African Journal of Biotechnology Vol. 10(24), pp. 4871-4878, 6 June, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB10.2106
ISSN 1684–5315 © 2011 Academic Journals

*Full Length Research Paper*

# Comparison of date-palm wastes and perlite as growth substrates on some tomato growing indexes

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Accepted 8 April, 2011

**Today, various organic matters are used as growth media. Most of them are combined with various materials, such as a mixture of peat moss and pine bark, or a mixture of peat moss and pine bark with mineral materials like perlite or vermiculite. All over the world, stone wool and other materials like perlite, pumice, polyortan phome, zeolite, coco peat and sawdust are used as growth media in soilless culture. The objective of this study was to assess the effects of incubation time on the physicochemical properties of date palm wastes and their effects on growing indexes of tomato in comparison with perlite when used as culture substrates. The date palm wastes were first manually chopped into small pieces, after which they were kept in plastic bags. They were adjusted to 55% moisture content and thoroughly mixed once every week. Treatments were done for 4 incubation times (0, 1, 3 and 9 months). The physicochemical properties of materials were analyzed during 3 months. After 3 months of incubation, for comparison of this composting materials (date-palm) with other substrates, perlite and the composting materials were used as growth media. The research was conducted in a completely randomized design with 6 replications of tomato for 6 months. Treatments included perlite, date-palm1 (without incubation time) and date-palm2 (with 3 months incubation time). During plant growth irrigation rate, temperature, humidity and pest control for all treatments were similar. During plant growth, Papadopolus formula with fertigation method was used for the nutrient solution. The plants were kept for 6 months, then after this period, the physicochemical properties of these materials were analyzed again. So, the growing indexes of tomato, which included fruit yield, plant height, fruit number, stem diameter, TSS and biomass, were measured. The results of incubation time period showed that changes of porosity, bulk density, pH, C/N ratio and CEC had significant differences ($p<0.05$). The C/N ratio reduced, while the bulk density and CEC increased by the increase in incubation time period. Comparison of tomato growing indexes in the different substrates showed that fruit yield, plant height and fruit number of tomato had no significant differences at 5% level, but stem diameter and biomass in date-palm1 was higher than other media and thus, had significant differences at 5% level.**

**Key words:** Date palm wastes, incubation time, aerating, perlite, fertigation, tomato.

## INTRODUCTION

Tomato is commonly produced as an early spring crop or out-of-season in open field, glasshouse or polyethylene tunnel. Pests and diseases in soil culture have always created problems, especially in protected areas (Gul et al., 2005). Material properties of substrate exhibit direct and indirect effects on plant physiology and production (Cantliffe et al., 2001). Many different organic matters are used for growth media. Most of them consist of various materials that are generally the mixture of peat moss, pine bark, or a mixture of peat moss and pine bark together

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with mineral materials like perlite and vermiculite (Bragg, 1990). At the end of the 1960s, producers of Dutch greenhouses encountered serious problems that were due to repeated usage of soil during long years. In subsequent years, the development of using stone wool as a growth media was a revolution in many countries. Besides stone wool, many other substitutes such as perlite, pumise, polyortan phome, zeolite, cocopeat and sawdust were used as growth media in soilless culture all over the world (Epstein et al. 1977; Gericke, 1929). Today, in many countries, soilless culture techniques are used for production, especially in greenhouses (Çlikel, 1999). Fascella and Zizzo (2005) evaluated the influence of perlite and perlite mixed with coconut coir dust (coco peat) (1:1, v/v) on the quantitative and qualitative parameters of cut flower (cv. Anastasia) production. They reported that the mix caused the highest amount of flowers (17.7 stems/plant) and the longest stems (65 cm). Tehranifar et al. (2007) reported that the vegetative growth of a number of strawberry cultivars were higher in the media with peat and coco peat as compared with 100% sand and perlite, and in the media with cocopeat 40% + perlite 60%. In order to grow strawberry, different substrates such as peat moss, coconut coir, perlite, rock wool and pine bark have been used. However, peat has been the best substrate for hydroponic culture (Lieten et al., 2001). Due to high price and non-easy availability of peat moss, its replacement with other substrates has been conducted in developing countries (Cantliffe et al., 2001). There are different reports related to the use of zeolite and perlite as substrates in hydroponic culture (Maloupa et al., 1999). Other properties of zeolites contain high absorption level, water retention and release, high cation exchange capacity (CEC) and high buffering against change of pH (Allen and Ming, 1995). Within perlite and mixtures of perlite and zeolite in 1:1, 2:1 and 1:2 ratios, the ratio of 2:1 increased yield, soluble solides content and quality in tomato. Zeolite, due to high CEC capacity to hold water and nutrient, led to improved yield and fruit quality (Djedidi et al., 1997). Soilless culture of gerbera gave higher yield on perlite/zeolite (P/Z 1:1 ratio) than other mixtures, due to sufficient aeration and improved water retention capacity (Issa et al., 1997). Turhan and Atilla (2004) studied the effect of perlite alone and the mixture of P/Z (1:1 ratio) on ionic composition in "camarosa" strawberry plantlets during the vegetative phase. They found that using P/Z mixtures as substrate to grow strawberry may be beneficial. Zeolite is available in Iran in abundant amounts, and is placed as a second mineral after iron stone.

Permuzic et al. (1998) showed that the quality and quantity of tomato fruit in the organic media was better than that in the inorganic media. The result of tomato, when cultured in different substrates, showed that the highest amount of total yield and numerous fruit was related to perlite + rice hull and the highest amount of total soluble solids (TSS) was related to coco peat substrate (Inden and Torres, 2004). Effect of combination of some substrates, such as perlite and compost, with soil for tomato plant was studied by Javanpour et al. (2005). Their results showed that the quality and quantity of tomato in the different substrates that were used had no significant differences. Effects of different substrates on growth, yield and quality of watermelon in soilless culture were studied by Yetisir et al. (2006) and they showed that the highest vegetative growth was observed in the basaltic mix, sand, peat and soil substrates, respectively. The weakest growth occurred in the mix of andesitic tuff and peat, while the highest and lowest yield was obtained from the perlite and andesitic tuff, and the mix of basaltic tuff substrates, respectively. Effect of the substrate on yield and fruit quality of tomato in soilless culture was studied by Tzortzakis and Economakis, (2008) and they showed that plants grown in pumice and perlite substrates obtained lower total yield, while higher yield was obtained from the maize substrate. Pumice + 50 and 100% maize produced higher total number of fruits per plant. Fruit quality parameters such as mean of fruit weight, fruit firmness, total soluble solid, titrable acidity, ascorbic acid and carotenoids were influenced by substrates, while they had no effect on EC, pH and dry matter content. The results suggested that addition of maize to perlite and pumice could improve properties of inorganic substrates for tomato soilless culture, leading to higher yields and better quality of fruit. Samiei et al. (2005) investigated the effect of peat moss, coco peat and date-palm wastes as substrates on the growth of Aglaonema, and their results showed that the leaf area, dry and wet weight of plant biomass, stool shoots and length of meiophylly in plants, cultured in peat moss and date-palm peat substrates, were similar, but these indexes for coco peat substrate were higher. Their results showed that some characteristics such as CEC, pH, EC and organic carbon in peat moss and date-palm peat substrates were similar, but the water holding capacity in peat moss was higher than in the date-palm peat. They proposed that if this characteristic of date-palm peat improved, it would be a proper substitute in the future.

In composting, the industry needs to analyze the physical, chemical and biological properties of compost to determine the completing degree of composting process with assessing the different changes in physicochemical and biological properties of raw compost (Levanon and Pluda, 2002). During the composting process, microorganisms transform organic raw materials into compost by breaking them down to simple compounds and reforming them into new complex compounds (Mohammad et al., 2008). Among these, the properties can point to C/N ratio, CEC, pH, porosity, bulk density and salinity of compost. Immature compost has high C/N ratio that can cause deficiency of N in plant. The falling value of C/N ratio is a sign of fermentation and the performance of the composting process during maintenance period. Microorganisms supply their primary energy from C of compost,

while the N of compost is used by microorganisms to develop their colonies for breaking down the organic matters. Microorganisms use the 30/1 ratio of C/N. If this ratio increases up to 30, the rate of compost breakdown will decrease. Of course, this ratio decreases in the composting process for a long period of time. As such, attention must be paid to this ratio, because the extra N changes to $NH_4^+$ when it decreases below 25, (Barrington et al., 2002). Soil cation exchange capacity was known significantly as a potential index of compost maturity. CEC increases in an organic matter as a function of humification, which is related to the formation of phenol and carboxyl groups (Lax et al., 1987). Harda et al. (1981) found a strong negative relation between CEC and C/N ratio. Organic matters can be composted in the vast range of pH levels (Baruah and Barthakur, 1998; Bragg, 1990). Availability of nutrient elements for plants was much more related to the pH of the media, but the composting process was not sensitive to pH, and the effect of pH changes on it was little and limited because microorganisms act at a wide range of pH (Epstein et al., 1977; Dinc et al., 1984).

The date palm (Phoenix dactylifera) is one of the important palm productions in the gardens of Iran. Based on published statistics, more than 180,000 ha of the country's lands are under the cultivation of date palm, and many provinces of the country, especially southern provinces, grow it. 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. Presently, there are no suitable and optimal management on them. 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. Date palm peat is the waste and residual of date palm tree. Presently, no effort has been made for date palm wastes' composting. Composting (bioalteration) is a simple and direct way for reducing the volume of biodegradable wastes because in this way, under controlled conditions, degradable and changeable organic compounds of solid wastes are transformed to available, storeable and applicable states that are adequate for field and hydroponic cultures, but without negative effect on the environment (Golueke, 1981). Date-palm extensively exists in the world and in Iran, and it produces a lot of residues and wastes every year. Unfortunately, at the moment, there are no appropriate management and optimization procedure for the adequate usage of these materials, even though it seems that residues and wastes of date-palm can be used as a substrate in greenhouse cultivation. The objective of this study was to compare some of the growing indexes of tomato that were cultured in the perlite and date-palm peat (composted and uncomposted) substrates, and then evaluate the incubation time effects on growing indexes of tomato. Finally, the study finds answer to this question: "Can we use date-palm peat as a substrate in soilless culture?"

## MATERIALS AND METHODS

This study was done in the greenhouse research site of Khorasgan University. At first, palm wastes were chopped into smaller sizes; then, they were kept in 1.5 $m^3$ plastic bags for controlling the moisture and temperature. Some amounts of N and P fertilizers were added to them as a fermentation starter, and these bags were placed in hot (25 to 30°C) condition. For respiration, some air holes were made on the bags. Every week, these materials were mixed together and put into the bags again and their moisture was adjusted to 55%. Then, the bags were closed. The experiment was conducted in a completely randomized design for 3 incubation times (0, 1, 3 and 9 months) as treatments with 3 replications. Physicochemical properties (porosity, bulk density, pH, C/N and CEC) of these materials were analyzed at the beginning of the study, and at 1 and 3 months after the starting date. After 3 months, for comparison of these materials (date-palm peat) with other substrates same as perlite, a greenhouse examination was done. The research was conducted in a completely randomized design with 6 replications of tomato for 6 months. Treatments included perlite, date-palm 1 (without incubation time) and date-palm 2 (with 3 months incubation time). During the plant growth irrigation rate, temperature, humidity and pest control were similar for all treatments. Average day and night temperature were 30 and 18°C, respectively. During plant growth, Papadopolus formula (1991) with fertigation method was used for plant nutrition. Some growth indexes that were determined included the stem diameter of plant, the height of plant, number of fruit, plant biomass, fruit yield and fruit TSS. At the end of plant growth duration, the physicochemical properties of the palm wastes were analyzed again. The pH was determined in the suspension of 1: 5 (w/v) by using pH- meter (Mettler MP225). The total N was determined using the kjeldhal method (Bremner and Mulvaney, 1982). Acetate sodium method and experimental method were used for determining the CEC and BD, respectively. Mathematics equations related to bulk and particle density were used for determining porosity (Baruah and Barthakur, 1998). All the experimental data were analyzed statistically by using the analysis of variance (ANOVA). Duncan's multiple range test was used for comparison of treatment means when F values were significant at $p<0.05$.

## RESULTS AND DISCUSSION

### Incubation effect

The effect of incubation time on the physicochemical properties is given in Table 1. Initial value of C/N of 63.7 in the control dropped to 38.01 (in 270 days of incubation time). Various treatments showed significant differences ($p<0.05$) in the C/N ratio. During the material biotransformation process, the C concentration decreased, while the concentration of N increased. In the result, the C/N ratio decreased. This decrease was related to C loss as $CO_2$ from these organic materials (Hamoda et al., 1998). In various samples, the N concentration is less during the

**Table 1.** Some physiochemical characteristics of date palm waste under incubation time.

| Variable | Incubation time (day) | | | |
|---|---|---|---|---|
| | 0 | 30 | 90 | 270 |
| C/N (%) | 63.07$^{d}$ | 57.35$^{c}$ | 53.44$^{b}$ | 38.01$^{a}$ |
| Pb (g/L ) | 166.8$^{a}$ | 168.3$^{ab}$ | 171.6$^{b}$ | 293.8$^{c}$ |
| Porosity (%) | 91.75$^{b}$ | 90.5$^{b}$ | 83$^{b}$ | 75.6$^{a}$ |
| EC (d/m) | 2.25$^{ab}$ | 2.02$^{a}$ | 3.18$^{c}$ | 2.81$^{bc}$ |
| CEC (Cmol/kg) | 86.53$^{a}$ | 92.5$^{a}$ | 95.2$^{a}$ | 127.75$^{b}$ |
| pH | 5.4$^{a}$ | 7.3$^{c}$ | 6.7$^{b}$ | 6.6$^{b}$ |

Means with different letters within the row indicate significant differences ($p < 0.05$) using Duncan's multiple range test.

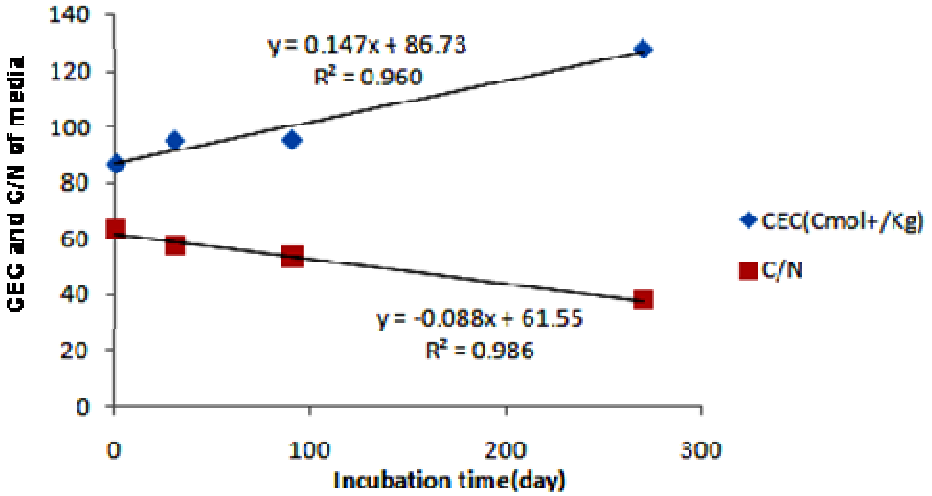


**Figure 1.** Changes of CEC and C/N ratio of palm media under incubation time.

primary stages, but the concentration will be increased gradually when it gets to the end point (Neto et al., 1993). In some samples, these values are constant. The C/N ratio is important after composting because it determines the value of the mature compost as a soil amender material for plants. The C/N ratio must be between 15 and 20 in mature compost. If the ratio is more than 20, it has negative effects on plants and damages seed germination.

Means comparison for CEC did not show any significant ($p<0.05$) difference among the treatments from zero to 90 incubation days, but CEC value on the 270th day treatment had a significant difference ($p<0.05$) than other treatments. This access, to the value obtained from the treatment on day 270, was due to more fermentation in the date palm wastes, substances degradation and increment in material specific surface.

With the passage of time, the carboxyl groups from the oxidation of straight chains of aromatic circles or from esters or lactones hydrolysis increased. This increase in carboxylic groups caused an increase in CEC (Lax et al., 1987). Besides, based on the Fontanive findings of 2004, CEC increases through the composting process was due to organic matters changing and transforming into humic. In the result, whenever humification was increased more, the CEC went higher and so the compost quality was improved. The changes of C/N ratio and CEC to incubation time are shown in Figure 1, which displays the fermentation process and chemical changes in the materials (Bulter et al., 2005). By going over the incubation time, CEC values increased and C/N ratio decreased, in that they display the fermentation process and chemical changes in the materials (Bulter et al., 2005). Means comparison for bulk density showed that there was no significant difference between zero and 30 days treatments, but the 270 days treatment had significant difference ($p<0.05$) from other treatments. The lowest and highest values of bulk density were related to zero and 270 days treatments that were 166.75 and 293.75 g/l, respectively. In the composting process duration, the bulk density decreased, and the total organic matters decreased. In the composting process, the large particles are transformed into smaller particles. These small particles fill the coarse porosity and cause decreasing bulk density. In 2009, Bernal et al. reported that during the active time of the composting process, the value of

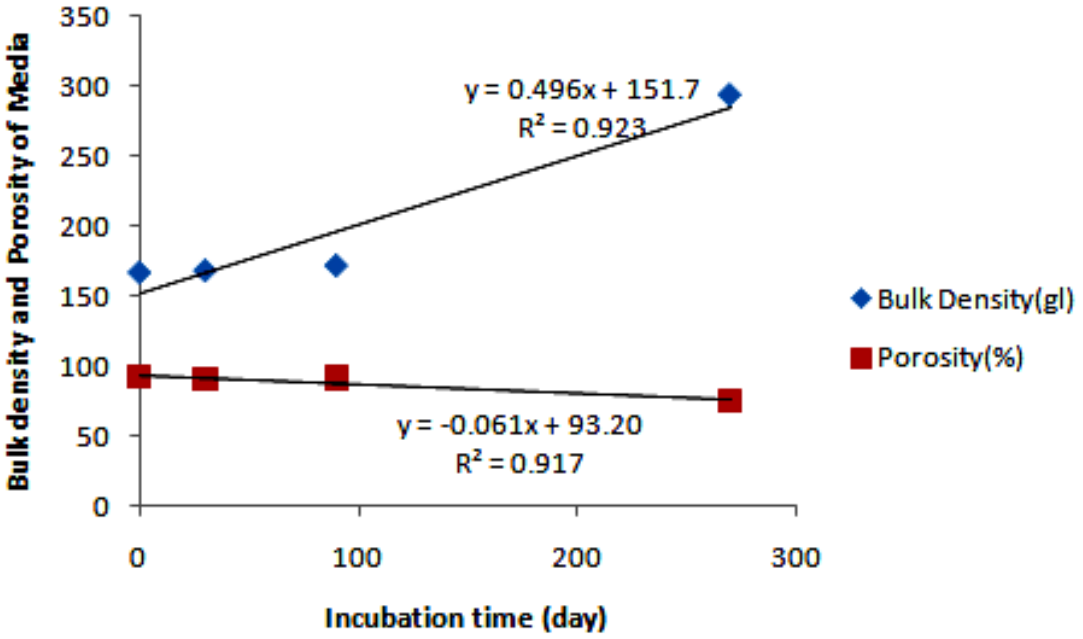


**Figure 2.** Changes of bulk density and porosity of date-palm media under incubation time.

organic carbon declined, and it was due to the composition of organic carbon by microorganisms. When organic matters decrease, mass weight declines and so the C/N ratio decreases. Consequently, it results to significant differences ($p<0.05$) in losing volume among the treatments than in the control. So, because of volume loss, the bulk density of the media will be increased during the time.

In Table 1, means comparison of the materials porosity showed that the zero, 30 and 90 days treatments did not have significant differences, but 270 days treatment had significant difference ($p<0.05$) from the other treatments. The maximum value of porosity was related to zero treatment (91.75%) and the least value was related to 270 days treatment (75.6%). Nancy (1996) declared that with an increase in the compost waste fermentation, coarse fragments degrade, while the small fragments that are placed in coarse porosity, caused a compression of the mass, decreased the porosity and increased the bulk density. In this situation, because of the decrease in porosity, the required oxygen value of microorganisms will be decreased and the rate of microbial activity will decrease as well. Figure 2 shows porosity and bulk density changes with time incubation. Increasing the incubation time enhanced the bulk density value, but the rate of bulk density increment was more. Maybe, it was based on this reason that the small particles, with small pores filling the coarse pores, prevented porosity decrease in high values.

In this study, the pH range of date palm compost was from 5.37 to 6.56. When bacteria and fungus digest the organic matter, they release the organic acids. In the first stages of composting, the acids are often accumulated. The pH of compost mixture, after 270 days, was within the recommended level (5.8 to 8.0) by Kala et al. (2009).

From the result of Table 1, it can be observed that the mean value of EC had no significant difference between zero and 30 days treatments, and 90 and 270 days treatments, but the 30 days treatment has a significant difference from the two treatments (90 and 270 days). By measuring the fermentation and breakdown of the chemical materials, the salt value will be enhanced.

## Properties of the growing media

Palm and perlite substrates, used in a soilless culture, can differ in their physicochemical properties. Physicochemical properties affect the air content and retain the volume of available water. It also adsorbs the rate of nutrients in substrate. There was a slight difference in the physical and chemical properties of the studied growing media (Table 2). Bulk densities of media ranged between 0.13 and 0.17 g $cm^{-3}$, depending on the composition. Bulk density values between 0.1 and 0.3 g $cm^{-3}$ were considered acceptable for hydroponic seedlings and crops (Kampf et al., 1999). However, total porosity of the media was important (container media should contain 50 to 85% pore space), but probably more crucial than the portion of AFP versus WHC. On average, 10 to 30% of the media volume should be composed of air space, while 45 to 65% should be composed of water (Altland, 2006). The amount of WHC was between 69.8 and 83.5% of the volume for the three substrates. These results showed

**Table 2.** Some physicochemical properties of the different substrates used as media for tomato culture.

| Substrate | C/N | BD | pH | EC | CEC | Porosity | WHC |
|---|---|---|---|---|---|---|---|
| | (%) | (g/cm$^3$) | | (ds/m) | (Cmol /kg) | (%) | (%) |
| Perlite | 0.0 | 0.13 | 7.8 | 1.6 | 0.0 | 68 | 69.8 |
| Date-palm 1 | 63.57 | 0.16 | 6.5 | 2.3 | 86.5 | 91.8 | 78.3 |
| Date-palm 2 | 53.4 | 0.17 | 6.7 | 3.2 | 95.2 | 83 | 83.5 |

BD = Bulk density; CEC, cation exchangeable capacity; WHC, water holding capacity; EC, electrical conductivity.

**Table 3.** Some growing indexes of tomato cultivated in different substrates.

| Substrates | Fruit yield (kg) | PH (cm) | NF | S D (mm) | TSS (brix%) | Biomass (kg) |
|---|---|---|---|---|---|---|
| Date-palm peat1 | 3.84$^a$ | 276.6$^a$ | 61.3$^a$ | 18.45$^b$ | 5.38$^a$ | 1.76$^b$ |
| Date- palm peat2 | 3.82$^a$ | 287.5$^a$ | 72$^a$ | 15.18$^a$ | 6.25$^{ab}$ | 1.43$^a$ |
| Perlite | 4.17$^a$ | 298.5$^a$ | 69$^a$ | 14.96$^a$ | 6.37$^b$ | 1.13$^a$ |

PH = Plant height; NF = number of fruit; SD = stem diameter; TSS= total soluble sugar.

that the particle size of palm 1 was greater than that of palm 2 and the particle size of palm 2 was greater than that of the perlite, because by decreasing the particle size, the WHC will increase. The same trend was reported by other researchers (Wada, 2005). The results showed that the palm had similar properties with perlite, but the perlite generally held more air and less water. In 1984 Dink and etal indicated that volcanic ash material can be used as soil media in greenhouses not only for higher yield but also for early cropping due to its favorable physical conditions. The fruit size was correlated to the water content. Fruit as a strong sink, decreased the absorption of water and nutrient on substrates, with low ability to reserving water. Furthermore, with high EC of the ryzosphere, the plant water availability will be limited. Hence, in the plant with low level of carbohydrate and water leaf number, leaf surface, fruit weight and size were affected (Cantliffe et al., 2001). The date-palm, inversely found in perlite, had high CEC that caused easy storage and release of nutrients and it improved water management in soilless culture. The optimum pH of substrate for tomato growth was reported as 6 to 6.5, while the date-palm presented the optimum pH.

## Growing indexes

ANOVA results confirmed that the mean of fruit yield, plant height and fruit number of tomato had no significant difference, with respect to the media. The highest fruit yield (4.17 kg) and plant height (298.5 cm) was obtained with perlite, while the lowest fruit yield (3.84 kg) and plant height (276.6 cm) was obtained with palm 1. The similar effects of these substrates on the fruit yield, fruit number and plant height of tomato could be described to the almost similar C:N ratio of organic substrates and the comparatively similar speeds of the biological decomposition for these substrates at the same composting periods. Competition for nitrogen can result in nitrogen deficiency and poor plant growth (Ehrenfeld et al., 1997; Bottner et al., 1999). However, the porosity and CEC, which play an important role in root aeration, water and nutrient element supplement for plant, had no significant difference in date-palm 1 and date-palm 2 substrates. Therefore, some growing indexes, which include fruit yield, plant height and fruit number in date-palm 1 and date-palm 2, had no significant difference. Alifar et al. (2010) showed that the substrates, which included peat, coco peat and perlite, had no significant difference on cucumber yield. TSS (Brix) content of the fruit was not found to differ significantly between substrates. Perlite as compared from date-palm 2 produced no differences in TSS content, but it had significant differences from palm 1 substrate (Table 3). Plants grown on palm 1 produced low TSS values in fruit juice, while they had almost the same number of fruits in plant. Nevertheless, the higher sugar and organic acid content improves the quality of tomato fruits (Davies and Hobson, 1981). Palm is an organic substrate, while perlite is an inorganic substrate. In accordance with this study, Islam et al. (2002) recorded no differences between the organic and inorganic substrates in TSS in tomato fruit juice.

The highest amount of the plant's biomass weight was in the date-palm media 1 and it had significant differences as compared to other substrates. Biomass weight of the plant is an important factor which depends on water content in plant (Saied et al., 2005). The low water

rate, retained in the perlite, decreased the plant water level, which caused a decrease in the dry weight of the plant than in the dry weight of the palm.

## Conclusion

During the incubation time on date palm waste, until 90 days, the porosity and CEC that play an important role in root aeration, water and nutrient element supplement for plant did not change. Therefore, some growing indexes, which include fruit yield, plant height and fruit number in date-palm 1 and date-palm 2 had no significant difference. Increasing the incubation time to 270 days caused a change in the physiochemical properties of the date-palm. Results of some previous investigations introduced perlite and its mix with other materials as sufficient substrates for growing of some plants, especially for vegetables, and growers use these materials as growing media in greenhouses. Also, the results of this investigation indicated that perlite and date- palm media (composted and uncomposted) had similar properties and they had no significant difference on the qualitative and quantitative indexes in tomato. Thus, in considering the low cost, availability and abundance of date-palm cultivation in Iran (180000 ha), it seems that date-palm wastes can be used as media for growing certain vegetables in the world.

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