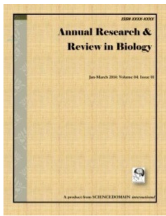

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Evaluation of Chemical Properties of Date-Palm Waste as Culture Media and Its Effect on Number and Yield of Tomato

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Authors' contributions

This work was carried out in collaboration between two authors. Author AMG designed the study, wrote the protocol and wrote the first draft of the manuscript. Author MS performed the statistical analysis, managed the analyses of the study, and managed the literature search. Both two authors read and approved the final manuscript.

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ABSTRACT

Aims: The objective of this research was to evaluate the chemical properties of Date-Palm waste as culture media and its effect on number and yield of tomato fruit.
Study Design: The experiment was conducted as factorial in a completely randomized block design with 9 treatments and 3 replications. Treatments included three sizes (S_1= <0.5, S_2=0.5-1 and S_3=1-2 cm) and three composting times (C_1=0, C_2=3 and C_3=6 months) of date palm waste.
Place and Duration of Study: This research was performed in the greenhouse research site of Isfahan Azad University (Khorasgan) from 2011 to 2012.
Methodology: Palm wastes were separated in three sizes (<0.5, 0.5-1 and 1-2 cm) and composted during the 3 and 6 months. Then, these materials were used as culture media for tomato cultivation. To compare the effect of plant cultivation, the same treatments were used for media without plant. Some chemical characteristics of the culture media including carbon to nitrogen ratio (C/N), cation exchange capacity (CEC), electrical conductivity (EC) and pH were measured before planting, and

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at the end of cultivation from culture medias without and with plant. Number, yield and firmness of tomato fruit were measured.
Results: Statistical analysis showed values of pH and CEC 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 EC in culture media before planting were significantly higher than culture media without and with plant ($P<0.05$). Also a significant reduction C/N ratio was occurred in culture media without plant in compare with culture media before planting and culture media with plant ($P<0.05$). Mature compost (C_3S_2) significantly increased number and yield of tomato fruit.
Conclusion: The overall results indicated composting process changed chemical properties of the media and difference in chemical properties of media had effect on yield and number of tomato fruit.

Keywords: Soilless culture; culture media; date-palm waste; chemical properties.

1. INTRODUCTION

The basic requirements for plant growing media are excellent chemical resistance properties, light weighted, inexpensive, free of pests and diseases and abundant in source materials [1]. Other than that, it also needs some essential requirements such as permeability and strength to support the plant and maintain crops growth [2] and the ability of the growing medium to retain water and transport gasses might be of importance for the keeping quality of plants [3]. The 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. [4] had the following chemical characteristics: pH = 5.2 – 6.3; EC (dSm-1) = 0.75 – 3.49; OM (%)= > 80; NO3 (gml-1) = 100 – 199; K+ (gml-1) = 150–249; Na+ (gml-1) = <115; Cl- (gml-1) = <180 and SO42- (gml-1) = < 960. In order to satisfy these important requirements, it is necessary to control the growing media structure carefully. Currently, the types of soilless growing media commonly used are wood residues, bark, rice hulls, sand, perlite, vermiculite, calcined clays, peat moss and rockwool [5]. Date-Palm extensively exists in the world [6]. The number of the date palms is about 100 million worldwide, of which 62 million palms can be found in the Arab world. The place of origin of the date palm is uncertain. Some claim that the date palm first originated in Babel, Iraq, while others believe that it originated in Dareen or Hofuf, Saudi Arabia or Harqan and an island on the Persian Gulf in Iran. The date palm tree grows up to 99 feet tall with leaves that are between 14 and 16 feet in length. The leaves grow around the trunk in a spiral pattern [7]. Based on published statistics, more than 180,000 ha of the Iran's lands are under the date palm cultivation. When the old leaves begin to get dried, they are cut and collected. During a year, about 15 to 25 leaves are picked out from the tree. In addition, the leaf frame and husk, around it, must be pollarded from the tree. The average weight of every palm leaf is between 2 and 3 kg, and paying attention to some millions of date palm trees, the waste volume is very high. Recently, most of the residuals of the palm grove were burnt. In some areas, the date palm leaves are used for making shade, alcove, break wind, and as a cover for new planted saplings of fruit trees like date palm tree. Samiei et al. [8] investigated the effect of peat moss and date-palm waste 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 can be replaced with peat moss. Mohammadi Ghehsareh et al. [9] showed that date-palm could be a media for soilless culture with available and low cost. Hematian et al. [10] investigated the effect of addition of some organic waste to soil on yield and some growth indices of greenhouse cucumber and reported higher yield were obtained from pure palm peat media. The objective of this research was to evaluate the chemical properties of Date-Palm waste as culture media in tomato soilless culture and its effect on number and yield of tomato fruit.

2. MATERIALS AND METHODS

This research was performed in the greenhouse research site of Isfahan Azad University (Khorasgan). The experiment was conducted as factorial in a completely randomized block design with 9 treatments and 3 replications. Palm wastes were chopped into smaller sizes and chopped wastes are separated in three sizes

(<0.5, 0.5-1 and 1-2 cm) by sieve. Then, they were kept in 1.5 m^3 plastic bags for controlling the moisture and temperature. Some amounts of animal fertilizer, N and P fertilizers were added to them as a fermentation starter and these bags were placed in hot (25 to 30℃) condition. For respiration, some air holes were made on the bags and the moisture was adjusted to 65%. Every week, these materials were mixed together and put into the bags again (During the 3 and 6 months). Then, these date palm wastes were used as culture media for tomato cultivation. Treatments were three composting times (C) and three sizes (S) included: C_1S_1= (0 month composted + size 0-0.5 cm), C_2S_1= (3 months composted + size 0-0.5 cm), C_3S_1= (6 months composted + size 0-0.5 cm), C_1S_2= (0 month composted + size 0.5-1 cm), C_2S_2= (3 months composted + size 0.5-1 cm), C_3S_2= (6 months composted + size 0.5-1 cm), C_1S_3= (0 month composted + size 1-2 cm), C_2S_3= (3 months composted + size 1-2 cm), C_3S_3= (6 months composted + size 1-2 cm). To compare the effect of plant cultivation, the same treatments were used for media without plant. Chemical characteristics of the culture media including organic carbon (% OC) [11], cation exchange capacity (CEC) [12], total nitrogen (N) [13,14], electrical conductivity (EC) and pH [15] were measured before planting, and at the end of cultivation from culture medias without and with plant. For culture media with plant, seeds of tomato (Izmir cultivar) were planted in cocopeat. After transplanting growth, they were transferred to 10 liter pots filled with above treatments. Irrigation was done by hand and Papadopolus formula [16] with fertigation method was used as nutrient solution for treatments without and with plant. Average temperature of day and night were 30 and 18ºC respectively in greenhouse. During plant growth, irrigation rate, temperature, humidity and pest control for all treatments were similar. Leaching (20%) of all treatments was performed every fifteen days. Number, yield (by digital scale) and firmness (by Penetrometer) of tomato fruit were measured. Experimental data normality was verified, and then data were submitted to analysis of variance, using SAS [17] software package. Means were compared using Duncan multiple test P< 0.05.

3. RESULTS AND DISCUSSION

In the beginning of composting period, temperature of pill in all sizes were 25ºC and it increased with time until 15 days (45-47ºC) and then it decreased with time so the temperature of pill in 30, 60, 90, 120 and 180 days after starting for three sizes (<0.5, 0.5-1 and 1-2 cm) were 41-43ºC, 33ºC, 28-31ºC, 28-29ºC and 25ºC respectively. Chemical properties of culture media before planting, without and with plant are illustrated in Table 1. Before planting, the highest pH value was significantly recorded in the culture media C_3S_1 (P<0.05). Maximum pH values in culture media without and with plant were related to culture media C_1S_3 (P<0.05). It could be due to this matter that composting itself leads to major changes in materials and their pH, as decomposition occurs. The initial decrease in pH is due to the formation of organic acids that are formed during rapid degradation which can occur prior to composting. The subsequent increase in pH is due to volatilization of organic acids, and accumulation of ammonia [18]. Hachicha et al. [19] reported higher surface area in smaller particles caused more decomposition of organic matter and more production of organic acids. Highest amount of EC before planting was significantly observed in culture media C_1S_1 (P< 0.05). It could be due to increase of dissolution of solutes in smaller sizes which had effect on EC. High EC in palm wastes was due to this matter that dust and solution salt particles had covered date palm leaves and when date palm wastes were chopped and sieved, these fractions were released. Also maximum EC in culture media without and with plant was significantly related to culture media C_3S_1 (P<0.05). Carbon (C) compounds present in organic materials are used by microorganisms as an energy source, transformed into carbon dioxide (CO_2) and released into the environment. As C is lost from the compost pile, the compost becomes more condensed and air spaces within the pile become smaller [20]. Therefore weight of primary matter is decreased and it increases mineral elements concentration and EC. Also with increasing composting time, microbial activity was increased and it released more solutes which had effect on EC. The highest amounts of CEC before planting and in culture media without and with plant were significantly related to culture media C_3S_1 (P<0.05). It was because of smaller sizes had a larger surface area. Also with increasing of composting time, CEC was increased. Fontanive et al. [21] reported CEC increased through the composting process was due to changing of organic matters and transforming into humic, whenever humification was more increased, the CEC went higher and compost quality was improved.

The lowest amount of C/N ratio in culture media without and with plant was significantly observed in culture media C_3S_1 (P<0.05). Minimum C/N ratio before planting was related to culture media C_3S_3 (P<0.05). Microorganisms need carbon and nitrogen for their metabolism; breaking of carbon-bonds rich in energy supplies microorganisms with energy, while nitrogen is incorporated into amino acids to build proteins [22]. Smaller particles of organic material increase the surface area available for microbial attack. However, very small particles pack tightly together; preventing movement of air into the composting heap and movement of carbon dioxide out of the heap. Large size particles reduce surface area for microbial attack which slows down or may stop composting process altogether [23].

Means comparison of culture media's chemical properties before planting, at the end of cultivation from culture media without and with plant are shown in Table 2. During the experiment apparent shift in measured values was recorded. Values of pH were significantly increased at the end of cultivation from culture media without and with plant in compare to before planting (P<0.05). It could be due to continue composting process in all culture media. Hernando et al. [24] reported that compost products usually have a near to neutral or slightly alkaline pH with a high buffering capacity.

Amounts of EC in culture media before planting were significantly higher than culture media without and with plant (P<0.05). It was because of leaching of culture media during experiment. A high salt concentration constitutes a critical and significant limiting factor, particularly in nursery production, since the early growth stages of the plant are very sensitive to growing media salinity [25]. Therefore Abad et al. [26] reported leaching the composts with water decreased substantially the salinity and the concentration of soluble mineral elements. Also amounts of EC in treatments with plant, were significantly lower than treatments without plant (P<0.05). It could be due to nutrients absorption by plants during the experiment. Amounts of CEC in culture media without plant were significantly higher than culture media with plant and before planting (P<0.05). Also a significant reduction C/N ratio in culture media without plant in compare to other culture medias was occurred (P<0.05). As mentioned, it could be due to continue composting process in culture media without and with plant. In culture media with plant, when media was fertigated with nutrient solution, some of nutrient elements were used by plant and microorganisms. Therefore media with plant had lower content of available elements and led to decrease in waste decomposition compared with treatments without plant and this matter affected on CEC and C/N ratio. Organic matter degradation caused particles to be more chopped in compost pile and so surface area and CEC were increased. Also it seems speed of composting process in culture media without plant was higher than culture media with plant (with attention to C/N ratio). The rate of aerobic decomposition is increased with smaller particle size. Therefore, reducing the particle size of raw materials will increase the speed of the composting [27].

Table 3 shows effect of culture media on some tomato fruit properties. Culture media had a significant effect on yield and number of tomato fruit (P<0.05). Treatment C_3S_2 had higher number and yield than other treatments (P<0.05). It could be due to maturity of compost. Maturity is associated with plant-growth potential and mature compost gives plants an advantage in increased nutrients and water availability, and reduces disease pressures [28,29]. Statistical analysis illustrated culture media had no significant effect on firmness of tomato fruits. Fandi et al. [30] showed different substrates (tuff, sand and soil) had no significant effect on tomato fruit firmness in second growing season.

Table 1. Some chemical properties of the culture media

	Treatment	pH	EC	CEC	C/N
		-	(ds/m)	(Cmol/Kg)	(%)
Media before planting	C_1S_1	6.83^{ab}	6.29^{a}	38.83^{c}	37.87^{c}
	C_2S_1	6.72^{cde}	5.68^{c}	47.49^{b}	29.84^{e}
	C_3S_1	6.91^{a}	5.98^{b}	59.23^{a}	25.42^{g}
	C_1S_2	6.74^{bcd}	3.91^{f}	28.83^{e}	40.82^{b}
	C_2S_2	6.62^{ef}	4.42^{e}	36.26^{d}	33.56^{d}
	C_3S_2	6.85^{ab}	4.61^{e}	38.29^{c}	28.2^{f}
	C_1S_3	6.69^{de}	3.4^{g}	18.18^{f}	43.66^{a}
	C_2S_3	6.54^{f}	3.8^{f}	28.98^{e}	30.75^{e}
	C_3S_3	6.82^{abc}	4.96^{d}	38.26^{c}	23.68^{h}
Media without plant	C_1S_1	7.48^{c}	3.5^{b}	41.1^{d}	13.45^{f}
	C_2S_1	$7.5b^{c}$	3.72^{ab}	50.34^{b}	14.51^{f}
	C_3S_1	7.45^{c}	3.96^{a}	61.63^{a}	10.23^{g}
	C_1S_2	7.59^{ab}	3.12^{c}	31.83^{h}	19.82^{b}
	C_2S_2	7.5^{c}	2.96^{dc}	39.14^{f}	16.36^{d}
	C_3S_2	7.52^{abc}	3^{dc}	42.26^{c}	14.45^{e}
	C_1S_3	7.6^{a}	2.72^{d}	21.24^{i}	21.3^{a}
	C_2S_3	7.5^{bc}	2.79^{d}	31.98^{g}	17.41^{c}
	C_3S_3	7.48^{c}	$2.9d^{c}$	40.33^{e}	16.53^{d}
Media with plant	C_1S_1	7.49^{ab}	2.1^{a}	39.2^{c}	36.85^{d}
	C_2S_1	7.48^{b}	2.03^{a}	48.3^{b}	30.44^{e}
	C_3S_1	7.5^{ab}	2.12^{a}	59.76^{a}	26.17^{f}
	C_1S_2	7.5^{ab}	1.51^{c}	29.2^{e}	45.11^{a}
	C_2S_2	7.5^{ab}	1.56^{c}	37.45^{d}	39.07^{c}
	C_3S_2	7.48^{b}	1.73^{b}	39.6^{c}	30.77^{e}
	C_1S_3	7.51^{a}	1.07^{f}	19.79^{f}	40.38^{b}
	C_2S_3	7.49^{ab}	1.22^{e}	29.52^{e}	40.72^{b}
	C_3S_3	7.5^{ab}	1.32^{d}	39.39^{c}	37.09^{d}

Means followed by the same letter are not significantly different according to Duncan's Multiple Range test, $p < 0.05$. EC: electrical conductivity, CEC: cation exchange capacity, C/N: carbon to nitrogen ratio, C_1S_1: (0 month composted + size 0-0.5 cm), C_2S_1: (3 months composted + size 0-0.5 cm), C_3S_1: (6 months composted + size 0-0.5 cm), C_1S_2: (0 month composted + size 0.5-1 cm), C_2S_2: (3 months composted + size 0.5-1 cm), C_3S_2: (6 months composted + size 0.5-1 cm), C_1S_3: (0 month composted + size 1-2 cm), C_2S_3: (3 months composted + size 1-2 cm), C_3S_3: (6 months composted + size 1-2 cm).

Table 2. Means comparison of chemical properties of the culture media before planting (b), at the end of cultivation from culture media without (c) and with plant (p)

Chemical properties	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
$(pH)_b$	6.84^{b}	6.72^{b}	6.91^{b}	6.74^{b}	6.62^{b}	6.86^{b}	6.69^{b}	6.54^{b}	6.82^{b}
$(pH)_p$	7.49^{a}	7.48^{a}	7.50^{a}	7.51^{a}	7.51^{a}	7.48^{a}	7.52^{a}	7.50^{a}	7.50^{a}
$(pH)_c$	7.48^{a}	7.50^{a}	7.45^{a}	7.5^{a}	7.5^{a}	7.52^{a}	7.6^{a}	7.49^{a}	7.48^{a}
$(EC)_b$	6.29^{a}	5.68^{a}	5.99^{a}	3.91^{a}	4.42^{a}	4.62^{a}	3.41^{a}	3.8^{a}	4.97^{a}
$(EC)_p$	2.1^{c}	2.03^{c}	2.1^{c}	1.51^{c}	1.56^{c}	1.7^{c}	1.07^{c}	1.22^{c}	1.3^{c}
$(EC)_c$	3.52^{b}	3.72^{b}	3.96^{b}	3.12^{b}	2.96^{b}	3^{b}	2.72^{b}	2.79^{b}	2.9^{b}
$(CEC)_b$	38.83^{c}	47.49^{c}	59.11^{c}	28.84^{c}	36.26^{c}	38.3^{c}	18.18^{c}	28.98^{c}	38.26^{a}
$(CEC)_p$	39.2^{b}	48.2^{b}	59.76^{b}	29.2^{b}	37.45^{b}	39.6^{b}	19.79^{b}	29.52^{b}	39.38^{a}
$(CEC)_c$	41.10^{a}	50.34^{a}	61.63^{a}	31.83^{a}	39.14^{c}	42.26^{a}	21.24^{a}	31.98^{a}	40.33^{a}
$(C/N)_b$	37.88^{a}	29.85^{a}	25.43^{b}	40.83^{b}	33.56^{b}	28.2^{b}	43.67^{a}	30.76^{b}	37.09^{a}
$(C/N)_p$	36.85^{b}	30.44^{a}	26.17^{a}	45.11^{a}	39.07^{a}	30.77^{a}	40.38^{b}	40.72^{a}	23.68^{b}
$(C/N)_c$	13.45^{c}	14.51^{b}	10.23^{c}	19.82^{c}	16.36^{c}	14.45^{c}	21.3^{c}	17.41^{c}	16.53^{c}

Means followed by the same letter are not significantly different according to Duncan's Multiple Range test, $p < 0.05$. EC: electrical conductivity, CEC: cation exchange capacity, C/N: carbon to nitrogen ratio, C_1S_1: (0 month composted + size 0-0.5 cm), C_2S_1: (3 months composted + size 0-0.5 cm), C_3S_1: (6 months composted + size 0-0.5 cm), C_1S_2: (0 month composted + size 0.5-1 cm), C_2S_2: (3 months composted + size 0.5-1 cm), C_3S_2: (6 months composted + size 0.5-1 cm), C_1S_3: (0 month composted + size 1-2 cm), C_2S_3: (3 months composted + size 1-2 cm), C_3S_3: (6 months composted + size 1-2 cm).

Table 3. Effect of culture media on some tomato fruit properties

Treatment	Fruit yield (Kg)	Fruit number -	Fruit firmness (kg/cm^3)
C_1S_1	9.68^{ab}	73.5^{ab}	10.19
C_2S_1	7.78^{b}	76.5^{ab}	10.1
C_3S_1	9.83^{ab}	69^{ab}	10.38
C_1S_2	8.74^{b}	74.75^{ab}	10.25
C_2S_2	9.78^{ab}	74^{ab}	10.35
C_3S_2	12.12^{a}	80.25^{a}	10.45
C_1S_3	7.45^{b}	66.75^{b}	10.38
C_2S_3	7.45^{b}	65.25^{b}	10.43
C_3S_3	8.92^{b}	67.25^{ab}	10.25

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

4. CONCLUSION

The overall results of this research indicated composting process changed chemical properties of the media. Also during the tomato cultivation, an apparent shift in media chemical properties was recorded. Difference in chemical properties of media had effect on some tomato fruit properties so that mature compost increased yield and number of tomato fruit.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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