

Use of Municipal Solid Waste Compost as Growing Medium Component for Melon Seedlings Production

Keywords: Compost; Municipal Solid Waste; Peat; Growth; Fertigation; Melon; Seed Emergence

Abstract

The impacts of municipal solid waste compost (MSWC) in different contents were evaluated in melon (*Citrus melo* L.) seed germination and seedling production in nurseries study. Extracts (10^{-9} up to 10^{-6} dilutions) of MSWC evaluated for seed priming/germination in Petri dishes. The MSWC extracts at 10^{-1} – 10^{-6} enhanced (up to 20%) seedling germination as well as shoot and root radicle length. However, pure extracts (at 10^{-9}) delayed the seed germination for 3 days which was less than 25%. Under nursery conditions, six media [(% v/v): peat: MSWC (100:0) as control; peat:MSWC (85:15); peat: MSWC (70:30); peat:MSWC (55:45); peat:MSWC (40:60) and peat:MSWC (0:100)] were prepared from commercial peat and MSWC. Seedling growth/development parameters were assessed. Seed emergence enhanced when low MSWC content (< 30%) used while increased MSWC content (>60%) reduced (up to 80%) emergence and delayed up to 6 days the emergence time. Under nursery conditions, addition of MSWC (especially in content greater than 30%) reduced leaf numbers produced, seedling fresh weight (and dry matter content), chlorophyll a and total carotenoids content. Increased MSWC content into the substrate affected negatively the seedling height and leaf internal CO₂ concentration. Stem diameter, leaf fluorescence and chlorophyll b content accelerated when 15-45% MSWC content used into the substrate. No significant differences observed in leaf stomatal conductance in plants grown in different MSWC contents. No visual phytotoxicity obtained macroscopically. Thus, low content (up to 30%) of MSWC may act as an alternative substitute of peat in melon seedling production.

Introduction

Transplants, compared with direct sowing, are a more reliable method of ensuring the proper establishment of a range of commercial horticultural crops with great economic value including vegetables. The production of vegetable seedlings, especial in Mediterranean countries with great field and greenhouse crops expansion, is a highly-competitive business; uniform and rapid seed emergence is essential prerequisites to increase yield, quality, and profits in crops. Use of good crop substrates with appropriate physicochemical properties, is therefore critical [1].

Under nursery conditions, peat is widely used as the main substrate component for production of seedlings in containers, and this is expanded in Southern Europe. However, peat is imported from Northern and Central Europe and recently has become more expensive and its properties more variable, which is due to material shortage as well as the environment disturbance through peat mining and processing. Thus, it is important to look for good quality and locally available low-cost peat substitutes. The need to recycle wastes



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and increasing environmental pressures against peat extraction leads to an increasing interest in the feasibility of substituting peat by organic wastes and by-products. A number of potential alternatives have been identified [2], and composts obtained from different organic materials have been proved to be promising [3]. However, the use of compost into substrates in different ratios may cause some problems as a consequence of its high salt content [4], unsuitable physical properties (water holding capacity, aeration etc.), heavy metal toxicity [5,6] and variable quality and composition [7].

The appropriate amount of composts added in growth medium needs to be determined to improve plant growth [8-9]. In some cases, mixtures of compost with per liter may be used as substrates without the need for additional mineral fertilizer [4,10], as the necessary nutrient amount is provided by the compost itself.

Exploring the municipal solid waste compost (MSWC) as an organic soil additive when applied in field trials suggested that it can be used in agricultural production, improving soil physicochemical properties, increasing water retention as well as supply with considerable amount of essential nutrients [11-13]. Herrera et al. [14] reported that the urban waste compost can be used for tomato (*Solanum lycopersicum* L.) transplant production, which is also the case for cucumber (*Cucumis sativus* L.) transplants [15]. However, little information is available regarding the use of the MSWC as a peat alternative for nursery production of horticultural crops. Indeed, most studies have focused on ornamental potted plants, woody shrubs and trees [13,16]. The best amount of each particular compost needs to be determined for particular plant growth as there is no one standard growing medium recommended for all container crops under all growing conditions. A previous study showed that the growth and development of nursery-produced tomato seedlings using a peat+MSWC mixture was similar to those obtained using the standard peat mixture [4].

The present study examined the impacts of the MSWC mixed with

conventional peat substrates at various ratios, as a growth medium in the nursery production of melon.

Material and Methods

Seed and municipal solid waste compost source

Seeds of melon (*Citrulus melo* L. cv Ananas) were purchased from Agrosposito company (Goldsmith seeds Ltd, CA, USA). The municipal solid waste compost was purchased from Inter-Municipal Enterprise for the Management of Solid Wastes (IMEMSW), based in Chania, Greece. The compost used was made from the organic fraction of selectively-collected urban waste while the composting procedure lasted for 5-6 months, and the organic fraction were regularly turned and watered, following standard composting procedures. Sixty percent of the compost consisted of particles with <4mm size. The main physicochemical characteristics (in dry weight: dwt) of the compost had been described previously [13]. In details characteristics of compost were pH: 7.7; electrical conductivity (EC): 17.9 dS m⁻¹ (1:1 v/v); ashes: 50.1% dwt; organic matter: 49.9% dwt; organic Carbon: 27.2% dwt; N: 1.9% dwt; ratio C/N: 7.1; P: 164 µg g⁻¹; K: 727 µg g⁻¹; Na: 403 µg g⁻¹, under low limits for heavy metal content.

MSWC Extracts and Germination Studies *in vitro*

Municipal solid waste compost extracts obtained by using a 2-L capacity plastic container which was filled with MSWC:water (1:1.5) and was shaking for 24 h at room temperature. The EC and pH of MSWC extract were evaluated with a portable EC/pH-meter. The MSWC extract was diluted in the ratios of 1:0, 1:10, 1:100, 1:1000, 1:10000, 1:100000 (MSWC:water at 10⁰ up to 10⁻⁶ dilutions). For germination tests, air-dried melon seeds were placed in Petri dishes with filter paper (four replicates/treatment, 25 seeds/replicate) in a completely randomized design under laboratory conditions (average temperatures: 24.1±2.3°C max, 21.5±2.8°C min) and monitored daily. Filter papers were moistened daily using aliquots of diluted MSWC extract for the six treatments. Control treatments (Plates) were moisturised with dH₂O. Seeds were considered germinated upon radicle emergence. Mean shoot and root length was evaluated on the sixth day.

Germination and Plant Growth Studies in Nursery Tests

A mix of commercial peat (P-Professional peat, Gebr. Brill Substrate GmbH & Co.KG, Georgsdorf, Germany), Perlite (Perloflor, Protectivo EPE, Athens, Greece) and MSWC were used to create six treatments which were (% v/v): 1) peat:MSWC (100:0) as control, 2) peat:MSWC (85:15), 3) peat:MSWC (70:30), 4) peat:MSWC (55:45), 5) peat:MSWC (40:60) and 6) peat:MSWC (0:100). In each substrate medium 10% (v/v) of Perlite was added for adequate substrate aeration.

Seeds of melon were sown (5 seeds per well; 4 wells per replication; 5 replications per treatment, 40 cm³ well capacity) in black plastic seedling trays and watering by mist through a timer and according to seedling needs. The experiment was carried out in a completely randomized design in an unheated glasshouse with a north-south orientation at the School of Agricultural Technology at Heraklion, Greece. Seed germination was daily recorded. Twelve days after seeding, seedlings were thinned to single plant, maintaining 4-5 cm distance among seedlings. Mean germination time (MGT) was calculated as follows, according to Labouriau [17]:

$$t = \frac{\sum ni \cdot ti}{\sum n} \text{ (days)}$$

Where: t = mean germination time, ti = given time interval, ni = number of germinated seeds during a given time interval, n = total number of germinated seeds.

After 31 days, seedling growth was assessed by harvesting six individuals/treatment. Seedlings were harvested above substrate, the leaf number and height (cm) per seedling, measured from substrate surface, stem diameter (mm) measured below the cotyledon node, upper fresh weight (g), total dry matter (%), content (µg/g fresh weight) of chlorophyll a (Chla), chlorophyll b (Chlb) and total carotenoids (Car) determined according to Porra [18]. Leaf fluoresces determined (chlorophyll fluorometer, opti-sciences OS-30p, UK) and leaf photosynthetic rate (pn), the stomatal conductance (gs) and the internal leaf concentration of CO₂ (Ci) measured using a portable infra-red gas analyser (model Li-6200, Li-Cor, Inc., Lincoln, Nebr.). Measurements were carried out between 9:00–11:10 AM, the leaf temperature within the chamber was (28 ± 2)°C, photosynthetic photon flux density of 1300 µmol/m²/s at the ambient CO₂ concentration. The Li 6200 was equipped with a leaf chamber with constant area inserts (6.0 cm²). All gas-exchange measurements started 3 h after the onset of the photoperiod and were replicated in nine plants of each treatment and on two fully expanded, healthy, sun-exposed leaves per plant.

Leaf elemental analysis for potassium-K, phosphorus-P, sodium-Na and nitrogen-N was determined at the end of the experiments. After a hydrochloric digestion of the plant sample ash, nutrients analysis for K and Na (photometric; JENWAY, PEP-7 Jenway, Dunmow, UK), P (spectrophotometric; Pye Unicam Hitachi U-1100, Tokyo, Japan) was determined while total N determined through Kjeldahl method.

Statistical Analysis

The experiment was carried out twice. Percentage data were log-transformed before analysis. Data were tested for normality, and then subjected to analysis of variance (ANOVA). Significant differences between mean values were determined using Least Significant Difference (LSD) following one-way ANOVA. Statistical analyses were performed using SPSS (SPSS Inc., Chicago, Ill.).

Results and Discussion

Seed Germination and Emergence Time *in vitro*

The first germination was observed after one day after seeding while the final germination was obtained before six days. The municipal solid waste compost extract at 10⁻¹-10⁻⁶ concentrations increased seed germination comparing with the control treatment (water) with significant differences marked at 10⁻²-10⁻⁶ concentrations (Figure 1). However, when pure (10⁰ concentration) extract used, seed germination was delayed (up to 3 days) and reduced up to 69% compared with control treatment, and this may be attributed to high EC and pH values of MSWC extract (1:1.5 v/v; EC: 11.21 dS m⁻¹; pH: 6.87), being in agreement with relevant studies contacted with MSWC in marigold and basil seedling production [13]. In previous studies, it was reported that there was no inhibition of germination in case of cucumber seeds in relation to the control treatment when MSWC:water extracts used [19]. The MSWC extract increased shoot length at concentrations of 10⁻¹ and root radicle

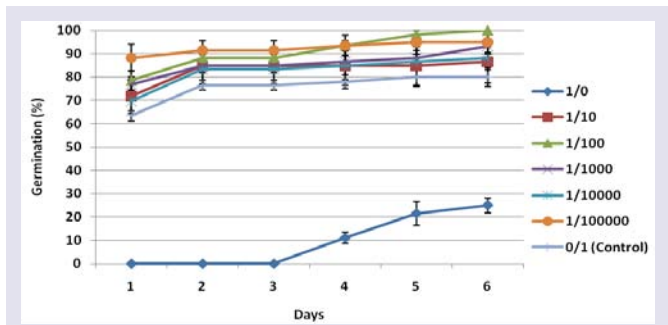


Figure 1: Effects of municipal solid waste compost extracts at concentrations (10^0 – 10^{-6}) on cumulative seed germination of melon *in vitro*. Values represent mean (\pm SE) of measurements made on four Petri dishes (25 seeds per Petri dish) per treatment.

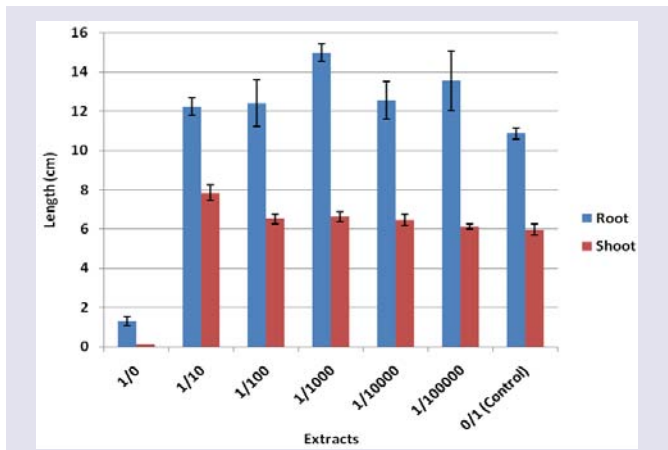


Figure 2: Effects of municipal solid waste compost extracts at concentrations (10^0 – 10^{-6}) on shoot and root length of melon, *in vitro*. Values represent mean (\pm SE) of measurements made (five radicle/dish) on four Petri dishes per treatment.

length at concentrations of 10^{-1} – 10^{-6} of germinated seeds comparing with the water treatment, while the pure MSWC extract inhibited germination (Figure 2). Similar findings observed in previous studies when olive-mill wastes extracts used for seed priming procedure in lettuce and radish [20]. Moreover, severe reduction in root length and shoot length were observed for the cucumber seeds treated with 1:7.5 MSWC:water extracts [19]. The stimulatory effects due to the MSWC extract on seed germination may help early seed germination, providing a higher competitive ability [21] and reducing losses in seed germination.

Seed germination and emergence time *in vivo*

The first seed emergence observed at four days after sowing (Figure 3). When the MSWC amount increased into the substrate it delayed the emergence time and reduced seed emergence percentage initially, but there were no differences after 8 days and so on. Seed emergence was reduced up to 24% and 80% when 60% and 100% of the MSWC were added, respectively and this is possible due to the fact that the MSWC provided nutrients as organic material and increased EC values (see Figure 1). Indeed, no differences were observed in seed emergence when <30% MSWC was used. Moreover, increasing the MSWC content into the substrate resulted in MET delayed (up

to 6 days) (Figure 4) which is in accordance with previous studies employing MSWC in marigold seeds emergence [13].

Seedling growth *in vivo*

Substrate with different mixtures of MSWC and peat (P) affected some characteristics of plant growth and yield. Analyses of variance indicated that addition of MSWC in peat significantly reduced seedling height (between 34% and 87%) and dry matter content (between 34% and 100%) (Table 1) which are in agreement with previous studies in cucumber seedlings [15]. Seedling resistance to transplant stress is directly related to dry matter content, which improves seedling establishment in the soil or growth substrate [22]. Leaf number and seedling fresh weight reduced in MSWC content $\geq 30\%$ while no differences observed between control [P:MSWC (100:0%)] and P:MSWC (85:15%). MSWC add of 15-45% into peat accelerated (up to 36%) stem diameter while MSWC content greater than 60% reduced significantly the stem diameter comparing with the control (see Table 1).

The increase MSWC content (between 15% and 60%) into the substrate resulted in increased K and Na content of seedlings biomass providing nutritive value for the examined substrates but decreased

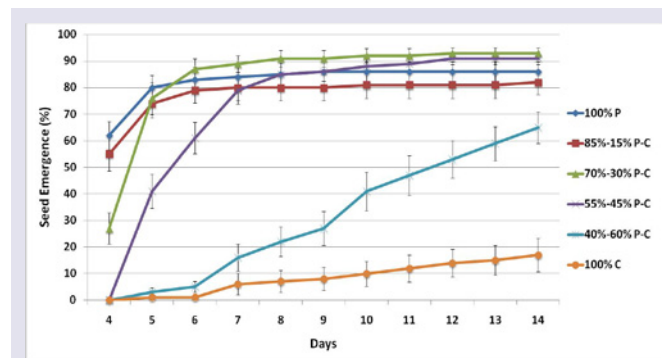


Figure 3: Impact of municipal solid waste compost (C) in different ratios with commercial peat (P) on cumulative seedling emergence of melon seeds germinated in greenhouse nursery. Values represent mean (\pm SE) of measurements made on 5 independent replication (4 wells per replication; 5 seeds per well) per treatment.

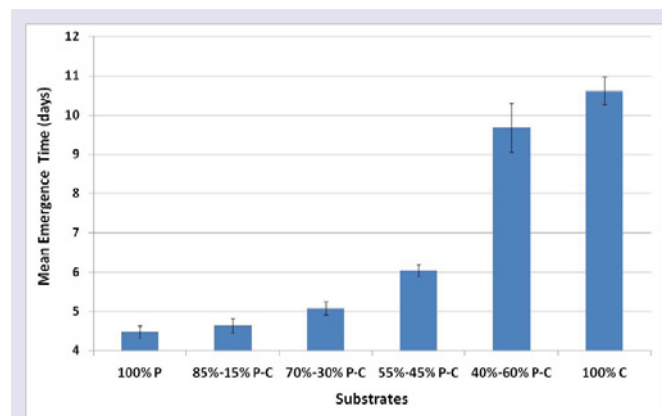


Figure 4: Impact of municipal solid waste compost (C) in different ratio with commercial peat (P) in mean emergence time for melon seeds germinated in greenhouse nursery. Values represent mean (\pm SE) of measurements made on 5 independent replication (4 wells per replication; 5 seeds per well) per treatment.

Table 1: Impact of municipal solid waste compost (C) in different ratio with commercial peat (P) on seedling height (cm/plant), number of leaf produced, stem diameter (mm), fresh weight (g/plant), dry matter content (%) and on leaf elemental (potassium-K, phosphorus-P, sodium-Na, nitrogen-N) concentration (mg/g fresh weight) on melon plant grown in nursery.

	Height	Leaf No	Stem diameter	Fresh weight	Dry matter	N	K	P	Na
P:C (100:0)	25.88 a ^Y	5.51 a	2.85 c	6.20 a	13.28 a	4.20 b ^Z	0.104 b ^Z	0.0069 a ^Z	0.022 c ^Z
P:C (85:15)	17.02 b	5.83 a	4.47 a	6.23 a	8.80 b	6.10 a	0.118 b	0.0066 a	0.060 b
P:C (70:30)	13.05 b	3.50 b	4.04 ab	4.63 b	8.25 b	4.43 b	0.111 b	0.0073 a	0.063 b
P:C (55:45)	11.88 b	3.81 b	3.67 b	4.21 b	7.51 b	3.95 b	0.114 b	0.0032 c	0.058 b
P:C (40:60)	5.97 bc	1.61 c	1.85 d	2.65 c	6.94 c	3.40 b	0.159 a	0.0052 b	0.078 a
P:C (0:100)	3.41 c	0.21 d	0.45 e	0.00 d	0.00 d	0.00 c	0.000 c	0.0000 d	0.000 d

^Y values (n=6) in columns followed by the same letter are not significantly different, $P \leq 0.05$.

^Z values [represent measurements made on 3 replication (3 seedlings mixed per replication) per treatment] in columns followed by the same letter are not significantly different, $P \leq 0.05$.

Table 2: Impact of municipal solid waste compost (MSWC) in different ratio with commercial peat (CP) on leaf fluoresces (Fv/Fm), Chlorophyll a (Chla; $\mu\text{g/g fw}$), Chlorophyll b (Chlb; $\mu\text{g/g fw}$), total carotenoids (Car; $\mu\text{g/g fw}$), leaf photosynthetic rate (P_n ; $\mu\text{mol m}^{-2} \text{s}^{-1}$), leaf stomatal conductance (g_s ; $\mu\text{mol m}^{-2} \text{s}^{-1}$) and leaf internal CO_2 concentration (c_i ; $\mu\text{mol mol}^{-1}$) on melon plant grown in nursery.

	Fluoresces	Chla	Chlb	Car	P_n	g_s	c_i
P:C (100:0)	0.73 b ^Y	58.06 a	38.80 b	25.21 a	4.43 b	0.096 ab	314.63 a
P:C (85:15)	0.82 a	54.65 a	41.14 b	25.68 a	6.77 ab	0.089 ab	251.93 b
P:C (70:30)	0.81 a	52.16 b	52.53 a	22.08 b	9.10 a	0.130 a	247.61 b
P:C (55:45)	0.73 b	47.46 c	47.80 ab	20.09 b	5.09 b	0.052 b	214.30 b
P:C (40:60)	0.54 b	52.91 ab	50.17 ab	22.96 ab	6.80 ab	0.075 ab	234.13 b
P:C (0:100)	0.00 c	0.00 d	0.00 c	0.00 c	0.00 c	0.000 c	0.00 c

^Y values (n=6) in columns followed by the same letter are not significantly different, $P \leq 0.05$.

P content for P:MSWC (55:45%) and P:MSWC (40:60%). Nitrogen content did not change among the different MSWC contents with exception the P:MSWC (85:15%) which marked an increased value, comparing with the control. It's worthwhile to mention that seedlings in 100% MSWC did not survive (grown) as a consequence this treatment was not possible to be analysed further.

Leaf fluoresces increased in seedlings grown in P:MSWC (85:15%) and P:MSWC (70:30%) (see Table 2). The content of Chla and total carotenoids decreased in P:MSWC (70:30%) and P:MSWC (55:45%) comparing with the control while the leaf photosynthetic rate and Chlb content increased in case of P:MSWC (70:30%) possible due to the better physiological status of plant development and/or improved media physicochemical properties. The addition of MSWC into the substrate reduced leaf internal concentration of CO_2 . No major differences were observed in leaf stomatal conductance among treatments.

The rapid and uniform seed emergence is an essential prerequisite to increase yield, quality, and profit. Slow emergence results in smaller plants and seedlings, which are more vulnerable to soil-borne diseases while extended emergence periods predispose the planting bed to deterioration and increased soil compaction, particularly under adverse environmental conditions [23]. Although there is no single, ideal growth medium for nursery-produced horticultural crops [24], most greenhouse-grown species display better growth at slight acid pH values (5.2–7.0); peat mixtures approached these values but MSWC did not. Like pH levels, the highest initial substrate EC values were recorded for mixtures containing MSWC. Ribeiro and e Santos [25] reported that substrates with high EC values reduced water retention, negatively affecting the imbibing process and may delay seed emergence rates.

Thus, seedlings grown in the MSWC mixtures in high content displayed worse plant development and suitability for seedling production, possible due to increased EC and/or alternated medium physicochemical properties. Low content (up to 30%) of MSWC may act as an alternative substitute of peat for melon seedling production, while additional fertigation may need to be examined in future study.

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