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The Effect of Composted and Un-Composted Date-Palm Waste as a Media on Some Microelements of Tomato Fruit

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Abstract

The experiment was conducted as spilt factorial in a completely randomized block design with 9 treatments and 4 replications under greenhouse condition. Treatments were three composting times (C) and three sizes (S) included: C_1S_1*= (size 0-0.5 cm + 0 month composted),* C_2S_1*= (size 0-0.5 cm + 3 months composted),* C_3S_1*= (size 0-0.5 cm + 6 months composted),* C_1S_2*= (size 0.5-1 cm + 0 month composted),* C_2S_2*= (size 0.5-1 cm + 3 months composted),* C_3S_2*= (size 0.5-1 cm + 6 months composted),* C_1S_3*= (size 1-2 cm + 0 month composted),* C_2S_3*= (size 1-2 cm + 3 months composted),* C_3S_3*= (size 1-2 cm + 6 months composted). During cultivation, the Papadopolus formula was used as fertigation solution. To compare the effect of plant cultivation, we measured the effects of the same treatments on media without plant. Statistical analysis showed concentrations of Mn, Cu, Fe and Zn were significantly increased at the end of cultivation from culture media without and with plant in compare to before planting (*$P<0.05$*). Amounts of Mn, Cu, Zn and Fe in tomato fruit and leaf differed significantly depending on composting time and particle size of culture media (*$P< 0.05$*). Maximum concentrations of Mn, Cu, Zn and Fe in tomato fruit and leaf indicated that culture media 6 months composted and size 0.5-1 cm increased microelements of tomato fruit and leaf more than the other treatments. The overall results of this research showed that properties of culture media, media irrigation with nutrient solution and micronutrients absorption by plants were determinant of amounts of available microelements in culture media before and after planting. Also the characteristics of the growing media determined the amounts of microelements in tomato fruit and leaf.*

Keywords: Soilless culture, date-palm waste, composting time, size, microelements.

Introduction

Soilless culture is an artificial means of providing plants with support and a reservoir for nutrients and water. Successful production of container-grown plants is dependent on the physical and chemical properties of the growing media selected. Some critical physical and chemical properties need to be evaluated before making a media decision[1]. Therefore components of soilless substrates must have stable physical and chemical properties during plant cultivation. The biostability of alternative substrates varies considerably, which also affects the chemical properties of substrates, their management and the growth of plants. The 'ideal substrate' proposed by Abad et al.[2] had the following chemical characteristics: pH = 5.2 – 6.3; EC (dSm^{-1}) = 0.75 – 3.49; OM (%) > 80; NO_3-N (_gml^{-1}) = 100 – 199; K+ (_gml^{-1}) = 150–249; Na+ (_gml^{-1}) = <115; Cl- (_gml^{-1}) = <180 and SO_2- 4 –S (_g ml-1) = < 960. Also the amount of pore space and the continuity of pores in container media are the most critical physical characteristics which influence water and nutrient absorption and gas exchange by the root system[3]. Nowadays, numerous studies have demonstrated that the organic residues, including livestock solid waste, sewage sludge and even green plant waste, after proper composting, could be used with very desirable results as growth media[4]. Date-Palm extensively exists in the world and produces a lot of waste per annum[5]. Samiei et al.[6] investigated the effect of peat moss and date-palm wastes as substrates on growing of Aglaonema and their results showed that peat moss and date-palm peat were similar in some characteristics such as CEC, pH, EC and organic carbon but water holding capacity in peat moss was higher than date-palm peat and date-palm waste could be replaced with peat moss substrates. The use of palm waste cellulose as a substitute for common growing media in Aglaonema growing was investigated by Basirat[7] and showed that palm celluloid waste could be used as a media individually; and also as an amendment for other media such as sugarcane compost. Mohammadi-Ghehsareh et al.[8] and Borji et al.[9] showed that date-palm waste could be a media for soilless culture with suitable physical and chemical properties, available and low cost in compare to perlite and coco peat. The objective of this research was to assess the effect of composted and un-composted date-palm waste as a media on some microelements of tomato fruit.

Material and Methods

This research was carried out in the greenhouse research site of Isfahan Azad University (Khorasgan) in Iran. The experiment was conducted as split factorial in a completely randomized block design with 9 treatments and 4 replications. Palm wastes were chopped, sieved and separated in three sizes (<0.5 cm, 0.5-1 cm and 1-2 cm). Then, they were kept in 1.5 m^3 plastic bags for composting. Animal fertilizer (200 gram Cow manure), mineral N (450 gram Urea Fertilizer) and P (200 gram Superphosphate) were added to the wastes and the bags were placed in hot condition. For respiration, some air holes were made on the bags and the moisture was adjusted to 65%. Every week, the materials were mixed and put into the bags again (during the 3 and 6 months after the starting date). Then, the processed palm wastes were used as culture media for tomato cultivation. Treatments were three composting times (C) and three sizes (S) included: C_1S_1= (size 0-0.5 cm + 0 month composted), C_2S_1= (size 0-0.5 cm + 3 months composted), C_3S_1= (size 0-0.5 cm + 6 months composted), C_1S_2= (size 0.5-1 cm + 0 month composted), C_2S_2= (size 0.5-1 cm + 3 months composted), C_3S_2= (size 0.5-1 cm + 6 months composted), C_1S_3= (size 1-2 cm + 0 month composted), C_2S_3= (size 1-2 cm + 3 months composted), C_3S_3= (size 1-2 cm + 6 months composted). Seeds of tomato (Izmir cultivar) were planted in cocopeat and transferred to 10 L pots filled with palm wastes. One plant was grown per replicate. Average temperature of day and night were 30 and 18°C respectively in greenhouse. During cultivation, irrigation was done by hand and Papadopolus[10] formula was used as fertigation solution. Leaching of pots (culture media) were performed every fifteen days for prevention of salt accumulation in the pots.

Some physiochemical characteristics of the culture media including bulk density and porosity[11], carbon to nitrogen ratio (C/N)[12], water holding capacity (WHC)[13], cation exchange capacity (CEC)[12], electrical conductivity (EC) and pH[14] were measured. To compare the effect of plant cultivation, we measured also the effects of the same treatments on media without plant. Table 1 illustrates average of some physicochemical properties of culture media with four replications before planting.

For measuring available iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn) of date palm waste, samples were extracted by $CaCl_2$. 2 H_2O + DTPA then available Fe, Mn, Cu and Zn were read by Atomic absorption model of Perkin Elmer Analyst 800. Concentrations of Fe, Mn, Cu and Zn in tomato fruit and leaf were determined based on dry matter and read by atomic absorption model of Perkin Elmer Analyst 800. Experimental data normality was verified, and then data were submitted to analysis of variance, using SAS[15] software package. Means were compared using Duncan multiple test ($p< 0.05$).

Results and Discussion

Table 2 shows comparison means of some available microelements of culture media before planting, at the end of cultivation from culture media without and with tomato plant. Amounts of available Mn, Cu, Fe and Zn in culture media before planting were significantly lower than culture media without and with plant ($p< 0.05$). It was because of irrigation of culture media with nutrient solution during experiment. Also amounts of available Mn, Cu, Fe and Zn in treatments without plant were significantly higher than treatments with plant ($p<0.05$). It could be due to continue composting process in culture media without plant. Carbon compounds present in organic materials are used by microorganisms as an energy source, transformed into carbon dioxide and released into the environment. As carbon is lost from the compost pile, the compost becomes more condensed and air spaces within the pile become smaller[16]. Therefore weight of primary matter is decreased and it increases mineral elements concentrations. Also in culture media with plant, when media was fertigated with nutrient solution, some of nutrient elements were used by plants and microorganisms. Therefore media with plant had lower content of available elements and led to decrease in waste decomposition compared with treatments without plant. The effects of composting times, sizes and their interaction on some microelements of tomato fruit and leaf are presented in tables 3 and 4 respectively.

Table-1
Some physicochemical properties of culture media before planting

Treatments		pH	BD	Porosity	WHC	EC	CEC	C/N
Composting time	**Size**	**-**	**(g/cm^3)**	**(%)**	**(%)**	**(ds/m)**	**Cmol/kg)**	**(%)**
C_1S_1 = 0 month	<0.5 cm	6.84	0.25	83	89.65	6.29	38.85	37.88
C_2S_1= 3 months	<0.5 cm	6.72	0.18	88	94.26	5.68	47.49	29.85
C_3S_1= 6 months	<0.5 cm	6.91	0.19	87	92.62	5.99	59.11	25.43
C_1S_2= 0 month	0.5-1 cm	6.74	0.17	89	57.5	3.91	28.84	40.83
C_2S_2= 3 months	0.5-1 cm	6.62	0.18	88	74.57	4.42	36.26	33.56
C_3S_2= 6 months	0.5-1 cm	6.86	0.19	87	58.91	4.62	38.3	28.2
C_1S_3= 0 month	1-2 cm	6.69	0.15	90	37.75	3.41	18.22	43.67
C_2S_3= 3 months	1-2 cm	6.54	0.16	89	53.48	3.8	28.99	30.76
C_3S_3= 6 months	1-2 cm	6.82	0.17	88	59.31	4.97	34.95	23.68

BD: bulk density, WHC: water holding capacity, EC: electrical conductivity, CEC: cation exchange capacity, C/N: carbon to nitrogen ratio.

Table-2
Comparison means of some available microelements of the culture media before planting (b), at the end of cultivation from culture media without (c) and with plant (p)

Microelements (mg/kg)	Treatment								
	C_1S_1	C_2S_1	C_3S_1	C_1S_2	C_2S_2	C_3S_2	C_1S_3	C_2S_3	C_3S_3
$(Mn)_b$	35.15^c	37.16^c	43.48^c	33.75^c	36.48^c	38.4^c	27.39^c	29.48^c	35.22^c
$(Mn)_p$	39^b	47^b	69.02^b	36^b	41.5^b	53.75^b	21^b	27^b	36^b
$(Mn)_c$	48.9^a	53.24^a	66.65^a	37.62^a	48.2^a	58.6^a	31.62^a	38.6^a	40.15^a
$(Cu)_b$	0.87^c	1.23^c	1.26^c	0.70^c	0.79^c	1.17^c	0.64^c	0.81^c	0.71^c
$(Cu)_p$	1.04^b	1.17^b	1.68^b	1.04^b	1.62^b	1.89^b	1.22^b	1.35^b	1.63^b
$(Cu)_c$	2.43^a	2.84^a	3.03^a	2.12^a	2.46^a	2.78^a	2^a	2.32^a	2.69^a
$(Fe)_b$	23.3^c	34.46^c	36.69^b	20.97^c	28.72^c	35.82^c	14.57^c	20.35^c	35.14^c
$(Fe)_p$	27.4^b	39.29^b	47.75^a	24.5^b	29.97^b	38.5^b	24.25^b	25.11^b	38.25^b
$(Fe)_c$	34.2^a	47.3^a	59.5^a	27.8^a	33.2^a	44^a	28.02^a	30.1^a	40^a
$(Zn)_b$	11.11^c	18.1^c	20.23^c	10.18^c	11.62^c	15.49^c	8.87^c	10.8^c	13.82^c
$(Zn)_p$	21.1^b	24.3^b	28.4^b	18.12^b	23.37^b	27.01^b	17.2^b	18.9^b	25.11^b
$(Zn)_c$	28.9^a	30.02^a	39^a	24.13^a	27.2^a	31^a	21^a	20^a	27.1^a

Means followed by the same letter are not significantly different according to Duncan's Multiple Range test, $p < 0.05$. C_1S_1: (size 0-0.5 cm + 0 month composted), C_2S_1: (size 0-0.5 cm + 3 months composted), C_3S_1: (size 0-0.5 cm + 6 months composted), C_1S_2: (size 0.5-1 cm + 0 month composted), C_2S_2: (size 0.5-1 cm + 3 months composted), C_3S_2: (size 0.5-1 cm + 6 months composted), C_1S_3: (size 1-2 cm + 0 month composted), C_2S_3: (size 1-2 cm + 3 months composted), C_3S_3: (size 1-2 cm + 6 months composted).

Table-3
The effects of different composting times and sizes of culture media on some microelements of tomato fruit

Treatment	Mn (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Zn (mg/kg)
Composting time				
C_1=0 month	11.54^b	1.41^c	19.66^c	1.32^c
C_2=3 months	11.6^b	1.47^b	21.9^b	1.49^b
C_3=6 months	14.24^a	1.68^a	22.08^a	1.64^a
Size				
S_1=< 0.5 cm	10.76^b	1.3^c	19.87^c	1.44^b
S_2=0.5-1 cm	13.86^a	1.6^a	23.41^a	1.53^a
S_3=1-2 cm	12.75^a	1.42^b	20.36^b	1.48^b
Significance of main effects and mean separation values for interactions				
Composting	*	*	*	*
Size	*	*	*	*
Composting × Size	NS	*	*	NS

Means followed by the same letter are not significantly different according to Duncan's Multiple Range test, $p < 0.05$. * Significant at α= 0.05 probability level; NS = non significant.

Table-4
The effects of different composting times and sizes of culture media on some microelements of tomato leaf

Treatment	Mn (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Zn (mg/kg)
Composting time				
C_1=0 month	53.2^c	15.21^b	61.02^c	26.37^c
C_2=3 months	54.47^b	15.61^a	81.01^b	27.11^b
C_3=6 months	55.8^a	15.8^a	89.76^a	28.95^a
Size				
S_1=< 0.5 cm	51.98^c	15.34^b	75.02^c	26.68^c
S_2=0.5-1 cm	58.31^a	15.65^a	79.49^a	29.35^a
S_3=1-2 cm	53.36^b	15.64^a	76.36^b	27.4^b
Significance of main effects and mean separation values for interactions				
Composting	*	*	*	*
Size	*	*	*	*
Composting × Size	*	NS	*	*

Means followed by the same letter are not significantly different according to Duncan's Multiple Range test, $p < 0.05$. * Significant at α= 0.05 probability level; NS = non significant.

Statistical analysis showed that composting time of culture media had a significant effect on concentrations of Mn, Cu, Fe and Zn in tomato fruit and leaf ($p< 0.05$). Highest concentrations of Mn, Cu, Fe and Zn in tomato fruit and leaf were significantly related to media C_3. It could be due to maturity of compost in C_3 in compare to other treatments. In mature compost biological activity has been decreased and required nutrients are present in adequate amounts for plant growth. A fine texture, dark color, and a rich earthy smell often characterize mature composts but Forster et al.[17] reported the best definition for maturity of compost is applied concept of it with attention to plant response.

Results illustrated that concentrations of Mn, Cu, Fe and Zn in tomato fruit and leaf were significantly affected by size of culture media ($p< 0.05$). Maximum concentrations of Mn, Cu, Fe and Zn in tomato fruit and leaf were significantly observed in size S_2. This result showed size 0.5-1 cm was a good growing media providing sufficient anchorage to the plant, served as reservoir for nutrients and water, allowing oxygen diffusion to the roots and permitting gaseous exchange between the roots and atmosphere outside the root of culture media in compare with the other sizes. Benito et al.[18] reported the best substrate is that with medium to coarse texture that allows retention of enough readily available water together with adequate air content. A significant composting time × size interaction ($p< 0.05$) occurred for Fe, Mn and Zn in tomato leaf and Fe and Cu in tomato fruit indicating that culture media 6 months composted with size 0.5-1 cm increased these microelements in tomato fruit and leaf compared with other treatments. Borji et al.[9] reported different substrates (date-palm peat, perlite, and perlite + date-palm peat) had a significant effect in concentrations of Fe and Mn in tomato fruit so that the highest amounts of Mn and Fe in tomato fruit were related to date-palm peat ($p< 0.05$).

Conclusion

The results of this research showed that properties of culture media, media irrigation with nutrient solution and microelements absorption by plants were determinant of amounts of available microelements in culture media before and after planting. Also the results illustrated that culture media with size 0.5-1cm and composting time of 6 months created the highest microelements in tomato fruit and leaf. Therefore the characteristics of the growing media determined the amounts of microelements in tomato fruit and leaf. Nutrient elements content is important for the nutritional value of tomato especially iron; it has an important role in tomato nutrition and fruit quality. The overall results illustrated that composting time of 6 months and size 0.5-1 can be considered as a proper treatment for palm waste in soilless culture.

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