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EFFECT OF IRRIGATION AND FERTILIZATION ON GROWTH AND YIELD OF SWEET PEPPER GROWN HYDROPONICALLY

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ABSTRACT

The present experiment was carried out during 2007/2008 and 2008/2009 successive seasons using sweet pepper (*Capsicum annuum L.*) cv. Gedeon cultivated within a part of a double-span screen-house at Dokki protected cultivation site, Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center (ARC).

This investigation aimed to study the effect of nitrogen concentrations and irrigation levels on growth and yield of pepper. Three nitrogen concentrations (150, 200, and 250 ppm) and three irrigation levels [100%, 120% and 140% of crop evapotranspiration (ET_c)] with three replicates were applied in a split plot design.

The results showed that nitrogen concentration at 200 ppm improved the number of leaves, total leaf area and P content. While, yield characteristics increased with N concentration at 150 ppm. Moreover; increasing irrigation level to 140% of ET_c led to the highest vegetative growth while the highest yield characteristics and K and Mg contents were recorded with irrigation level at 120% of ET_c. The highest P content was recorded with irrigation level at 100% of ET_c. However, the effect of interaction showed that, increasing vegetative growth recorded at 200 ppm N combined with 140% irrigation level except total plant fresh and dry weight and Vitamin C which, increased with 250 ppm nitrogen concentration combined with 140% of ET_c irrigation level treatment. Nitrogen concentration 150 ppm combined with irrigation level of 120% treatment increased significantly yield characteristics and chlorophyll and K contents in both seasons.

Key words: *Capsicum annuum L., growth, hydroponic, irrigation levels, nitrogen concentrations, screen house, yield.*

1. INTRODUCTION

Commercial hydroponics are a modern technology involving plant growth on inert media in place of the natural soil, in order to uncouple the performance of the crop from problems associated with the ground, such as soil-borne diseases, nonarable soil, poor physical properties, etc. Various non-toxic porous materials are used as plant growth substrates, including rockwool, perlite, pumice, expanded clay, various volcanic materials, polyurethane foam, coir dust, etc. (Savvas, 2003).

Moreover, soilless culture is considered an important new technique where it allows water and nutrients to be supplied according to the requirements of the plant, thus raising the efficiency of water and fertilizer use. It contributes to high yield and better quality crops due to good control of the plant growth, earliness and development. It decreases the application of pesticides and other toxic agrochemicals. However, it requires optimal climatic and nutritional conditions in the greenhouse. (Hamad 2003, Savvas 2003, Dasgan and Ekici, 2005 and Rincon *et al*., 2005).

Many studies have indicated that the current regimes of N fertilization practiced in soilless cultures not only lead to ineffective nitrogen use but also to large losses of N to the environment. For this reason, Guzmán and Sánchez (2003) reported that such nutritive imbalance techniques should only be used in controlled conditions and when manual fruit elimination constitutes a normal practice. Also at this fertigation frequency twice a week the tested vegetables maintain high productivity, compared with yields gained with more frequent fertigation. (Al-Ghawas and Al-Mazidi, 2004).

Environmentally compatible production practices should improve irrigation and nutrient efficiency, reduce contaminated effluent and affect fruit yield and fruit quality of soilless-greenhouse-grown pepper plants. (Le Bota *et al*., 2001)

Therefore, the objective of the present work was to investigate the effects of three N concentrations and three irrigation levels on plant growth, dry matter production, and yield of greenhouse-grown pepper.

2.MATERIALS AND METHODS

This study was carried out in the research greenhouse of the Central Laboratory for Agricultural Climate (CLAC), Dokki location, throughout the two successive seasons 2007/2008 and 2008/2009 to investigate the effect of three nitrogen concentrations (150, 200, and 250 ppm) with three irrigation levels (100%, 120% and 140%) of daily crop evapotranspiration) on the growth and yield of sweet pepper (*Capsicum annuum*) cv. Gedeon. The study was conducted in a double-span screen house with an area of 18 m x 60 m and a height of 4.5 m).

2.1. Plant material

Seedlings of sweet pepper (*Capsicum annuum* L. cv. Gedeon F1 hybrid from Suez Canal Company) were transplanted during the first week of August in both seasons. Plants were pruned in horizontal form. The experiment was designed using split plot design with three replicates. The main plot was nitrogen levels and the subplots were the irrigation regime treatments. The experiment was divided into nine beds. Each bed was 0.45 m wide, 7 m long and a height of 0.30 m. The beds were covered with polyethylene, filled with marble residues (size 8-12 mm) which were considered as gravel, and each was divided to three plots of 8 plants giving a plant density of three plants per square meter.

2.2. Treatment

Water and nutrient uptake were measured daily by calculating the daily difference between supplied and leached amounts of nutrient solution. The used nutrient solution was prepared according to Jovicich *et al*. (2003). Micronutrients were applied using chelated commercial liquid fertilizer according to Xu *et al*. (2001b). Moreover, three levels of nitrogen (150, 200 and 250 ppm) were used in the experiment. N was increased from ammonium nitrate (NH_4NO_3) with 200 ppm & 250 ppm. Thirty days after transplanting, nine fertigation levels were started. Plants were irrigated and drainage was measured daily in open systems according to Stanghellini *et al*.(2003). The amount of the used actual water was calculated according to Doorenbos and Pruit (1977) as follows:

$\mathbf{ET_c = ET_o * K_c}$; Where:-

ET_c = Crop evapotranspiration, (Actual water needs) mm/day.

ET_o = Reference evapotranspiration, mm/day.

K_c = Crop Coefficient (Crop factor) between 0.4 to 1.2

Daily needs of water requirement (WR) for each method of irrigation were calculated in the following:

$WR = ET_c * L\%$ mm/day, Where:-

ET_c = Crop evapotranspiration (Actual water needs), mm/day.

L% = Leaching requirement percentage was estimated be the addition of 20% of WR

2.3. Data recorded

Three plants were randomly selected from each replicate to be used for measuring the growth and yield parameters.

2.3.1. Plant growth parameters

2.3.1.1. Number of leaves: The average number of leaves was counted at the end of the season.

2.3.1.2. Total leaf area: Ten leaves were measured from each experimental plot. Three plants per replicate were removed at the end of the season from each treatment and all leaves were removed. Their total surface area was determined using LI-3000 portable area meter.

2.3.2 Yield measurements

2.3.2.1. Early yield: The early yield was determined from the first harvest up to the end of January in each season.

2.3.2.2. Total yield: Cumulative yield was recorded and the total fruit weight per plant was determined.

2.3.3. Chemical analysis

2.3.3.1. Plant sample: Blades of 10 fourth leaves were collected from each replicate for chemical analysis. Samples of the leaves were taken every 25 days from starting treatment. The samples were oven dried at 70° C then ground in a blender and stored in glass vials for chemical analysis. The samples were digested by the wet digestion method using the sulfuric acid and hydrogen peroxide as described by Chapman and Pratt (1961). The following chemical analyses were done:

2.3.3.1.1. The contents of N, P and K in the dry plant samples (leaves and roots) were determined at 40, 65 and 90 days after transplanting date.

Nitrogen, phosphorous and potassium in the acid digested solution were determined applying Micro-Kjeldahl for N, colorimetric method (ammonium molybdate) using spectrophotometer for P and by flame photometer for K (Chapman and Pratt, 1961).

2.3.3.1.2. Calcium and magnesium contents were determined in the dried youngest mature leaves and roots, in the acid digested solution using atomic absorption spectrophotometer according to Chapman and Pratt (1961).

2.3.3.2. Total chlorophyll: Total chlorophyll was measured at the end of the two seasons, for the recently mature leaf from terminal bud, using Minolta Chlorophyll Meter SPAD-501. Ten leaves were measured from each experimental plot. SPAD unit = 10 mg/100 g fresh weight of leaves.

2.3.3.3. Vitamin C: Ascorbic acid (vitamin C) was determined in the fresh fruits by using the 2, 6 Dichlorophenolindophenol method described in A. O. A. C. (1990).

2.4. Statistical analyses

The obtained data were statistically analyzed using the analysis of variance method according to Snedecor and Cochran (1980). Duncan's multiple range test at 5% level of probability was used to compare means of the treatments.

3. RESULTS AND DISCUSSION

3.1. Vegetative growth characteristics

The different applied nitrogen concentrations and irrigation levels affected the vegetative parameters of pepper plants such as the number of leaves, total leaf area, fresh and dry weights as shown in Tables (1 and 2). Data indicte that there were significant differences among treatments during the two studied seasons.

Regarding to nitrogen concentrations, the highest significant value of the number of leaves and total leaf area were obtained with N at 200 ppm. Using of N 250 ppm had a negative effect on the number of leaves but the total leaf area decreased with 150 ppm compared to other nitrogen treatments as presented in Table (1).

Concerning, irrigation level, increasing irrigation level (up to 140% of ET_c) led to increase the number of leaves and total leaf area. The lowest number of leaves and the total leaf area were obtained with the lowest irrigation level (100% of ET_c) while with irrigation level of 120% of ET_c gave lower number of leaves, which was not significantly different as compared with the lowest recorded content .

Regarding the interaction treatments on the number of leaves and total plant leaf area, the combination between N at 200 ppm with the highest irrigation level gave the highest number of leaves and leaf area at the end of both seasons. However, the lowest values were recorded with the highest nitrogen concentration (250 ppm) combined with the lowest irrigation level at 100% of ET_c during the two seasons.

On the other hand, the effect of nitrogen concentrations on the total fresh and dry weight showed that the highest values were recorded with N at 150 ppm while N at 200 ppm gave a high dry weight, which was not significantly different than the highest value recorded in two seasons. The

Table (1): Effect of nitrogen concentrations and irrigation levels on the vegetative growth characteristics of sweet paper in two seasons (2007/2008 & 2008/2009).

First season					Second Season				
N. concent-ration ppm	Irrigation levels (% of ET_c)			Mean	N. concent-ration ppm	Irrigation levels (% of ET_c)			Mean
	100%	120%	140%			100%	120%	140%	
Number of leaves									
150	400.7b	385.3bc	380.0bcd	**388.7B**	**150**	560.7b	535.3c	546.0bc	**547.3B**
200	356.5d	375.2bcd	497.7a	**409.8A**	**200**	471.5e	505.2d	697.7a	**558.1A**
250	283.0e	290.5e	361.0cd	**311.5C**	**250**	376.0g	395.5f	541.0c	**437.5C**
Mean	**346.7B**	**350.3B**	**412.9A**		**Mean**	**469.4B**	**478.7B**	**594.9A**	
Total leaf area (cm^2)									
150	2106.2de	2096.1de	3013.0b	**2405.07C**	**150**	2118.2ef	2107.2f	3027.2b	**2417.6C**
200	2149.0d	2339.0c	3349.68a	**2612.53A**	**200**	2156.9de	2351.1c	3360.1a	**2622.7A**
250	1984.9e	2156.1d	3305.9a	**2482.32B**	**250**	1999.7g	2166.7d	3319.4a	**2495.3B**
Mean	**2080.03C**	**2197.04B**	**3222.85A**		**Mean**	**2091.6C**	**2208.3B**	**3235.6A**	

*Different letters indicate significant difference at 5%

lowest values were obtained with N at 250 ppm in Table (2).

Referring to the effect of irrigation levels, the highest level increased the values of both the total fresh and dry weight per plant. The lowest values were recorded with the lowest irrigation level during the two seasons. These results disagree with those obtained by Stanghellini *et al*. (2003), who found that there was no relevant difference in water uptake, or fresh weight.

early yield and total yield per plant were obtained from 150 ppm N meanwhile increasing of nitrogen decreased the values. Nitrogen concentration at 200 ppm gave a high average fruit weight, which was not significantly different from the highest recorded content.

Through the obtained results, it is noted that decreasing the total N concentration improved yield. In addition, nitrogen concentrations affected the yield. The increments in these parameters were statistically significant especially with 150 ppm, compared to other treatments in both seasons. These results agree with those obtained by Xu *et al*., (2001a and 2001b) and Silber *et al*.(2005). Schon *et al*.(1994) found that during both trials, plants receiving N at 175 mg.liter^{-1} produced significantly more fruits (8 %) and 14 % higher total fruit weight than plants receiving lower levels of N (120 mg.liter^{-1}). Also, Bar-Tal *et al*. (2001a) found that the optimal values of N concentration for total fruit yield was 9.3 mmol.l^{-1}.

Table (2): Effect of nitrogen concentrations and irrigation levels on total fresh weight and dry weight of sweet paper in two seasons (2007/2008 & 2008/2009).

First season					Second Season				
N. concent-ration ppm	Irrigation levels (% of ET_c)				N. concent-ration ppm	Irrigation levels (% of ET_c)			
	100%	120%	140%	Mean		100%	120%	140%	Mean
Total Fresh Weight (G/Plant)									
150	272.3d	322.0bc	313.8c	**302.7A**	**150**	300.5ed	402.6b	398.8b	**367.3A**
200	322.5b	238.4e	321.5bc	**294.2B**	**200**	375.8c	306.8d	400.8b	**361.2B**
250	163.6f	240.8e	360.9a	**255.1C**	**250**	180.8f	297.5e	430.9a	**303.0C**
Mean	**252.8C**	**267.1B**	**332.1A**		**Mean**	**285.7C**	**335.6B**	**410.2A**	
Total dry weight (g/plant)									
150	65.31d	81.13bc	83.72ab	**76.72A**	**150**	67.81ef	90.33c	93.22bc	**83.79A**
200	76.62c	60.91de	85.42ab	**74.32A**	**200**	78.62d	70.41e	95.92ab	**81.65A**
250	47.07f	58.29e	88.27a	**64.54B**	**250**	50.67g	65.09f	98.97a	**71.58B**
Mean	**63.00C**	**66.77B**	**85.81A**		**Mean**	**65.70C**	**75.27B**	**96.04A**	

*Different letters indicate significant difference at 5%

The highest nitrogen concentration combined with the highest irrigation level gave the highest values of both total fresh and dry weight per plant. The lowest values were obtained with N at 250 ppm and irrigation at 100% of ET_c in both seasons. This is in agreement with Marcelis *et al*. (2005) where it was assumed that no nutrient limitations occurred as related to dry matter, because there was always an abundant supply of water and nutrients and because total dry matter production agreed well with stimulation results for situations without nutrient limitation. The measured nitrogen concentration of all organs showed a clear ontogenetic decline.

This suggests that excessive fertilization through more frequent fertigation directly or indirectly had hindered the crop yield potential. Higher nutrition for growing plants, particularly N, can physiologically induce more vegetative growth (Al-Ghawas and Al-Mazidi, 2004).

3.2. Yield characteristics

Data shown in Table (3) indicate that the highest average fruit weight, number of fruits,

Irrigation level of 120% of ET_c gave the highest average of fruit weight, early yield and total yield per plant while the number of fruits did not differ significantly. The lowest early yield and total yield per plant were recorded with the highest irrigation level (140% of ET_c) while the lowest average fruit weight was obtained with the lowest irrigation level (100% of ET_c).

The data regarding the interaction between the effects of both nitrogen concentrations and irrigation levels showed that the highest values were obtained with N at 150 ppm and irrigation using 120% of ET_c while the number of fruits increased with N at 200 ppm and irrigation using 100% of ET_c.

Frequent fertigation may improve the uptake of nutrients through two main mechanisms: continuous replenishment of nutrients in the depletion zone in the vicinity of the root/medium interface, and enhanced transport of dissolved nutrients by mass flow, because of the higher time-averaged water content in the medium (Silber *et al*., 2003; Xu *et al*., 2004 and Silber 2008) which translated to improve yield characteristics.

The lowest values were recorded with N at 250 ppm, and irrigation at 100% of ET_c while number of fruits decreased the interaction treatments had the same trend during both seasons.

Furthermore, a high concentration of some compounds can complex the phosphate compounds in unavailable forms. Phosphorus is required in higher amounts during fruit setting and these possible nutrient antagonisms could have reduced the yield potential (Al-Ghawas and Al-Mazidi , 2004).

3.3. Chemical analysis

The statistical analysis of both tested seasons for the two investigated factors on nitrogen percentage in pepper leaves is shown in Table (4), however insignificant differences were obtained.

Concerning the effect of different treatments on nitrogen percentage in pepper leaves, the data indicated that the highest value was recorded in plants under N at 150 ppm combined with 100% of ET_c. This is in agreement with Bar-Tal, *et al*. (1995). The N at 150 ppm combined with irrigation level at 140% of ET_c recorded the lowest nitrogen percentage during both seasons. That was in agreement with results of Silber, *et al.*

Table (3): Effect of nitrogen concentrations and irrigation levels on yield characteristics of sweet paper in two seasons (2007/2008 & 2008/2009).

First season					Second Season				
N. concent-ration	Irrigation levels (% of ET_c)				N. concent-ration	Irrigation levels (% of ET_c)			
ppm	100%	120%	140%	Mean	ppm	100%	120%	140%	Mean
Average fruit weight (g)									
150	60.7d	80.1a	60.4d	**67.1A**	**150**	70.7cd	80.6a	74.6bc	**75.3A**
200	61.1d	72.8b	61.3d	**65.1A**	**200**	73.9bc	70.8cd	75.2b	**73.3A**
250	53.7e	68.0c	60.1d	**60.6B**	**250**	54.2f	66.7d	60.1e	**60.3B**
Mean	**58.5C**	**73.6A**	**60.6B**		**Mean**	**66.3C**	**72.7A**	**70.0B**	
Early yield (g/plant)									
150	424.9c	640.8a	362.4e	**476.0A**	**150**	445.4c	644.8a	395.4d	**495.2A**
200	488.8b	385.8d	306.5g	**393.7B**	**200**	539.5b	354.0f	376.0e	**423.2B**
250	268.5i	340.0f	300.8h	**303.1C**	**250**	233.1i	333.5g	318.5h	**295.0C**
Mean	**394.1B**	**455.6A**	**323.2C**		**Mean**	**406.0B**	**444.1A**	**363.3C**	
Number of fruits									
150	20.0a	22.9a	17.1b	**20.0A**	**150**	18.0b	22.9a	15.1bc	**18.7A**
200	22.9a	15.1b	14.3b	**17.4B**	**200**	20.9a	14.3c	14.3c	**16.5B**
250	14.3b	14.3b	14.3b	**14.3C**	**250**	12.3c	14.3c	15.1bc	**13.9C**
	19.1A	**17.4A**	**14.4A**		**Mean**	**17.1A**	**17.1A**	**14.9A**	
Total yield (g/plant)									
150	1214.0c	1830.9a	1035.4e	**1360.1A**	**150**	1272.6c	1842.3a	1129.7d	**1414.9A**
200	1396.6b	1102.4d	875.7g	**1124.9B**	**200**	1541.3b	1011.4f	1074.3e	**1209.0B**
250	767.1i	971.4f	859.4h	**866.0C**	**250**	665.9i	952.9g	910.1h	**842.9C**
Mean	**1125.9B**	**1301.6A**	**923.5C**		**Mean**	**1159.9B**	**1268.9A**	**1038.0C**	

***Different letters indicate significant difference at 5%.**

Therefore, excessive fertilization through more frequent fertigation directly or indirectly had hindered the crop yield potential. High nutrition for growing plants, particularly N, can physiologically induce more vegetative growth.

Table (4): Effect of nitrogen concentrations and irrigation levels on the chemical compounds in the seasons of 2007/2008 & 2008/2009.

First season					Second season				
N. concent-ration	Irrigation levels (% of ET_c)				N. concent-ration	Irrigation levels (% of ET_c)			
ppm	100%	120%	140%	Mean	ppm	100%	120%	140%	Mean
Nitrogen (%)									
150	3.52a	3.23b	2.55e	**3.10A**	150	3.88a	3.79ab	3.23e	**3.63A**
200	2.86d	3.30ab	2.67de	**2.94A**	200	3.63abc	3.73ab	3.44cde	**3.60A**
250	2.70de	3.18bc	2.91cd	**2.93A**	250	3.35ed	3.60bcd	3.52bcd	**3.49A**
Mean	**3.03A**	**3.24A**	**2.71A**		Mean	**3.62A**	**3.71A**	**3.40A**	
Phosphorus (%)									
150	0.732e	0.769c	0.663g	**0.721B**	150	0.807e	0.890c	0.892c	**0.863B**
200	0.832a	0.613h	0.776b	**0.740A**	200	1.058a	0.735f	0.930b	**0.908A**
250	0.700f	0.763d	0.588i	**0.684C**	250	0.858d	0.918b	0.667g	**0.814C**
Mean	**0.754A**	**0.715B**	**0.675C**		Mean	**0.907A**	**0.848B**	**0.830C**	
Potassium (%)									
150	0.960h	1.998a	0.876i	**1.278B**	150	0.910e	1.405a	0.864f	**1.060B**
200	1.040f	1.195c	1.036g	**1.090C**	200	0.944d	1.000c	0.926c	**0.957C**
250	1.092e	1.098d	1.902b	**1.364A**	250	0.932dc	0.945d	1.333b	**1.070A**
Mean	**1.031C**	**1.430A**	**1.271B**		Mean	**0.929C**	**1.117A**	**1.041B**	
Magnesium (%)									
150	1.45a	1.65a	1.36a	**1.49A**	150	1.25a	1.28a	1.13a	**1.22A**
200	1.32a	1.45a	1.35a	**1.37A**	200	1.19a	1.23a	1.19a	**1.20A**
250	1.31a	1.41a	1.30a	**1.34A**	250	1.07a	1.21a	1.06a	**1.11A**
Mean	**1.36B**	**1.50A**	**1.34B**		Mean	**1.17B**	**1.24A**	**1.13B**	
Calcium (%)									
150	1.50a	2.33a	1.57a	**1.80A**	150	1.78a	1.94a	1.76a	**1.83A**
200	1.85a	2.36a	1.29a	**1.83A**	200	1.81a	2.14a	1.64a	**1.86A**
250	2.35a	2.17a	2.00a	**2.20A**	250	1.89a	1.93a	1.73a	**1.85A**
Mean	**1.90A**	**2.29A**	**1.62A**		Mean	**1.83A**	**2.00A**	**1.71A**	
Leaf chlorophyll content (10 mg/100 g)									
150	60.14ab	62.45a	52.57c	**58.39A**	150	63.94abc	67.25a	58.17c	**63.12A**
200	62.32a	55.38bc	61.66ab	**59.79A**	200	67.12a	58.88bc	64.16ab	**63.39A**
250	60.07ab	61.18ab	59.71ab	**60.32A**	250	62.57abc	66.98a	61.71abc	**63.75A**
Mean	**60.84A**	**59.67A**	**57.98A**		Mean	**64.54A**	**64.37A**	**61.34A**	
Vitamin C (mg/ 100g)									
150	61.26ab	55.81bc	60.46ab	**59.18A**	150	62.16ab	60.81abc	62.46ab	**61.81A**
200	60.53ab	50.48c	55.96bc	**55.66A**	200	63.33ab	53.58d	60.46bc	**59.12A**
250	52.75c	61.77a	62.44a	**58.99A**	250	56.25cd	64.27ab	66.24a	**62.25A**
Mean	**58.18A**	**56.02A**	**59.62A**		Mean	**60.58A**	**59.55A**	**63.05A**	

***Different letters indicate significant difference at 5%.**

(2005) who, found that irrigation frequency had no influence on leaf-N concentrations during vegetative growth, or during harvest**.**

Referring to the effect of treatments on phosphorus percentage in the leaves, the data indicated that the highest value was recorded in plants under N at 200 ppm with 100% of ET_c. The highest nitrogen concentration 250 ppm combined with irrigation level at 140% of ET_c treatment significantly recorded the lowest phosphorus percentage of the leaves in both seasons.

However, the data revealed that the highest potassium percentage in the leaves was obtained with N at 250 ppm treatment. The treatment of 200 ppm had the lowest potassium percentage in both seasons. Where, Johnson and Decoteau (1996) concluded that the optimum N rate for pod yield was 15 mM. Biomass, fruit count, and fruit weight per plant increased linearly with increasing K rate in the first experiment and curvilinearly in the second experiment.

While, increasing irrigation level to 120% of ET_c increased potassium percentage of the leaves significantly and the lowest value was observed under 100% of ET_c treatment during the two seasons.

According to the effect of the treatments on potassium percentage of the leaves, data indicated that the highest value was recorded under N at 150 ppm combined with 120% of ET_c treatment. The N at 150 ppm combined with 140% of ET_c treatment recorded the lowest value during both seasons.

Moreover, the statistical analysis indicated that there were no significant differences among the treatments and factor (B) (nitrogen concentrations) on magnesium percentage in the leaves during the two seasons. While, the effect of factor (A) (irrigation levels of ET_c) was significant where, the highest magnesium percentage in the leaves was obtained with irrigation level of 120% from ET_c. Both treatments of 100% and 140% of ET_c significantly decreased magnesium percentage of the leaves during the two tested seasons. This indicates that increased fertigation frequency could serve as an efficient means of enhancing crop yield, by improving the uptake by plants, of less mobile nutrients and increasing water availability. Yield thus is primarily related to increased nutrients availability as long as the effects on plant growth, of water content (θ) and of the unsaturated hydraulic conductivity in the substrate were minor. An increase in fertigation frequency enables reduction of the concentrations of immobile elements such as P, K and trace metals in irrigation water (Silber, 2008).

On the other hand, calcium percentage in the leaves under different nitrogen concentrations, irrigation levels and the interaction between them was not significant during the two successive seasons.

The represent data showed that the effect of nitrogen concentrations and irrigation levels in Table (4) were not significant for both leaf chlorophyll content and vitamin C during the two seasons.

The interaction between effects of nitrogen concentration and irrigation levels resulted in significant differences in the chlorophyll content. The highest chlorophyll content was obtained with N at 150 ppm combined with irrigation level of 120% of ET_c, followed with N at 200 ppm combined with irrigation level at 100% of ET_c. Nitrogen concentration at 150 ppm combined with irrigation level of 140% of ET_c gave the lowest chlorophyll content.

As for the interaction effect on vitamin C, the highest value was obtained in plants fertilized with N at 250 ppm combined with irrigation at 140% ET_c. In the first season, N at 250 ppm with irrigation at 120% of the crop evapotranspiration gave high vitamin C content, which was not significantly different than the highest recorded content . The lowest content was obtained when N at 200 ppm was combined with irrigation at 120% ET_c treatment. In the first season, N at 250 ppm with irrigation at 100% of the crop evapotranspiration gave high vitamin C content, which gave no significant difference than the lowest recorded content.

These results agree with Bar-Tal *et al*. (2001b) who reported that the leaf chlorophyll content increased quadratically as the optimal N concentration was applied in the nutrient solution, whereas the maximum high-quality yield was achieved by the highest nitrogen concentration. Vitamin C content did not affect NO_3^- treatments. An increased supply of NO_3^- in the culture medium could constitute a useful practice for improving the nutritional attributes of pepper as well as its commercial quality (Flores *et al*., 2004).

The stimulation results show that the uptake by the plants is definitely not constant. Adapting the water and nutrient supply to the demands of the plant may lead to further optimization of crop growth and quality as well as the sustainability of the production system (Marcelis *et al*., 2005).

Conclusion

It could be stated that high N concentration up to 200 ppm treatments in the nutrient solution gave the highest growth characteristics but reduced yield characteristics. Increasing the amount of irrigation water to (120% of ET_c) throughout the growing season may improve plant growth, which stimulated and encouraged yield characteristics. Pepper plants are sensitive to continuous N nutrition and the current regimes of

N fertilization practiced in soilless cultures not only lead to ineffective nitrogen use but also to large losses of N in the drainage. Using the lowest nitrogen concentration in the growing medium will improve plant growth and lead to increasing yield. This new technique of soilless culture need to adapt the water and nutrient supply to the demands of the plant may lead to further optimization of crop growth and quality as well as the sustainability of the production system. These results proved that during the harvest period, P, K and Ca concentrations in the leaves were in the normal range and were not affected by the treatments applied (Silber *et al*. 2005).

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تأثير الرى والتسميد على نمو ومحصول الفلفل المزروع بدون تربة

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ملخص

زرعت نباتات الفلفل صنف جديون خلال موسمى الزر اعة المتتالين 2007-2008 و 2008-2009 بصوبة سيران مزدوجه بالمعمل المركزى للمناخ الزراعى بالدقى التابع لمركز البحوث الزراعية. استهدفت هذه التجربة دراسة تأثير تركيزات النيتروجين المختلفة (150و 200 و 250 جزء فى المليون) مع مستويات الرى المختلفة (100% و 120%و 140%) من الاستهلاك المائي الفعلى للمحصول تحت الصوب الزراعية) على كل من النمو والمحصول. صممت التجربة لقطعة منشقة بثلاث مكرارت . و تشير النتائج الى زيادة عدد الأوراق و مساحة سطحها الكلية ومحتواها من الفوسفور عند تركيز 200 جزء فى المليون للنيتروجين. بينما زاد الانتاج عند المعاملة ب 150 جزء فى المليون للنيتروجين. وقد أدت زيادة معدل الرى (140% من الاستهلاك المائى للمحصول) إلى زيادة النمو الخضرى بينما ادى استخدام 120 % من الاستهلاك المائى الفعلى للمحصول إلى زيادة الانتاج و محتوى الاوراق من البوتاسيوم و الماغنسيوم. و ارتفاع محتوى الاوراق من الفوسفور عند المعاملة باقل مستوى رى (100% من الاستهلاك المائى للمحصول). و تم الحصول على اعلى معنوية للانتاج و الكلوروفيل و محتوى الاوراق من البوتاسيوم من استخدام تركيز 150 جزء فى المليون للنيتروجين مع مستوى 120% من الاستهلاك المائى للمحصول فى كل من الموسمين وذلك على العكس مع الصفات الخضرية و حمض الاسكوربيك.

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