver Instrument, New York, NY, USA) and EC meter (SC-2300 conductivity meter; Suntex Instrument Co. Ltd, New Taipei City, Taiwan); 20 g of substrate were mixed with 100 ml water (ratio 1:5) to wet the sample to saturation, shaken for 15 min and left for 60 min, and filtered before the measurements were made. The mineral-N concentration in each substrate was determined by the colorimetrical methods of Sims and others (1995) by using a modified indophenol blue technique. For determining the nutrient elements P, K, Ca, Ma, Fe, Mn, Zn, and Cu, 5 g of samples were extracted with H_2O and 0.1 N HCl, and then analyzed by inductively coupled plasma atomic emission spectroscopy.

Germination Rate, Survival Rate, and Morphological Parameters

Germination rate was determined 1 week after sowing and indentified as the number of seeds germinating. Seedling height and leaf number were collected 1, 2, 3, and 4 weeks after sowing. Seedling height was measured with a ruler from the cotyledon to the maximum height of the shoot. Number of leaves per plant was also counted. At the end of experiment, ten seedlings per replication were taken. Seedlings were washed and separated into shoot and root to measure fresh weight. The shoots and roots were dried in an electric oven at 70 °C for 48 h to measure the dry weight of the shoot and root. Root volume was measured by submerging roots in a cup of water, and then counting the increase of water in the cup. Stem diameter were determined 4 weeks after sowing and measured at the base of the cotyledon. Leaf area was measured according to the methods of Pandey and Singh (2011). Leaf area (cm^2 $plant^{-1}$) = x/y, in which x is the weight (g) of the area covered by the leaf outline on a millimeter graph paper, y is the weight of 1 cm^2 of the sample graph paper. Chlorophyll content was measured by using a portable SPAD meter. The SPAD value of each seedling is a mean of leaf SPAD values taken from the five youngest fully expanded leaves. The survival rate is the number of seedlings surviving 4 weeks after sowing. Total nitrogen in seedlings was measured according the methods of Kjeldahl (Bremner 1996). Other nutrient elements were measured as for substrates mentioned above.

Statistical Analysis

All data were analyzed by using the SAS statistical software package (SAS Institute 1990). To separate means ($P < 0.05$), Duncan's multiple range test was also used.

Results

Physical and Chemical Properties of ChMC, CaMC, and SMS

The physical and chemical properties of ChMC, CaMC, and SMS are shown in Table 1. The aeration porosity value was higher in SMS (36.47 %) than in ChMC (18.56 %) and CaMC (18.71 %). The bulk density of organic materials ranged from 0.308 g cm^{-3} in SMS to 0.389 g cm^{-3} in ChMC. The highest WHC was recorded for CaMC, whereas the lowest was for SMS. Of the three kinds of materials, SMS was the most alkaline with the highest pH value (7.65). Most organic materials had substantial amounts of soluble salts, and the highest electrical conductivity (EC = 5.82 dS m^{-1}) was measured for ChMC. Regarding the nutrient concentration, ChMC was richer in N, P, and K concentrations, whereas the highest concentrations of Fe, Mn, and Zn were shown in CaMC.

Physical and Chemical Properties of the Growing Media

Aeration porosity, bulk density, total porosity, and WHC are very important factors for seedling production so they must be considered in preparing the growing media (Moldes and others 2007). Regarding aeration porosity, the value of this parameter was highest in T9 (36.47 %) and lowest in T1, T5 (20.46 and 21.14 %, respectively). In the experiment, bulk density was higher in growing media T1, T2, T3, and T5 than in the control treatment (T9). After the addition of SMS, the value of total porosity was raised with the highest values attained in T9, T8 (89.73 and 88.91 %, respectively), whereas WHC was lowered with the lowest values recorded at T9, T4 (53.26 and 54.40 %, respectively).

The main physical and chemical properties of the growing media are shown in Table 2. The pH values of growing media varied significantly from 7.18 to 7.65. Growing medium T9 showed the highest pH value (7.65), whereas growing medium T2 showed the lowest pH value (7.18). When SMS was mixed with ChMC or CaMC in different proportions, pH values were lower compared with 100 % SMS. Electrical conductivity also changed significantly among growing media. EC values ranged from 3.50 to 5.33 dS m^{-1}, and the highest EC values were recorded when 20 % SMS was mixed with 80 % ChMC or 80 % CaMC.

Nutrient Concentration of the Growing Media

In general, macronutrient concentration was significantly affected by the increasing compost percentage in the growing media (Table 3). Growing medium with 80 % ChMC (T1) had the highest concentration of N (0.803 g kg^{-1} dry weight), whereas N content in T9 was

Table 2 Physical and chemical properties of the growing media

Growing medium[a]	Aeration porosity (%)	Bulk density (g cm^{-3})	Total porosity (%)	WHC (%)[d]	pH	EC (dS m^{-1})[e]
T1	20.46f[c]	0.368a	80.68f	60.22b	7.18e	5.33a
T2	23.21e	0.355ab	81.10f	57.90c	7.23d	4.45b
T3	27.17d	0.337b	83.08e	55.91d	7.45c	4.12d
T4	31.16c	0.322c	85.56 cd	54.40e	7.57b	3.86e
T5	21.14f	0.358ab	84.09de	61.95a	7.22d	5.23a
T6	26.53d	0.332bc	85.87c	59.34b	7.24d	4.26c
T7	29.70c	0.321c	87.59b	57.89c	7.47c	4.04d
T8	32.86b	0.311c	88.91ab	56.05d	7.54b	3.59f
T9	36.47a	0.308c	89.73a	53.26e	7.65a	3.50f
IS[b]	20.00–30.00	0.200–0.400	70.00–90.00	50.00–60.00	5.80–6.80	<2.50

[a] T1 = SMS (20 %) + ChMC (80 %); T2 = SMS (40 %) + ChMC (60 %); T3 = SMS (60 %) + ChMC (40 %); T4 = SMS (80 %) + ChMC (20 %); T5 = SMS (20 %) + CaMC (80 %); T6 = SMS (40 %) + CaMC (60 %); T7 = SMS (60 %) + CaMC (40 %); T8 = SMS (80 %) + CaMC (20 %); T9 = SMS (100 %)

[b] Ideal substrate according to Abad and others (2001) and Noguera and others (2003)

[c] The same letters within the same column are not significantly different ($P < 0.05$) according to least significant different (LSD) test

[d] Water holding capacity

[e] Electrical conductivity

the lowest (0.218 g kg^{-1} dry weight) compared to other growing media. An increasing trend of P and K was reported when ChMC was gradually supplemented in the growing media. When ChMC was mixed at the rate of 80 and 60 %, P content in the growing media was the highest. The highest concentration of K was also recorded in T1 (80 % ChMC). Regarding micronutrient concentration, the application of CaMC elevated concentrations of Fe, Mn, and Zn in the growing media (Table 3), but when using ChMC, the concentrations of Cu, Fe, Mn, and Zn were reduced. Growing medium T1 showed the lowest values of Cu, Mn, and Zn (0.069, 122.39, and 45.34 mg kg^{-1} dry weight, respectively).

Morphological Growth of Honeydew Melon Seedlings

The germination percentages of honeydew melon seeds in the growing media with doses of compost at 60, 40, and 20 % were similar to those obtained in the control treatment (T9) (Table 4). The leaf number of honeydew melon seedlings was different among growing media. The number of leaves varied from 3.20 to 5.20 leaves $plant^{-1}$. Growing media T2 and T6 resulted in the highest numbers of leaves per plant (5.20 and 5.13 leaves $plant^{-1}$, respectively). Fresh weight, dry weight, and root volumes of honeydew melon seedlings were affected by different doses of ChMC and CaMC (Table 4). The lowest values for fresh weight, dry weight, and root volumes were recorded in T9 (3.45 g $plant^{-1}$, 0.58 g $plant^{-1}$, and 0.65 ml $plant^{-1}$, respectively) (Table 4). The chlorophyll content of honeydew melon seedlings differed significantly among growing media. Seedlings grown in T1 showed the highest chlorophyll content with a SPAD value of 29.64. The survival rate of seedlings at the end of the nursery period (4 weeks after sowing) differed significantly under different growing media. The lowest survival rate was in T1 and T5 (32.43 and 35.48 %, respectively).

Nutritional Status of Honeydew Melon Seedlings

In general, using different proportions of SMS, ChMC, and CaMC in the growing media influenced the nutritional status of honeydew melon seedlings (Table 5). Honeydew melon seedlings grown in all growing media (except for T8) had higher N and K concentrations than those in T9 (the control treatment). On the other hand, almost all honeydew melon seedlings in the growing media had similar P concentration to those in the control treatment, except for T4. The contents of both Ca and Mg in honeydew melon seedlings were different in the growing media. The highest contents of Ca and Mg were recorded at the growing media T4, T8, and T9. Regarding the micronutrient concentration, the Cu concentration in honeydew melon seedlings decreased with an increase of ChMC and CaMC in the growing media (Table 5). The content of Fe was highest in seedlings grown in T5 (421.29 mg kg^{-1} dry weight), whereas the highest values of Zn were attained in seedlings grown in T3 and T4. The content of Mn in honeydew melon seedlings varied from 37.66 to 93.31 mg kg^{-1} dry weight. Seedlings grown in T1 resulted in the lowest concentration of Mn (37.66 mg kg^{-1} dry weight), which was statistically similar to those obtained from seedlings grown in T2 and T3.

Table 3 Macro and micronutrient concentrations of the growing media extracted with 0.1 N HCl

Growing medium[a]	N g kg^{-1} dry weight	P	K	Ca	Mg	Cu mg kg^{-1} dry weight	Fe	Mn	Zn
T1	0.803a[b]	15.21a	20.78a	27.66f	6.68cde	0.069 g	58.07 g	122.39 g	45.34f
T2	0.656c	14.49a	18.90b	29.81d	6.87 cd	0.118f	82.23 fg	169.30f	93.94e
T3	0.487d	13.11b	17.59 cd	31.02c	7.15bc	0.151e	107.17ef	228.42e	106.93e
T4	0.322e	12.29bc	15.52e	32.25b	7.43ab	0.189d	121.09ef	275.35bcd	131.85d
T5	0.716b	7.42f	18.29bc	28.94e	6.31e	0.210c	560.06a	332.57a	244.28a
T6	0.636c	8.11f	17.12d	30.07d	6.60de	0.213bc	451.78b	307.05ab	203.01b
T7	0.507d	9.34e	15.72e	31.22c	7.01bcd	0.220abc	355.12c	282.48bc	186.53bc
T8	0.371e	10.18d	14.57 cd	32.45b	7.40ab	0.223ab	247.38d	257.40cde	167.80c
T9	0.218f	11.49c	13.85f	33.45a	7.79a	0.227a	146.37e	241.81de	142.55d

[a] T1 = SMS (20 %) + ChMC (80 %); T2 = SMS (40 %) + ChMC (60 %); T3 = SMS (60 %) + ChMC (40 %); T4 = SMS (80 %) + ChMC (20 %); T5 = SMS (20 %) + CaMC (80 %); T6 = SMS (40 %) + CaMC (60 %); T7 = SMS (60 %) + CaMC (40 %); T8 = SMS (80 %) + CaMC (20 %); T9 = SMS (100 %)

[b] The same letters within the same column are not significantly different ($P < 0.05$) according to Least Significant Different (LSD) test

Table 4 Effects of the growing media on the morphological growth of honeydew melon seedlings 4 weeks after sowing

Growng medium[a]	Germination rate (%)	Stem diameter (mm)	Seedling height (cm)	Fresh weight (g plant^{-1})	Dry weight	Root volume (ml plant^{-1})	Leaf number (number plant^{-1})	Leaf area (cm^2 plant^{-1})	Chlorophyl content SPAD value	Survival rate (%)
T1	64.43b[b]	3.21a	23.50 cd	7.72abc	0.90ab	1.25b	4.40bc	128.67bc	29.64a	32.43 g
T2	78.83a	3.22a	27.17a	8.75a	0.95a	1.41a	5.20a	139.05a	26.53b	72.11a
T3	77.23a	3.13ab	21.53d	6.04d	0.77c	1.27b	4.20bc	124.61c	22.17 cd	65.92bc
T4	81.42a	3.02bc	16.37ef	4.18ef	0.61e	1.07d	3.47de	112.00d	21.01d	60.04de
T5	65.43b	3.15a	24.27bc	7.22c	0.87b	1.23b	4.30b	126.00c	26.41b	35.48 g
T6	77.87a	3.19a	26.27ab	8.09ab	0.93a	1.38a	5.13a	135.70ab	24.47bc	68.63b
T7	80.83a	3.11ab	18.47e	6.04d	0.85b	1.13c	3.80 cd	122.00c	22.14 cd	62.55 cd
T8	82.27a	2.92c	15.10f	4.48e	0.69d	0.95e	3.27e	108.16d	22.69 cd	58.38e
T9	80.60a	2.91c	14.43f	3.45f	0.58e	0.65f	3.20e	96.40e	20.86d	53.55 g

[a] T1 = SMS (20 %) + ChMC (80 %); T2 = SMS (40 %) + ChMC (60 %); T3 = SMS (60 %) + ChMC (40 %); T4 = SMS (80 %) + ChMC (20 %); T5 = SMS (20 %) + CaMC (80 %); T6 = SMS (40 %) + CaMC (60 %); T7 = SMS (60 %) + CaMC (40 %); T8 = SMS (80 %) + CaMC (20 %); T9 = SMS (100 %)

[b] The same letters within the same column are not significantly different ($P < 0.05$) according to least significant different (LSD) test

Discussion

Generally aeration porosity of the growing media increased with increased SMS proportion in the media. This result was also found in growing media mixed with other wastes such as sweet sorghum bagasse with pine bark (Sánchez-Monedero and others 2004), and distillery wastes (Bustamante and others 2008). In the experiment, the bulk density of the growing media was enhanced with increased ChMC and CaMC in the media (Table 2). However, the bulk density of all growing media was within the established ideal substrate range according to Abad and others (2001). Regarding total porosity, we observed that all growing media values were within the optimal range (Table 2). We also found that there is a positive correlation between total porosity and aeration porosity, similarly reported by Abad and others (2005). The WHC of the growing media decreased with increasing proportions of SMS in the media. This reduction was also observed by Medina and others (2009) in an experiment mixing SMS of *Agaricus bisporus* mushrooms with *Sphagnum* peat. The pH of all growing media exceeded the acceptable limit for an ideal substrate (Noguera and others 2003). In general, the pH value of growing media increased with increased proportions of SMS in the media. This fact is due to the high concentration of Ca in SMS (Table 3). The EC values increased with proportion of manure compost in the growing media. The increase in EC values with rising proportions of compost

Table 5 Effects of the growing media on the macro and micronutrient contents of honeydew melon seedling 4 weeks after sowing

Growing medium[a]	N g kg^{-1} dry weight	P	K	Ca	Mg	Cu mg kg^{-1} dry weight	Fe	Mn	Zn
T1	44.75a[b]	9.43a	47.35ab	4.64 g	13.15d	1.26f	190.11f	37.66e	91.07e
T2	40.85ab	9.10a	45.05b	6.37ef	13.22d	1.87e	203.00ef	43.18e	110.68c
T3	35.55bc	8.59ab	40.93b	9.96bc	18.67bc	2.62d	219.35def	45.10e	124.09ab
T4	28.83 cd	7.56b	32.51c	11.15ab	22.28a	6.12a	233.94d	78.89c	139.96a
T5	41.76ab	8.41ab	52.89a	5.29 fg	13.19d	1.79e	421.29a	60.44d	112.520bc
T6	38.60ab	8.68ab	42.23b	7.63de	14.75d	1.57ef	366.57b	74.28c	105.39 cd
T7	31.41 cd	8.65ab	31.86c	8.81 cd	15.65 cd	1.56ef	323.21c	82.12bc	94.93de
T8	26.77de	9.16a	26.26 cd	12.15a	20.76ab	3.38c	227.40de	93.31a	84.98ef
T9	20.34e	9.79a	22.88d	11.77a	20.83ab	4.33b	212.28def	88.58ab	72.84f

[a] T1 = SMS (20 %) + ChMC (80 %); T2 = SMS (405) + ChMC (60 %); T3 = SMS (60 %) + ChMC (40 %); T4 = SMS (80 %) + ChMC (20 %); T5 = SMS (20 %) + CaMC (80 %); T6 = SMS (40 %) + CaMC (60 %); T7 = SMS (60 %) + CaMC (40 %); T8 = SMS (80 %) + CaMC (20 %)

[b] The same letters within the same column are not significantly different ($P < 0.05$) according to least significant different (LSD) test

was reported by Herrera and others (2008) when using municipal solid waste compost as growing media for tomato seedling production. Restrepo and others (2013) also reported a similar result when using compost from cattle manure and maize silage codigestion for seedling production of melon, tomato, and pepper.

The results indicated that increasing proportions of compost significantly increased N, K, and P in ChMC-based growing media (Table 3). The increase of macronutrient levels with compost was observed by Ribeiro and others (2007) in an experiment using compost obtained from forestry wastes and the solid phase of pig slurry for seedling production. On the contrary, Ca and Mg concentrations increased with increased SMS in the growing media. This fact is due to the use of calcium sulfate in preparing substrate for mushroom production (Paredes and others 2006). Benito and others (2005) used SMS as a nutrient-rich material in growing media, which shows that SMS is a great source of macronutrients, especially Mg, Ca. Finally, increasing additions of CaMC to the growing media augmented Fe, Mn, and Zn concentrations (Table 3). However, increasing additions of ChMC to the growing media decreased Cu, Fe, Mn, and Zn concentrations. It meant that the contents of Cu, Fe, Mn, and Zn in SMS were higher than those in ChMC. Medina and others (2009) also reported that using SMS of *A. bisporus* increased Fe, Mn, and Zn concentrations in growing media. The high contents of Cu, Fe, Mn, and Zn in SMS are due to the content of those micronutrients provided when preparing substrates for mushroom production (Stamets and Chilton 1983).

The seed germination rate in the growing media with 80 % ChMC (T1) and 80 % CaMC (T5) was the lowest. This fact is due to the high salinity (the high EC value). The similar result was also observed by Bustamante and others (2008) in an experiment using mixtures of peat and composts as growing media for horticultural and ornamental plants. The leaf number of honeydew melon in growing media T2 and T6 showed the best responses. The increase in leaf number is due to physical properties and the high concentration of NPK in T2 and T6 (Tables 2, 3). This positive impact of seedling growth parameters with NPK content in the growing media was reported by Ribas and others (2009) in a study using SMS from *Agaricus subrufescens* and *Lentinula edodes* in the enrichment of a soil-based potting media for lettuce cultivation and by Eklind and others (2001) in an experiment with farmyard manure compost-based substrates for lettuce production. Fresh weight, dry weight, and root volumes of honeydew melon seedlings were affected by different doses of ChMC and CaMC (Table 4). Fresh weight, dry weight, and root volumes in the control treatment (T9) were lowest, due to the low content of N, K in the substrates and low WHC of these media (Table 2). A similar result was also shown by Jayasinghe and others (2010a, b) in a study with substrates developed from cattle manure compost and synthetic aggregates for ornament plant production. The SPAD value is proportional to the amount of chlorophyll present in leaf. Thus, higher SPAD values indicate healthier plants. Seedlings grown in T1 recorded the highest chlorophyll content. This fact is due to the high content of N, P, and K in growing media. Growing media with a high content of NPK resulted in higher SPAD values. Survival rate of seedlings at the end of the nursery period (4 weeks after sowing) differed significantly under different growing media. The survival rate of seedlings was lower when grown in T1 (80 % ChMC) and T5 (80 % CaMC). This fact is due to the high salinity (the high EC value) in the growing media (Table 2). Wong (1985) also reported a similar result in a study using horse manure compost for *Acacia confusa* seedling production.

Honeydew melon seedlings grown in all growing media (except for T8) had a higher N and K concentration than those in T9 (the control treatment), which was attributed to the higher concentrations of these elements observed in the growing media containing ChMC, CaMC. The concentration of P in seedlings grown in all growing media (except for T4) showed no significant difference. This result was related to the salt sensitivity of honeydew melon seedlings. At the early stage, seedlings have a limited capacity for water uptake so they are more sensitive to salt. Medina and others (2009) also obtained similar results in a study using SMS of *A. bisporus, Pleurotus ostreatus*, and *Sphagnum* peat as growing media for courgette and pepper transplants. The content of Ca and Mg in honeydew melon seedlings increased with increased SMS in the growing media, which is due to the higher content of Ca and Mg in the growing media with SMS (Table 3). This fact expressed that growing media with SMS was suitable for Ca and Mg uptake of honeydew melon seedlings. A similar result was also reported by Zhang and others (2012) in a study using SMS of *Flammulina velutipes* as growing media for tomato and cucumber seedlings. Regarding the micronutrient concentration, the Cu concentration in honeydew melon seedlings decreased with an increase of ChMC and CaMC in the growing media (Table 5). The low Cu concentration in seedlings is related to the low content of this element in the growing media (Table 3). The contents of Fe and Zn in seedlings also decreased with an increase of ChMC. On the contrary, the concentration of these two elements was enhanced with increased CaMC in the growing media. These results are attributed to the concentration of Fe and Zn in the growing media. The content of Mn in honeydew melon seedlings decreased with an increase of ChMC and CaMC in the growing media, which produced an increase in the salinity of the media (the high EC value) (Table 2). Similar results have been reported by Ribeiro and others (1999) in a study using a sewage sludge-based compost for the production of container tree seedlings, by Perez-Murcia and others (2006) in a study with composted sewage sludge in growth for broccoli, and by Jayasinghe and others (2010a, b) in an experiment to evaluate containerized substrates developed from CaMC and synthetic aggregates for ornamental plant production.

Conclusions

From the experimental results, it was possible to conclude that, in general, the growing media mixed with SMS and ChMC or CaMC had physical properties within optimal ranges. However, chemical properties (pH, EC) were slightly higher than the optimal range. Regarding the nutrient content, using ChMC and CaMC enhanced the contents of N and K in both growing media and honeydew melon seedlings. In the case of unamended ChMC or CaMC, SMS had high contents of some elements such as Ca, Cu, and Mn. The media including 60 % of ChMC or CaMC gave the highest growth by increasing dry weight, root volume, and leaf number of honeydew melon seedlings. Using a high proportion (80 %) of ChMC or CaMC reduced the germination and survival rates of honeydew melon.

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