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ORIGINAL ARTICLES

Growth and Productivity of Cantaloupe Plants Grown under Different Soilless Culture Systems

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ABSTRACT

Cantaloupe plants (*Cucumis melo* L.) 6004 F1 hybrid Galia type, were grown under unheated plastic house at the Arid Land Agricultural Graduate Studies and Research Institute, Ain Shams University, Cairo, Egypt, during both experimental seasons of 2006/2007 and 2007/2008, to evaluate the effect of using different soilless culture systems (aeroponic, nutrient film technique and substrate culture perlite in horizontal bags) in comparison with soil cultivation as a control treatment on growth and productivity of cantaloupe plants in different growing plantations (autumn and spring), in a complete randomized block design with three replicates for each treatment. Growth parameters as plant length, number of leaves/plant, total leaf area, leaf total chlorophyll, leaf mineral contents, number of fruits/plant, average fruit weight and total yield/plant were recorded. The obtained results showed that all the soilless culture systems performed better than the soil cultivation system and NFT system resulted in the best vegetative growth, yield and N, P and K of leaves contents values followed by perlite system comparing with the other treatments. Concerning the plantation season, it seems that spring plantation exhibited faster growth and development compared with autumn plantation, Regarding the interaction effect, significant differences were noticed between different soilless culture and plantation season on all studied characters. Overall, the best values for measured characters were obtained by nutrient film technique in spring plantation followed by perlite system in spring plantation. Whereas, the lowest values were obtained with soil cultivation system even in spring or autumn plantations. Similar trends were obtained in both seasons of study.

Key words: Muskmelon, Aeroponic, Nutrient film technique (NFT), Substrate culture, Vegetative growth, Fruit yield.

Introduction

Cantaloupe is one of the most important and popular fruity vegetable grown in Egypt, and it is used mainly as a desert and refreshing fruit. Cantaloupe fruit is an excellent source of vitamin A and it is also rich in antioxidant compounds. These antioxidants have the ability to protect body cells against cancer. In addition, fruits are very low in calories (34 calories/100 g fresh fruit) and fats.

Open field production of cantaloupe in Egypt is focused generally during the summer season. Recently cantaloupe growers in many areas of Egypt have to use protected cultivation to produce an off-season crop for exportation as well as local consumption. During the winter season, the cash return from cantaloupe is much greater than that from the summer season. Egyptian cantaloupe exporting window for European markets extends from October until May with high prices from October through February. During this period, Egypt can export about 100 thousand tons every year with net income of 80 million US Dollars. Egyptian cantaloupe can also be exported to Arabian and Gulf markets (Al-Saied, 1998).

Limited water resources in the arid and semi-arid regions, and rapid growth rate of population as well as global warming were the major factors that drew the attention towards the use of intensive agriculture in Egypt and paved the way for new techniques such as soilless culture (Abou-Hadid and Medany, 1994). Soilless culture technique, had an enormous latent potential for agriculture production, i.e. reducing crop water consumption, possibility to grow all kind of vegetable crops, no crop rotation is required, easy to management, short growth cycle of crop, ensuring the sanitary quality of the fresh product and improvement of plant growth, yield, quality and earliness. Also, had a great potential for crop production in areas where soil has a physical problems (marginal lands) or pest and disease problems (Burrage, 1999), especially when methyl bromide phasing out in near future in Egypt according to Montreal protocol. However, alternatives to methyl bromide can also have adverse effects on human health and environment (Ozeker *et al.*, 1999).

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Nutrient film technique (NFT) can, also, overcome these problems where the plants grow in the nutrient solution without using any growing media. The yield of various vegetables tends to be higher for the NFT grown plants than those grown in the soil, this indicating that the NFT system could meet plant demands better than the soil. As well as, the cost of production by the NFT is similarly to the soil gown crops (Abou-Hadid *et al.,* 1989 and Olle *et al.,* 2012). Aeroponic system has been used successfully to produce wide range of high value crops (Christie and Nichols, 2004). Substrate culture offers a valuable alternative to crop production in soil, and has been widely adopted by specialist producers of greenhouse crops in the world, particularly for high-value crops. Perlite is a substrate, which is locally available in the Mediterranean region and very promising and easily adopted by growers.

Vegetative growth parameters, total yield and early yield as well as yield quality of plants grown in nutrient film technique was higher than those grown in other soilless or soil culture as reported by Abou-Hadid *et al.* (1989) and Rumple *et al.* (1996) on tomato; Al-Harbi *et al.* (1996) on cucumber; El-Shinawy and Gawish (2006) on lettuce and El-Behairy *et al.* (2001) and Singer *et al*. (2009 & 2012) on cantaloupe.

Cantaloupe plants grown in nutrient film technique gave the highest values for plant height, number of leaves/plant, total leaf area, number of fruits/plant, mean of fruit weight and total yield than substrate culture (Abed El-Rahman *et al.,* 2003). El-Behairy (2003) reported that using nutrient film technique can substitute soil cultivation for cantaloupe produced for winter production with a higher yield. Using nutrient film technique increased the average of fruit weight and fruit volume significantly compared with soil culture. In contrast, Natalini *et al*. (2007) concluded that nutrient film technique led to more luxuriant growth and higher yields but poorer quality than the other systems (soil, and perlite). The best quality was obtained from soil cultivation.

Fernández-Trujillo *et al*. (2004) reported that cucumber plants, grown in nutrient film technique gave higher fruits quality than using perlite culture. They also found that cucumber fruits produced in winter season were smaller than that produced during spring season by using nutrient film technique. In addition, Paradossi *et al*. (2000) stated that melon plants grown in nutrient film technique during summer season exhibited faster growth and development compared with spring season, while there no difference in total leaf area, mineral status and chlorophyll content was observed. Also, Yang *et al.* (1990) reported that tomato plant grown in aeroponics system gave higher concentrations of P, K and Mg and lower concentrations of Ca than nutrient film technique. In addition lettuce soil grown plant has statistically content higher of zinc and iron, while lettuce hydroponics grown plant of N, P, K, Ca, Cu, Mg and Mn (Santos *et al.,* 2003).

The main goal of this study was to evaluate the effect of using different soilless culture systems in comparison with soil cultivation as a control treatment on growth and productivity of cantaloupe plants in different growing plantations. In order to determine the most appropriate system of soilless culture for increasing cantaloupe fruit production with high quality under Egyptian conditions especially during the period from October to February.

Materials and Methods

Current experiment was conducted in the experimental farm of the Arid Land Agricultural Graduate Studies and Research Institute, Ain Shams University, Egypt, during the two successive seasons of 2006/2007 and 2007/2008 under unheated plastic house to evaluate the effect of using different soilless culture systems (aeroponic, nutrient film technique and substrate culture perlite in horizontal bags) in comparison with soil cultivation as a control treatment on growth and productivity of cantaloupe plants in different growing plantations (autumn and spring). In order to determine the most appropriate system of soilless culture for increasing cantaloupe fruit production with high quality under Egyptian conditions especially during the period from October to February.

Seedlings of cantaloupe (*Cucumis melo* L.), 6004 F1 hybrid, Galia type, were transplanted in autumn on 15^{th} of September of 2006/2007 and 2007/2008, in all systems. While in spring, on the 15^{th} of February of 2007 and 2008 in all systems. In case of aeroponic system, seeds were sown directly in netted growing cups, then housed on holes formed in the foam sheets at distance 50 cm between each hole. On the other hand, in NFT and perlite systems, seeds were sown directly in small black bags (8 cm diameter x 10 cm length) filled with a mixture of peat moss and vermiculite (1:1 v/v) in both growing seasons. Plant spacing was 50 cm in the gully, 60 cm between the gullies, and 100 cm between the double gullies.

Cantaloupe plants in aeroponic system were irrigated by pumped nutrient solution using no submersible pump 0.5 HP to PVC pipes installed inside the system every other 15 min. from 7:0 am until 7:0 pm, and every other 30 min. from 7:0 pm until 7:0 am. Five mist emitters were fixed on each pipe, the emitter characters were: misting distance 2 m, quantity = 40 litter/hour, droplets size =150 micrometer and water pressure was 2.0 bar.

Nutrient film technique system was designed as described by Zayed *et al.* (1989). Nutrient solution in this system was circulated by 0.75 HP submersible pump. The nutrient solution was introduced to the top of the gullies (double face of polyethylene sheets black/white, 200 micron thickness, 70 cm wide and 3.5 m length) through a flexible polyethylene pipe (16 mm). The flow rate was adjusted to give 2.5 liter/min. The drained nutrient solution was collected and returned to the catchment tank by PVC gutter. Nutrient solution returns back to the tank by gravity with slop (1%).

Perlite with particle sizes between 3 and 5 mm was used in this experiment and applied in horizontal bags (black/white polyethylene 200 micron thickness, 30 cm diameter, 1 m length and 20 liters capacity). In the horizontal bags, holes were made on 2 cm from the bottom along the bag and two plants were planted in each bag, then bags were placed in the formed gullies. The drained nutrient solution was collected and returned to the catchment tank by PVC pipe of 5 inch diameter. Nutrient solution was circulated by submersible pump 0.75 HP capacity. The solution was introduced to the top of the gullies through a small flexible pipe. The nutrient solution was delivered to each bag via dripper 4 liters per hour. The substrate treatment was used with closed system. The substrate treatments were irrigated fifteen times/day during the autumn and spring seasons for 10 min per each time.

The used nutrient solution was adapted from Cooper solution (Cooper, 1979) depending on the analysis of the local water (El-Behairy, 1994). The desired initial concentration of the nutrient solution was maintained by suitable dilution of the stock solutions with tap water. The nutrient solution volume was adjusted twice a week by adding tap water up to recognized mark in the tank. Electrical conductivity (EC) was maintained between 2.5 to 3 $m.mhos^{-1}$ and pH maintained between 5.5 to 6.5. The nutrient solution was circulated continuously and collected to one catchment tank with a capacity of 1 m^3, used for all soilless culture systems. The nutrient solution was completely renewed every month.

Data recorded: twelve weeks after transplanting date, six cantaloupe plants per replicate from each treatment were randomly taken to determine the following parameters, plant length, number of leaves/plant, total leaf area/plant (using a digital leaf area meter, LI-COR 300 portable area meter, LI-COR, Lincoln, Nebraska, USA), leaf total chlorophyll reading in the fifth mature leaf from the top of the plant (using Minolta chlorophyll meter Spad-501, Minolta Co., Japan).

At harvesting stage, the number of fruits per plant, the average of fruit weight and total yield per plant were recorded using a number of 12 fruits per replicate from each treatment.

Mineral nutrient contents were determined in the recently full expanded leaf (fifth mature leaf from the top of the plant) after 4 weeks from transplanting date (pollination and young fruit stage). Leaf samples were dried at 70 $^{\circ}$C for 72 h according to ADAS/MAFF (1987). Afterward, dried samples were grinded to a fine powder using a stainless steel blender and then used to determine mineral nutrient contents on a dry weight basis. A weight of 0.2 g of dried and grinded leaf samples was digested using wet digestion, in the sulphuric acid and hydrogen peroxide according to the method described by Allen (1974). Then the digested samples were used to determine minerals nutrient contents.

Total nitrogen was determined by Kjeldahl method according to the procedure described by FAO (1980). Phosphorus was determined using spectrophotometer (SPECTRONIC 20D, Milton Roy Co. Ltd., USA) according to Watanabe and Olsen (1965). Potassium was determined photometrically using flame photometer (JENWAY, PFP-7, ELE Instrument Co. Ltd., UK) as described by Chapman and Pratt (1982). While, calcium and magnesium were determined spectrometrically using Atomic Absorption spectrophotometer (Analyst 200, PerkinElmer, Inc., MA, USA), as described by Chapman and Pratt (1982).

The treatments were arranged in a complete randomized block design in a factorial experiment with three replicates for each treatment (15 plants/replicate). All data generated were tabulated and subjected to statistical analysis using the analysis of variance method ANOVA with M-Stat package software. Least significant differences test (LSD) was used to compare the significant differences among mean of the treatments at 0.05 level of probability according to the method described by Snedecor and Cochran (1980).

Results and Discussion

Vegetative growth characters:

Data presented in Table (1) clearly indicated that NFT system gave significantly the tallest plant followed by perlite, aeroponic and soil systems in decreasing order, with significant differences among these treatments. This findings were true during both seasons of study, regardless of plantation seasons.

Concerning the plantation season, spring plantation gave significantly taller plants than autumn plantation in both seasons of study.

The interaction effect, a significant difference was realized between different culture systems and plantation seasons. The highest values of cantaloupe plants length were obtained by using NFT in both spring and autumn plantations. While the lowest values were observed by using soil system in autumn or spring plantations in both season of 2006/2007 and 2007/2008.

Data presented in Table (1) showed the effect of different soilless culture systems in autumn and spring plantations on number of leaves per cantaloupe plant 12 weeks after transplanting date. There were significant differences noticed among different culture systems. The highest values for number of leaves per plant were recorded by NFT system followed by perlite system in comparison with soil cultivation system in both seasons of study.

It is cleared that spring plantation was significantly produced more leaves than autumn plantation, where spring plantation gave a number of leaves of 61.98 and 59.63 and autumn plantation gave 58.98 and 56.44 in the first and second seasons, respectively.

As for the interaction, the highest number of leaves was obtained by NFT system in spring plantation followed with a significant difference by NFT system in autumn plantation and perlite system in spring plantation without significant difference between both of them while the lowest number of leaves were obtained by using soil system in autumn plantation. These results held true in both seasons.

The highest values of total leaf area was obtained with NFT system followed by perlite system, aeroponic system and then soil cultivation system with significant differences among them. Similar trend was obtained in the second season (Table 1).

Regarding plantation season, spring plantation gave higher total leaf area than autumn plantation with significant difference between them in both seasons of 2006/2007 and 2007/2008.

The interaction effect stated that significant differences were detected between different culture systems and plantation seasons in both seasons. The best results for total plant leaf area was obtained by NFT system in spring and autumn plantations followed by perlite system in spring and autumn plantations. These results were obtained in both seasons.

The effect of different soilless culture systems in autumn and spring plantations on the total chlorophyll is presented in Table (1). At 12 weeks after transplanting date, the effect of different soilless culture systems on total chlorophyll was not apparent, in the first season there were no significant differences detected between each pairs of aeroponic and NFT systems or perlite and soil cultivation systems. But a significant difference was detected only between the first and second pairs. While in the second seasons no significant differences were observed among all the studied systems. The highest values for leaf total chlorophyll were recorded by soil cultivation system (control) followed by perlite system in both seasons, while the lowest values were recorded by aeroponic in the first season and NFT in the second season.

The plantation season, concluded that leaves of cantaloupe plants grown in spring plantation season showed a higher chlorophyll reading than those grown in autumn plantation season, with a significant difference between them in both seasons of study.

No clear trend was observed in both seasons of study regarding the interaction effect, where the best values for leaf total chlorophyll were fluctuated among treatments. Soil cultivation system in spring plantation gave the highest values followed by perlite in both plantations in the first season, while in the second season aeroponic system in spring plantation gave the highest value followed by soil cultivation system and then by NFT.

General notice, from the previously mentioned results on plant growth characters, it could be concluded that the best culture system for stimulating plant growth (length, leaf number and leaf area) was NFT system. The spring plantation was better for encouraging plant growth than autumn plantation. As for the interaction, the best results were obtained by NFT system in spring plantation.

The obtained results are in good accordance with Abed El-Rahman *et al.* (2003); El-Behairy (2003); Fernández-Trujillo *et al*. (2004); Natalini *et al*. (2007) and Singer *et al.* (2012). They reported that nutrient film technique led to more luxuriant vegetative growth of cantaloupe plant.

Such increase in plant growth characters could be a result of supplying the nutrient solution in available form which increases the uptake of nitrogen which in turn encourage the vegetative growth. This increase in the vegetative growth increased the cantaloupe yield. Bish *et al.* (1997); Hennion *et al.* (1997) and El-Behairy (2008) mentioned that bigger plants produced higher yield resulted from higher leaf area that increased photosynthesis and consequently the total yield.

Table 1: Effect of different soilless culture systems on cantaloupe plant length, number of leaves per plant, total leaf area and total chlorophyll after 12 weeks from transplanting date in autumn and spring plantations during both seasons of 2006/2007 and 2007/2008.

Systems	Plant length (cm)			Number of leaves/plant			Total leaf area (cm^2)			Total chlorophyll (Spad)		
	Autumn	Spring	Mean	Autumn	Spring	Mean	Autumn	Spring	Mean	Autumn	Spring	Mean
First season (2006/2007)												
Aeroponic	325.8 e	349.5 c	337.7 C	58.69 d	60.44cd	59.56 C	22160.6 e	22764.8 de	22462.7 C	33.00 d	34.00 c	33.50 B
NFT	368.6 b	408.5 a	388.5 A	69.44 b	72.44 a	70.94 A	26215.1 ab	27290.9 a	26753.0 A	34.00 c	34.00 c	34.00 B
Perlite	336.3 d	360.3 b	348.3 B	63.31 c	66.69 b	65.00 B	23896.1 cd	25159.4 bc	24527.8 B	35.00 b	35.00 b	35.00 A
Soil	238.3 g	312.3 f	275.3 D	44.50 f	48.38 e	46.44 D	16803.0 g	18959.9 f	17881.4 D	35.00 b	36.00 a	35.50 A
Mean	317.2 B	357.6 A		58.98 B	61.98 A		22268.7 B	23543.7 A		34.25 B	34.75 A	
Second season (2007/2008)												
Aeroponic	319.7 e	352.2 c	335.9 C	58.25 d	58.63 cd	58.44 C	21986.4 c	22081.7 c	22034.1 C	33.00 d	36.00 a	34.50 A
NFT	362.4 b	414.6 a	388.5 A	64.38 b	69.13 a	66.75 A	24305.6 b	26081.2 a	25193.4 A	33.00 d	34.75 bc	33.88 A
Perlite	342.8 d	363.7 b	353.2 B	60.25 c	64.44 b	62.34 B	22748.8 c	24273.1 b	23510.9 B	34.00 c	34.00 c	34.00 A
Soil	229.2 f	322.9 e	276.1 D	42.88 e	45.25 e	44.06 D	16187.6 d	17071.9 d	16629.8 D	34.00 c	35.00 b	34.50 A
Mean	313.5 B	363.4 A		56.44 B	59.36 A		21307.1 B	22377.0 A		33.50 B	34.94 A	

Fruit characteristics and yield:

Data shown in Table (2) showed that significant differences were detected among soilless culture systems on number of fruits per cantaloupe plant. The highest number of fruits per plant was obtained by using NFT system followed significantly by both perlite and aeroponic systems with no significant difference between both of them. The lowest number of fruits per plant was obtained by soil cultivation system (control). The same trends were obtained in the second season.

Regarding the plantation season, plants grown in autumn plantation produced higher number of fruits per plant compared to those grown in spring plantation. However, the difference between autumn and spring plantations was significant in the second season only.

As for the interaction effect, significant differences were detected between soilless culture systems and plantation season on the number of fruits per plant. Using NFT system in either autumn or spring plantations gave the highest number of fruits per plant, followed significantly by perlite system in both plantations. Whereas, the lowest number of fruits per plant was obtained using soil cultivation system (control) in both autumn and spring plantations without a significant difference. These results were obtained in both seasons.

The effect of different soilless culture systems in autumn and spring plantations on the average of fresh weight of cantaloupe fruits are presented in Table (2). There was a significant difference among all treatments. The highest values for average fruit weight were obtained by using NFT system followed significantly by perlite, aeroponic and soil cultivation systems in decreasing order. Similar trends were obtained in the second season.

Respecting the plantation season, plants grown in spring plantation gave significantly fruits of higher weight compared with those grown in autumn plantation in both seasons of study.

As for the interaction, the highest fruit weight was obtained by using NFT system in spring plantation followed by NFT system in autumn plantation, perlite system in spring plantation then aeroponic system in spring plantation with significant differences among these treatments. The lowest average fruit weight was obtained with soil cultivation system (control) in autumn plantation. These results were obtained in both seasons of study.

Data presented in Table (2) showed that the cantaloupe fruit yield per plant had the same trends of the average cantaloupe fruit weight. There was a significant difference among all treatments. The highest values of fruit yield per plant were obtained by using NFT system followed significantly by perlite, aeroponic and soil cultivation systems in decreasing order. Similar trends were obtained in the second season. NFT system gave fruit yield per plant approximately 3.5 and 4 times than soil cultivation system in the first and second season, respectively.

The plantation season, had similar trends also of average cantaloupe fruit weight, spring plantation gave significantly the highest fruit yield per plant compared with those grown in autumn plantation in both seasons of study.

The interaction effect followed the same trends as for the average fruit weight. The interaction effect had a significant effect on fruit yield per plant. The highest fruit yield per plant was obtained by using NFT system in both spring and autumn plantations, followed by perlite system in both spring and autumn plantations also, with significant differences among these treatments. These results were similar in both seasons of study. The lowest fruit yield per plant was obtained with soil cultivation system (control) in autumn plantation in the first season and spring plantation in the second season.

Using NFT system for producing cantaloupe increased vegetative growth and yield comparing with the other soilless culture systems. This could be due to that immersing cantaloupe roots in the nutrient solution all the time makes buffer for the temperature during winter and early spring where the water collects the heat during the day time slowly and release it also slowly during the night. This makes the root active most of the day which stimulate the uptake of water and nutrients that increase vegetative growth and consequently the yield.

The yield of various vegetables grown in soilless culture tends to be higher than those grown in the soil, indicating that the growing media could meet plant demands better than the soil. In addition, growth and development of vegetable crops are enhanced, when plants are grown in soilless culture compared to soil cultivation.

Regarding the growing season, data showed that cultivating cantaloupe in spring season increased vegetative growth, yield but reduced fruit quality while the autumn season reduced vegetative growth and yield but increased the fruit quality. This could be due to that increasing temperature during the season increase the water uptake and elements which increase vegetative growth and yield. The increase of the yield came from increasing main fruit weight but did not for increase in number of fruits. The increase of fruit weight came from the increase of water in the fruit (Abed El-Rahman *et al.*, 2003 and Singer *et al.*, 2009).

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From the overall results, it was clear that using NFT as a method of producing cantaloupe increased vegetative growth and total yield comparing with the other treatments. The increase of vegetable growth leads to more yields as suggested by Economakis, (1992); Economakis and Krulj (2001) and El-Behairy (2003).

Concerning aeroponic system, Gysi and von Allmen (1997) found higher yield for tomato grown in NFT and aeroponic than grown in soil. Perlite substrate treatment, was better than the control treatment but less than NFT treatment. These results were similar as suggested by Abed El-Rahman *et al.* (2003) and Singer *et al.* (2009).

Table 2: Effect of different soilless culture systems on number of fruits per plant, fruit weight and total yield per plant at harvesting stage of cantaloupe plant in autumn and spring plantations during both seasons of 2006/2007 and 2007/2008.

Systems	Number of fruits/plant			Fruit weight (g)			Yield/plant (g)		
	Autumn	Spring	Mean	Autumn	Spring	Mean	Autumn	Spring	Mean
First season (2006/2007)									
Aeroponic	2.56 b	2.44 bc	2.50 B	608.5 e	680.7 d	644.6 C	1559.9 d	1654.5 d	1607.2 C
NFT	3.25 a	3.13 a	3.19 A	894.3 b	1040.4 a	967.3 A	2897.6 b	3219.6 a	3058.6 A
Perlite	2.63 b	2.63 b	2.63 B	620.3 e	816.4 c	718.3 B	1621.4 d	2127.3 c	1874.3 B
Soil	2.13 c	2.06 c	2.09 C	412.4 g	520.2 f	466.3 D	872.1 e	1054.5 e	963.3 D
Mean	2.64 A	2.56 A		633.9 B	764.4 A		1737.8 B	2014.0 A	
Second season (2007/2008)									
Aeroponic	2.44 cd	2.38 cd	2.41 B	605.2 e	688.6 d	646.9 C	1472.1 e	1628.1 de	1550.1 C
NFT	3.38 a	3.06 ab	3.22 A	930.7 b	1144.5 a	1037.6A	3139.3 b	3457.8 a	3298.5 A
Perlite	2.75 bc	2.56 cd	2.66 B	638.6 e	822.7 c	730.7 B	1768.6 d	2093.3 c	1931.0 B
Soil	2.19 d	1.81 d	2.00 C	418.1 f	446.8 f	432.4 D	916.4 f	805.3 f	860.8 D
Mean	2.69 A	2.45 B		648.1 B	775.6 A		1824.1 B	1996.1 A	

Leaf mineral nutrient contents:

Nitrogen percentage:

Data in Table (3) showed the effect of different soilless culture systems and plantation season on the nitrogen percentage in cantaloupe leaves. Significant differences were noticed among treatments. The highest percentage of nitrogen in leaves was recorded by NFT system followed by aeroponic system in both seasons with significant difference between them. The lowest percentage of nitrogen in leaves was noticed by perlite system, in the first season and by soil and perlite system in the second season.

Respecting the plantation season, leaves of cantaloupe plants grown in autumn plantation gave higher nitrogen percentage than those of spring plantation in both seasons. However, the significant difference was detected in the first season only.

Concerning the interaction effect between soilless systems and plantation season, the highest percentage of nitrogen in leaves was obtained with NFT system in autumn plantation followed significantly by NFT system in spring plantation in the first season and aeroponic system in spring plantation in the second season. The lowest percentage of nitrogen was obtained with perlite system in spring plantation in the first season and by soil system in autumn plantation in the second one.

Phosphorus percentage:

Data in Table (3) reported that using NFT or aeroponic systems gave the highest values of phosphorus percentage in leaves without a significant difference between them in both seasons. The lowest percentage of phosphorus in the first season was noticed by using soil cultivation system followed by perlite system with a significant difference between them and by both perlite and soil cultivation systems in the second season without a significant difference between them.

As to the plantation season, plants grown in spring plantation gave higher percentage of phosphorus in leaves compared with those of autumn plantation; the difference between plantations was significant. These results held true in both seasons of study.

Concerning the interaction, there were significant differences detected among treatments on the phosphorus percentage in leaves. The highest values of phosphorus percentage in leaves were obtained with NFT system in spring plantation followed significantly by aeroponic system in spring plantation. The lowest values of phosphorus percentage were obtained by using soil cultivation system in autumn plantation. These findings were true in both seasons.

Potassium percentage:

Data presented in Table (3) showed the effect of different soilless culture systems and plantation season on the potassium percentage in cantaloupe leaves. The highest percentage of potassium was observed in leaves of plants grown in either soil or aeroponic systems in the first season and by either aeroponic or perlite systems in the second season. The lowest percentage of potassium in the first season was observed in leaves of plants grown in perlite system followed by NFT system and by NFT system followed by soil cultivation system in the second season. It is of interest to note that the difference between the highest and lowest values were significant but no significant differences were realized within the highest or lowest values of potassium percentage in both season.

Concerning the plantation season, the obtained results indicated that there were no significant differences in potassium percentage between plants leaves grown in autumn or spring plantations. This was true in both seasons.

As for the interaction, the highest leaf potassium percentage in the first season was obtained by NFT system in spring plantation and aeroponic system in autumn plantation, followed by soil cultivation system in spring and autumn plantations. While, in the second season, it was observed by aeroponic system in autumn plantation and perlite system in spring plantation. The lowest potassium percentage was obtained by using NFT system in autumn plantation in both season of study.

The obtained results are in agreement with Yang *et al*. (1990) They reported that tomato plant grown in aeroponics system gave higher concentrations of P, K and Mg and lower concentrations of Ca than nutrient film technique.

Mineral contents were affected by cultivation system where using substrate culture increased the nutrients significantly. This also may be a result of increasing the vegetative growth of the plants cultivated in substrate culture system which may increase the uptake of these elements (El-Behairy, 1994).

Calcium percentage:

Table (4) showed the effect of different soilless culture systems and plantation season on the calcium percentage in cantaloupe leaves during both seasons. A significant difference was detected between perlite system and the rest of treatments only in the first season. While, in the second season significant differences were detected among all treatments. Perlite system gave the highest values of calcium percentage in leaves in both seasons. While, the lowest percentage of calcium in leaves was obtained with aeroponic system in both seasons.

Concerning the plantations, no significant differences in percentage of calcium in leaves were found between autumn and spring plantations in both seasons. In spite of no significant difference, autumn plantation gave higher values for calcium percentage in leaves in both seasons.

The interaction had a significant effect between soilless culture and plantation season on percentage of calcium in leaves in both seasons. The highest percentages of calcium in leaves was obtained with perlite system in autumn plantation followed by soil cultivation in spring plantation during the first season and in the second season by perlite system in autumn and spring plantations. The lowest calcium percentage in leaves was obtained with aeroponic system, either in spring or in autumn plantation during both seasons.

Magnesium percentage:

Data tabulated in Table (4) strongly indicated that there were significant differences among all treatments on magnesium percentage in leaves in both seasons. The highest magnesium percentage in leaves was obtained by soil cultivation system followed significantly by perlite system. The lowest magnesium percentage was obtained by aeroponic and NFT systems without significant difference between them. The obtained results were true in both seasons.

The plantation season, in the first season, spring plantation resulted in higher significantly leaf magnesium percentage compared with autumn plantation. The opposite trend took place in the second season, where, leaf magnesium percentage was higher in plants grown in autumn plantation compared to those of spring one. The difference between plantations was significant in both seasons.

Regarding the interaction, in the first season, the highest percentage of magnesium was obtained by soil cultivation system in spring plantation followed significantly by soil cultivation system in autumn plantation while, the opposite was detected in the second season. The lowest magnesium percentage was obtained with aeroponic system in autumn in the first season and NFT system in spring plantation.

High percentage contents of mineral nutrients in cantaloupe leaf may be due to that soilless culture systems could meet plant demands better than the soil.

Yang *et al.* (1990) reported that tomato plant grown in aeroponics system gave higher concentrations of Mg and lower concentrations of Ca than nutrient film technique. In addition lettuce hydroponics grown plant contains N, P, K, Ca, Cu, Mg and Mn higher than soil grown lettuce (Santos *et al.*, 2003).

Table 3: Effect of different soilless culture systems on cantaloupe plants mineral nutrient contents, nitrogen, phosphorus and potassium percentages after 12 weeks from transplanting date in autumn and spring plantations during both seasons of 2006/2007 and 2007/2008.

Systems	N %			P %			K %		
	Autumn	Spring	Mean	Autumn	Spring	Mean	Autumn	Spring	Mean
First season (2006/2007)									
Aeroponic	4.204 c	4.099 d	4.152 B	0.757 c	0.814 b	0.786 A	6.068 a	5.044 c	5.556 A
NFT	5.322 a	4.463 b	4.892 A	0.661 d	0.925 a	0.793 A	4.307 d	6.293 a	5.300 B
Perlite	3.973 e	3.827 f	3.900 D	0.607 e	0.735 c	0.671 B	5.443 b	5.027 c	5.235 B
Soil	3.903 e f	4.069 d	3.986 C	0.448 g	0.493 f	0.470 C	5.722 b	5.567 b	5.645 A
Mean	4.350 A	4.114 B		0.618 B	0.742 A		5.385 A	5.483 A	
Second season (2007/2008)									
Aeroponic	4.183 bcd	4.301 b	4.242 B	0.739 c	0.799 b	0.769 A	5.945 a	5.169 c	5.557 A
NFT	5.180 a	4.053 d	4.617 A	0.644 d	0.961 a	0.802 A	4.166 d	5.450 bc	4.808 B
Perlite	3.791 e	4.213 bc	4.002 C	0.592 e	0.624 de	0.608 B	5.304 bc	5.571 ab	5.437 A
Soil	3.710 e	4.134 cd	3.922 C	0.429 f	0.831 b	0.630 B	5.548 bc	4.471 d	5.009 B
Mean	4.216 A	4.175 A		0.601 B	0.804 A		5.240 A	5.165 A	

Table 4: Effect of different soilless culture systems on cantaloupe plants mineral nutrient contents, calcium and magnesium percentages after 12 weeks from transplanting date in autumn and spring plantations during both seasons of 2006/2007 and 2007/2008.

Systems	Ca %			Mg %		
	Autumn	Spring	Mean	Autumn	Spring	Mean
First season (2006/2007)						
Aeroponic	1.863 d	2.011 cd	1.937 B	0.651 e	0.746 cd	0.698 C
NFT	2.346 ab	2.167 bc	2.256 A	0.678 de	0.654 e	0.666 C
Perlite	2.530 a	2.061 c	2.296 A	0.770 c	0.758 c	0.764 B
Soil	2.130 c	2.498 a	2.314 A	0.875 b	0.997 a	0.936 A
Mean	2.217 A	2.184 A		0.743 B	0.789 A	
Second season (2007/2008)						
Aeroponic	1.766 d	1.823 d	1.794 C	0.741 cde	0.718 de	0.729 C
NFT	2.215 b	2.072 c	2.143 B	0.781 cde	0.705 e	0.743BC
Perlite	2.358 a	2.376 a	2.367 A	0.804 c	0.798 cd	0.801 B
Soil	2.157 bc	2.034 c	2.096 B	1.081 a	0.980 b	1.030 A
Mean	2.124 A	2.076 A		0.852 A	0.800 B	

Conclusion:

It could be concluded from the overall results that all the soilless culture systems performed better than soil cultivation system (control). The NFT system is considered to be the best system for producing off season cantaloupe. This may be due to that this system was the most favorable for vegetative growth and high production comparing with other tested soilless culture systems.

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