Annals of Agric. Sci., Moshtohor
Vol. 50(4) (2012), 435– 446

ISSN 1110-0419
http://annagricmoshj.com

Effect of Irrigation Rate and Some Fertilization Treatments on Vegetative Growth and Chemical Composition of *Stevia Rebaudiana*

Mohamed, S. M. *; Abou El-Ghait, E. M. *; Youssef, A. S. M. *; Khalil A. M. M. **; Attia, K. E. **
*Floriculture Dept., Fac. Agri., Benha, Univ.
** Hort. Res. Inst., Agric. Res. Center, Giza, Egypt

Abstract

Two field experiments were conducted at the Experimental Farm of EL-Kassasin Horticultural Research Station, Ismaillia Governorate during two successive seasons of 2010 and 2011 to study the effect of irrigation rate, biofertilizer and chemical fertilizers on vegetative growth and chemical composition of stevia (*Stevia rebuadiana* Bertoni). The experiment was laid out in split plot design with main plot having four drip irrigation rates (1248, 1632, 2016 and 2304 m^3/fed) and sub-plot treatments included seven biofertilizer and chemical fertilizers treatments [control (no fertilizer), biofertilizer, NPK 100% (24:12:18 kg/fed), biofertilizer + NPK 25 %, biofertilizer + NPK 50 %, biofertilizer + NPK 75 %, and biofertilizer + NPK 100 %].

The irrigation rates had an enhancing effect on vegetative growth characters and stevioside content in the leaves especially with the high rate. Concerning biofertilizer. and chemical fertilizers, plant height, number of branches/plant, dry weight of the herb, content of N, P, K in leaves and total sugar contents as well as stevioside content were increased by using all treatments, particularly the treatment of biofertilizer.+ NPK 75 % in both seasons. On the other side, water use efficiency was increased with decreasing irrigation rates in both seasons but increased with increasing biofertilizer. and chemical fertilizers treatments. Generally, the greatest values of the vegetative growth characters, stevoside, N, P, K and total sugar contents in the leaves in both seasons were gained by those plants which received the highest irrigation rate as 2304 m^3/fed and supplemented with biofertilizer and chemical fertilizers as biofertilizer. + NPK 75 %.

Key words: *Stevia rebaudiana*, Stevioside, Irrigation, Biofertilizer and chemical fertilizers.

Introduction

In Egypt, the needs for medicinal and aromatic plants have great attention because of the possibility of their export. Stevia (*Stevia rebaudiana* Bertoni.) is a herbaceous perennial small bush belonging to the family Asteraceae with carbohydrates based compounds in its leaves, which are many times sweeter than cane sugar and sugar beet. Dry leaves are the economic part in stevia plant. Stevia leaves have a sweet taste which is 20-30 times most than that of cane sugar but importantly without any calories. Hence, stevia is a potential natural source of no calorie sweetener, alternative to the synthetic sweetening agents viz., saccharine, aspartame, asulfam-K, sucralose that are available in the market to the diet conscious consumers and diabetics. In the recent years, the safe agriculture is one of the main attitudes in the world (**El-Kouny, 2002**). There is a great attention to increase the cultivated area of sandy soils. These soils suffer from lack of water resource and poor fertility. Many workers have reported the nutritional requirements of macronutrients for some medicinal plants, as **El-Sakov, *et al.* (2001)** on some medicinal and aromatic plants, **Xie-Youchao, *et al.* (2000)** on *Ginkgo biloba*, **Al-Fayyad, *et al.* (2002)** on *Colchicum* spp, **Thomas *et al.* (2002)** on *Curcuma longa*, **Kozera and Nowak (2004)** on *Silybum marianum*, **Ashorabadi, *et al.*, (2003)** on *Foeniculum vulgare*, **Lee *et al.*, (2005)** on *Chrysanthemum boreale* and **Niakan *et al.* (2004)** on *Mentha piperita*. They concluded that NPK fertilizers had important physiological and biochemical functions on structure of photosynthetic pigments, metabolism of carbohydrates and proteins. These effects were observed with significant increase in vegetative growth, seed yield and essential oil content of the different plant species.

Bio-fertilizers are reasonably safer to the environment than chemical fertilizers and play an important role in decreasing the use of chemical fertilizers. Consequently, it causes a reduction in environmental pollution. Soil inoculation with micro organisms may lead to increase soil available nitrogen and consequently increase formation of metabolites which encourage the plant vegetative growth and enhance the meristematic activity of tissues to produce more branches. Also, N-fixers synthesize stimulatory compounds such as gibberellins, cytokinins and IAA that act as growth regulators (**Sperenat, 1990 and Dadarwal, *et. al.*, 1997**).

This study was carried out to evaluate the effect of NPK mineral fertilizers, bio-fertilization and the optimum irrigation schedule applications as well as their combinations on vegetative growth and chemical composition of stevia plants (*Stevia rebuadiana* Bert.).

Materials and methods

Two field experiments were carried out at the Experimental Farm of EL-Kassasin Horticultural Research Station, Ismaillia Governorate during two successive seasons 2010 and 2011.

Plant materials

Stevia seedlings were purchased from the Institute of Sugar Crops at Agricultural Research Center, Ministry of Agriculture, Egypt. The seedlings were approximately 16-18 cm in length with 5-6 pairs \leaves.

Method of culture

The seedlings were planted in the first of May for the two seasons. The seedlings were planted on rows, 60 cm apart at 35 cm between plants in the row (20000 seedling per feddan), in a sandy soil, the physical and chemical properties were shown in Table (1).

I. Irrigation treatments

Drip irrigation system was used, the dropper gave 4 l/hour, discharge for each at 2 bar. All treatments of irrigation with drip irrigation were carried out twice a week.

The amount of applied irrigation water as liter/plant and m^3/feddan for irrigation treatments was determined during the cut period and shown in Table (2). Whereas the chemical analysis of the irrigation water is shown in Table (3)

II. Biofertilizer practices:

These microorganisms are *Bacillus polymyxa* as a nitrongen fixer , *Bacillus megaterium* as phosphorus dissolver and potassium releasing *Bacillus pasteurii* used in mixtures as 1:1:1 in a liquid form. The amounts of biofertilizer were divided into two equal portions as side drench at two dates on mid May and June of both seasons, respectivly.

III. Chemical and biofertilizer treatments:

Chemical fertilizer used was NPK at "24:12:18 kg/fed." (ammonium nitrate 33.5 % N), (calcium super phosphate 15.5 % P_2O_5) and (potassium sulphate 48.5 % K_2O) as recommended dose by **Chalapathi *et al.*,1999.**

Table 1. The physical and chemical properties of the used soil.

Properties	First	second
1- Physical analyses		
Saturation (capacity)	25	25
Field capacity %	11	11
Wilting coefficient	6	6
Available water %	5	5
2- mechanical analyses :		
Sand (%)	87.13	87.02
Silt (%)	7.24	7.42
Clay (%)	5.63	5.56
Soil texture	Sandy	Sandy
3- Chemical properties :		
3-1- Salt analysis :		
EC dS_m^{-1}	1.6	1.5
pH	7.08	7.09
Cations (meq/l) :		
Ca^{2+}	5.7	5.4
Mg^{2+}	2.6	2.6
Na^{+}	7.0	7.02
K^{+}	0.8	0.7
Anions (meq/l) :		
Cl^{-}	7.6	7.4
CO_3^{2-}	0	0
HCO_3	2.8	2.9
SO_4^{2-}	5.6	5.1
3-2- Available		
Nitrogen	7.1	7.3
Phosphorus	2.1	2.8
Potassium	13.4	13.9
3-3- Organic matter	0.01	0.03

Table 2. Irrigation treatments and water amount added per plant and per feddan during the cut period 84days.

Irrigation treatments	The irrigation period (minute)/ time	The amount of irrigation water (liter)/time/plant	The amount of irrigation water (liter)/ week/plant	Water quantity (liter)/plant/cut period 84 day	Water quantity (m^3)/feddan/cut period 84 day
50% Field capacity	**19 minute**	**1.3 liter/plant**	**2.6 liters/plant**	**31.2 liters/plant**	**624 m^3/fed.**
70% Field capacity	**26 minute**	**1.7 liters/plant**	**3.4 liters/plant**	**40.8 liters/plant**	**816 m^3/fed.**
85% Field capacity	**31 minute**	**2.1 liters/plant**	**4.2 liters/plant**	**50.4 liters/plant**	**1008m^3/fed.**
100% Field capacity	**37 minute**	**2.4 liters/plant**	**4.8 liters/plant**	**57.6 liters/plant**	**1152 m^3/fed.**

Table 3. The chemical analysis of the used irrigation water.

Characters	EC dS_m^{-1}	pH	Cations (meq/l)				Anions (meq/l)			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
Value	**0.387**	**8.35**	**1.8**	**1.0**	**0.86**	**0.17**	**0.00**	**2.70**	**1.00**	**0.14**

Experiment layout:

This experiment was set up in a split plot design with three replicates. The main plots were occupied by four irrigation rates (50, 70, 85 and 100% field capacity).

The sub plots were entitled to seven fertilization treatments i.e. (0.0 % NPK, 100 % NPK, biofertilizer

+ NPK 25%, biofertilizer + NPK 50%, biofertilizer + NPK 75 % and biofertilizer + NPK 100%) where the recommended dose were NPK as "24:12:18 kg/fed." as recommended dose by **Chalapathi *et al.*,1999.**

The amont of calcium super phosphate was added during preparing the soil.

The amount of N and K fertilizers were divided into two equal portions as side dressing at two dates on mid May and June of both seasons.

Data recorded:

I. Vegetative growth characters:

1- Plant height (cm)

2- Number of main branches per plant

3- Dry weight of yield of herb in both seasons (kg/fed.).

4- Water use efficiency in both seasons according to the following equation

$$\text{Water use efficiency} = \frac{\text{Dry weight of herb (kg/fed.)}}{\text{Total amount of applied water (m3/fed.)}} = (\text{kg/m3})$$

II. Chemical components:

Stevioside: stvioside content in leaves was determined according to the procedure described by **Kolb *et al* (2001)** while, leaves nitrogen, phosphorus, potassium and total sugars contents were determined according to the procedure described by **Mazumdar and Majumder (2003).**

Results and discussion

I- Vegetative growth

1- Plant height

Data in Table (4) show that plant height of *Stevia rebaudiana* Bertoni was generally increased by increasing the irrigation rates in the two seasons (regardless the biofertilizer and chemical fertilizers).

The reduction in plant growth under condition of low soil moisture level may be due to that water stress causes losses in tissue water which reduce turger pressure in the cell, thereby inhibition of enlargement and division of cells as concluded by **Hsiao and Acevedo (1974)**

Concerning the effect of biofertilizer and chemical fertilizers on plant height it was significantly increased gradually by increasing chemical fertilizers percentage from biofertilizer. + NPK 25 % to biofertilizer. + NPK 100 % in both seasons as presented in Table (4). This trend was true in the first cut, while in the second cut the treatment of biofertilizer + NPK 75% gave the tallest plants in both seasons.

The increasing in plant growth due to biofertilizer was found to have not only the ability to fixing nitrogen but also to release certain phytohormones of gibberlic and indolic nature compounds which could stimulate plant growth , absorption of nutrients and photosynthesis process **(Fayez *et al.*,1985)** and **Leithy *et al.*, (2006)** on rosemary plant.

In general, all tested combinations between irrigation rate and two kinds of fertilizer treatments increased plant height, especially those received the highest irrigation rate and fertilized with the treatments of biofertilizer + NPK 75 % and biofertilizer + NPK 100% as compared with control in both seasons of this study. This trend was true in the first and second cuts.

2- Number of main branches per plant

Data in Table (5) indicated that the irrigation rates had an increasing effects on number of branches/plant, in both seasons, regardless the effects of , biofertilizer and chemical fertilizers. The treatment which received irrigation rate of 2304 m3/fed. Produced the largest number of branches/plant (16.57 and 25.76) in first and second cuts, respectively of the first season and 18.43 and 26.14 in first and second cuts respectively in second one. However, the irrigation rate of 1248 m^3/fed. Produced the least number of branches/plant in the first and second seasons, respectively.

In both seasons, data in Table (5) indicate that the average number of branches/plant was significantly increased by applying all fertilizer treatments with superiority for the treatments of biofertilizer + NPK 75% and biofertilizer + NPK 100% in the first and second cuts in both seasons.

These results agree with those of **Mahfouz and Shams-Eldin (2007)** on fennel and, **Attia and Abdel-Azeem (2005)** on henna

Generally, the largest number of branches/plant was obtained by the treatment of irrigation rate at 2304 m^3/fed and biofertilizer and chemical fertilizers as biofertilizer. + NPK 100 % in the two seasons. This trend was true in the first and second cuts in both seasons.

3- Dry weight of herb per feddean (kg/fed.).

It is clear from Table (6) that dry weight of herb in both seasons was gradually increased as the irrigation rates going upward from 1248 to 2304 m^3/fed with significant differences between any successive applications of irrigation rates in both experimental seasons.,

These results are in agreement with those revealed by **El-Leithy *et al.*, (2007)** on rosemary and **El-Mogy *et al.*, (2008)** on basil plants.

Concerning biofertilizer and chemical fertilizers, dry weight of herb became significantly heaviest in both seasons, due to the use of biofertilizer and chemical fertilizers, especially the treatment of biofertilizer.+ NPK 75 % (Table, 3). Significant reduction was occurred with control.

Table 4. Effect of irrigation rates, biofertilizer and chemical fertilizers and their combination on plant height (cm) of stevia plants for two cuts during 2010 and 2011 seasons.

Fertilization (B) / Irrigation (A)	First season							(A) Mean of Irrigation	Second season							(A) Mean of Irrigation
	1	2	3	4	5	6	7		1	2	3	4	5	6	7	
	First cut								First cut							
1248 m^3/fed.	34.00	42.33	51.00	47.33	50.67	55.67	56.00	48.14	41.00	44.00	54.33	48.33	54.67	58.33	57.67	51.19
1632 m^3/fed.	41.67	49.33	57.00	52.67	57.33	61.67	61.00	54.38	43.00	47.67	57.67	52.67	59.33	61.00	60.67	54.57
2016 m^3/fed.	44.00	53.33	60.00	57.33	60.67	66.33	66.67	58.33	46.00	50.67	59.67	55.67	61.67	63.33	66.00	57.57
2304 m^3/fed	45.33	56.33	63.33	58.33	64.67	69.67	70.00	61.10	48.67	53.33	61.67	58.00	62.00	67.00	69.67	60.05
(B) Mean of Fertilization	41.25	50.33	57.83	53.92	58.33	63.33	63.42		44.67	48.92	58.33	53.67	59.42	62.42	63.50	
		A		B		AB				A		B		AB		
New L.S.D. at 5%		1.53		1.37		2.43				1.03		1.13		2.25		
New L.S.D. at 1%		2.22		1.95		3.24				1.47		1.51		3.01		
	Second cut								Second cut							
1248 m^3/fed.	30.67	33.00	37.33	35.00	37.33	40.33	38.67	36.05	32.67	34.00	43.00	36.67	45.33	49.33	45.67	40.95
1632 m^3/fed.	33.33	35.33	40.33	38.67	41.67	43.33	41.67	39.19	32.67	37.33	49.67	40.00	52.00	52.33	51.00	45.00
2016 m^3/fed.	37.33	40.33	49.00	45.67	50.00	53.00	51.67	46.71	35.00	38.00	55.33	45.67	57.33	59.33	56.33	49.57
2304 m^3/fed	42.33	45.33	51.67	47.67	52.67	54.67	54.67	49.86	36.33	41.00	57.67	46.67	57.00	62.33	59.33	51.48
(B) Mean of Fertilization	35.92	38.50	44.58	41.75	45.42	47.83	46.67		34.17	37.58	51.42	42.25	52.92	55.83	53.08	
		A		B		AB				A		B		AB		
New L.S.D. at 5%		0.91		1.00		2.73				0.54		1.04		2.84		
New L.S.D. at 1%		1.30		1.34		3.79				0.76		1.39		3.94		

Fertilizations (B)

1= Control 2= biofertilizer 3= 100% NPK 4= biofertilizer. + 25 % NPK

5= biofertilizer. + 50 % NPK 6= biofertilizer. + 75 % NPK 7= biofertilizer. + 100 % NPK

Table 5. Effect of irrigation rates, biofertilizer and chemical fertilizers and their combination on number of branches/plant of stevia plants for two cuts during 2010 and 2011 seasons.

Fertilization (B)	First season							(A) Mean of Irrigation	Second season							(A) Mean of Irrigation
	1	2	3	4	5	6	7		1	2	3	4	5	6	7	
Irrigation (A)	First cut								First cut							
1248 m^3/fed.	7.33	10.67	12.67	12.67	14.33	16.00	15.67	12.76	9.33	10.00	12.33	12.33	13.00	15.00	14.67	12.38
1632 m^3/fed.	8.33	12.33	14.33	13.00	14.67	17.33	16.67	13.81	10.67	12.67	13.67	12.67	14.33	18.33	17.33	14.24
2016 m^3/fed.	10.67	13.67	15.33	14.33	16.33	18.33	18.00	15.24	12.00	14.00	15.00	16.33	16.67	20.33	19.67	16.29
2304 m^3/fed	11.00	14.33	17.00	14.67	17.00	20.67	21.33	16.57	12.67	15.33	18.33	17.33	19.33	23.33	22.67	18.43
(B) Mean of Fertilization	9.67	13.17	15.17	13.83	16.00	18.25	18.33		11.17	13.00	14.83	14.67	15.83	19.25	18.58	
		A		B		AB				A		B		AB		
New L.S.D. at 5%		0.43		3.50		----				0.56		0.65		1.77		
New L.S.D. at 1%		0.62		4.37		------				0.80		0.86		2.46		
	Second cut								Second cut							
1248 m^3/fed.	12.33	14.33	20.33	16.67	21.67	23.67	22.67	18.81	12.67	15.67	19.33	20.67	19.00	24.67	24.33	19.48
1632 m^3/fed.	13.67	16.33	24.33	19.33	25.67	28.00	26.67	22.00	13.67	18.00	22.33	19.67	22.67	26.67	25.33	21.19
2016 m^3/fed.	16.00	19.00	25.67	23.33	26.67	30.33	29.00	24.29	16.33	20.33	24.67	24.67	26.00	28.33	27.33	23.95
2304 m^3/fed	18.00	21.67	27.33	24.33	29.00	30.67	29.33	25.76	19.00	22.67	27.67	24.33	28.67	31.00	29.67	26.14
(B) Mean of Fertilization	15.00	17.83	24.42	20.92	25.75	28.17	26.92		15.42	19.17	23.50	22.33	24.08	27.67	26.67	
		A		B		AB				A		B		AB		
New L.S.D. at 5%		0.61		0.91		3.45				0.59		1.38		5.20		
New L.S.D. at 1%		0.87		1.20		---				0.84		1.82		----		

Fertilizations (B)

1= Control **2= biofertilizer** **3= 100% NPK** **4= biofertilizer. + 25 % NPK**
5= biofertilizer. + 50 % NPK **6= biofertilizer. + 75 % NPK** **7= biofertilizer. + 100 % NPK**

These results are in agreement with those revealed by **Soliman *et al.*,(2009)** on *Ocimim bacilicum*, **Ahmad *et al.*, (2010)** on *Majorana hortensis*. and **Veerendra *et al.*, (2011)** on stevia plants.

In regard to the combination between irrigation rates, biofertilizer and chemical fertilizers, the heaviest dry weights of herb were obtained from stevia plants which received irrigation rate at 1248 m^3/fed and treated with two treatments either the biofertilizer. + NPK 75 % or biofertilizer. + NPK 100 % in both seasons (Table 6).

4- Water use efficiency (WUE)

Tables (7) showed water use efficiency of *Stevia rebaudiana* Bertoni. Asb was significantly increased with decreasing water quantity in both seasons. This means that irrigation rate at 1248 m^3/fed recorded maximum water use efficiency, while 2304m^3/fed recorded the lowest value in both seasons.

The effectiveness of water use efficiency was reported by **Koriem *et al.* (1994)** that the values of water use efficiency of onion plants increased with increasing soil moisture stress (irrigation after the depletion of 75 % of available soil moisture). Also **Glala (1997)** showed that increasing irrigation rates of onion plants reduced the water use efficiency (kg/m^3), where the highest WUE value was obtained with the lowest irrigation rate (60 % Penman). **El-Mansi *et al.*, (1999b)**, under sandy soil conditions, reported that the maximum value of water use efficiency of garlic plants was recorded with reducing water quantity to the lowest level ; i.e., 600m^3/feddan.

Concerning fertilizer treatments, water use efficiency was significantly increased by using all fertilizers treatments, with superiority for biofertilizer.+ NPK 25 % treatment, followed in a descending order by using the treatment of biofertilizer.+ NPK 100 % in both seasons as indicated in Table (7).

In general, the highest water use efficiency value was obtained from the treatment of irrigation rate at 1248 m^3/fed and fertilized with the biofertilizer. + NPK 75 % in the two seasons.

II. Chemical components:

1- Leaves stevioside content:

Data in Table (8) show that leaf content of stevioside was significantly increased due to the use of biofertilizers and chemical fertilizers with superior for the treatment of biofertilizer.+ NPK 50 % in comparison with those of plants received NPK 100 % and control treatment .

A similar trend was obtained by **Vijaya and Ramkrishnaiah (2006)** on *Stevia rebaundiana.* , **Kuntal *et al.*, (2007)** on *Stevia rebaundiana*, and **Kuntal Das Raman Dang (2010)**) who stated that biofertilization of stevia plants, led to the significantly highest content compared to control.

2 –Leaves N, P and K content in both seasons:

Nitrogen, phosphorus and potassium percentages as effected by different biofertilizer and chemical fertilizers and irrigation rates applications showed that NPK percentage was gradually increased by increasing irrigation rate up to 2304 m^3/fed. A significant difference was detected by all irrigation rates treatment in the two seasons as indicated in Tables (9,10,11).

In harmony with these results were those revealed **by Attia (2003)** on guar , and **Yousef *et al.*, (2008)** on *Majorana hortensis*.

Regarding biofertilizer and chemical fertilizers, leaf content of nitrogen, phosphorus and potassium were significantly increased due to the use of biofertilizer and chemical fertilizers, with superiority for the treatment of biofertilizer.+ NPK 75 % in comparison with those plants received NPK 100 % and control.

Such results are in harmony with the findings of **Earanna (2007)** on *Stevia rebaudiana* , **Khalil and Yousef (2005)** on caraway. And **Vijaya and Ramkrishnaiah (2006)** on *Stevia rebaundiana.*

The combination between biofertilizer and chemical fertilizers and irrigation rates applications was statistically significant for the nitrogen, phosphorus and potassium **percentage** in the leaves in the two seasons, with the highest values being obtained due to the use of irrigation rate of 2304 m^3/fed. and biofertilizerfertilizers and chemical fertilizers as biofertilizer.+ 75 % NPK (Table 9,10,11).

3- Leaves total sugars content:

Total sugars content as affected by different biofertilizer and chemical fertilizers and irrigation rate applications showed that total sugars content was gradually decreased by increasing irrigation rate up to 2304 m^3/fed.

Significant differences were detected by all irrigation rates treatment in the two seasons as indicated in Table (12).

Obtained results in this study were in harmony with those reported by **Kamel *et al.*, (2009)** on *Spartina alterniflora.*

Regarding biofertilizers and chemical fertilizers, leaf content of total sugars was significantly increased due to the use of biofertilizer and chemical fertilizers particularly the treatment of biofertilizer.+ 75 % NPK in comparison with those of plants which received 100 % NPK and control .

These results were in agreement with those revealed by **Abdou and El-Sayed (2002)** on *Carum carvi*, **Abd El-Ghani (2007)**on *Rosmarinus officinalis*, L. plants. and **El-Leithy *et al.*, (2007)** on rosemary plants.

The combination between biofertilizer and chemical fertilizers and irrigation rates applications was statistically significant for the total sugars content in leaves in the two seasons, with the highest values being obtained due to the use of irrigation rate at 1248 m^3/fed. with biofertilizer and chemical fertilizers as biofertilizer.+ 75 % NPK Table (12).

Table 6. Effect of irrigation rates, biofertilizer and chemical fertilizers and their combination on the yield of dry herb (kg)/fed. of stevia plants during 2010 and 2011 seasons.

Fertilization / Irrigation	1	2	3	4	5	6	7	(A) Mean of Irrigation
				First season				
1248 m^3/fed.	342.67	502.53	1150.13	1123.20	1372.13	1591.40	1509.27	1084.48
1632 m^3/fed.	436.60	547.40	1521.00	1409.20	1564.67	1827.20	1660.20	1280.90
2016 m^3/fed.	503.87	625.07	1903.00	1730.27	1991.00	2187.33	2066.67	1572.46
2304 m^3/fed	573.53	682.13	2062.87	1928.80	2150.07	2310.33	2264.27	1710.29
(B) Mean of Fertilization	464.17	589.28	1659.25	1547.87	1769.47	1979.07	1875.10	
		A		B		AB		
New L.S.D. at 5%		46.47		41.27		78.32		
New L.S.D. at 1%		66.19		54.40		115.37		
				Second season				
1248 m^3/fed.	381.40	568.13	1312.53	1178.80	1427.80	1775.27	1607.87	1178.83
1632 m^3/fed.	469.00	609.87	1613.60	1440.60	1684.87	1881.27	1789.00	1355.46
2016 m^3/fed.	534.80	659.13	1948.40	1788.47	2071.20	2249.07	2123.13	1624.89
2304 m^3/fed	663.60	738.67	2187.73	1984.67	2249.13	2419.80	2341.47	1797.87
(B) Mean of Fertilization	512.20	643.95	1765.57	1598.13	1858.25	2081.35	1965.37	
		A		B		AB		
New L.S.D. at 5%		22.86		30.07		61.50		
New L.S.D. at 1%		31.14		39.63		84.05		

Fertilizations (B)

1= Control 2= Biofertilizer 3= 100% NPK
4= Biofertilizer. + 25 % NPK 5= Biofertilizer. + 50 % NPK 6= Biofertilizer. + 75 % NPK
7= Biofertilizer. + 100 % NPK

Table 7. Effect of irrigation rates, biofertilizer and chemical fertilizers and their combination on the Water use efficiency (kg dry weight/m^3 water) of stevia plants during 2010 and 2011 seasons.

Fertilization / Irrigation	1	2	3	4	5	6	7	(A) Mean of Irrigation
				First season				
1248 m^3/fed.	0.27	0.40	0.92	0.90	1.10	1.28	1.21	0.87
1632 m^3/fed.	0.27	0.34	0.93	0.86	0.96	1.12	1.02	0.78
2016 m^3/fed.	0.25	0.31	0.94	0.86	0.99	1.08	1.03	0.78
2304 m^3/fed	0.25	0.30	0.90	0.84	0.93	1.00	0.98	0.74
(B) Mean of Fertilization	0.26	0.34	0.92	0.86	0.99	1.12	1.06	
		A		B		AB		
New L.S.D. at 5%		0.043		0.029		0.067		
New L.S.D. at 1%		0.065		0.038		0.090		
				Second season				
1248 m^3/fed.	0.31	0.46	1.05	0.94	1.14	1.42	1.29	0.94
1632 m^3/fed.	0.29	0.37	0.99	0.88	1.03	1.15	1.10	0.83
2016 m^3/fed.	0.27	0.33	0.97	0.89	1.03	1.12	1.05	0.81
2304 m^3/fed	0.29	0.32	0.95	0.86	0.98	1.05	1.02	0.78
(B) Mean of Fertilization	0.29	0.37	0.99	0.89	1.05	1.19	1.11	
		A		B		AB		
New L.S.D. at 5%		0.017		0.019		0.037		
New L.S.D. at 1%		0.024		0.025		0.054		

Fertilizations (B)

1= Control 2= Biofertilizer 3= 100% NPK
4= Biofertilizer. + 25 % NPK 5= Biofertilizer. + 50 % NPK 6= Biofertilizer. + 75 % NPK
7= Biofertilizer. + 100 % NPK

Table 8. Effect of, biofertilizer and chemical fertilizers on the stevioside (%) of stevia plants under the best irrigation rates during the second cut the second seasons.

Treatment/ IV= 2304 m^3/fed	concentration
1= Control	8.98
2= Biofertilizer.	9.78
3= 100% NPK	10.25
5= Biofertilizer. + 50 % NPK	11.74
6= Biofertilizer. + 75 % NPK	11.50

Table 9. Effect of irrigation rates, biofertilizer and chemical fertilizers and their combination on the nitrogen (%) of stevia plants for two cuts during 2010 and 2011 seasons.

Fertilization / Irrigation	1	2	3	4	5	6	7	(A) Mean of Irrigation
				First season				
1248 m^3/fed.	2.51	2.67	3.51	3.12	3.57	3.58	3.54	3.21
1632 m^3/fed.	2.55	2.79	3.57	3.15	3.69	3.69	3.64	3.30
2016 m^3/fed.	2.56	2.82	3.67	3.15	3.71	3.75	3.65	3.33
2304 m^3/fed	2.68	2.82	3.64	3.17	3.71	3.74	3.69	3.35
(B) Mean of Fertilization	2.57	2.77	3.60	3.15	3.63	3.69	3.67	
		A		B		AB		
New L.S.D. at 5%		0.03		0.03		0.05		
New L.S.D. at 1%		0.05		0.04		0.06		
				Second season				
1248 m^3/fed.	2.54	2.61	3.48	3.02	3.50	3.54	3.52	3.17
1632 m^3/fed.	2.50	2.73	3.56	3.11	3.61	3.66	3.58	3.25
2016 m^3/fed.	2.51	2.80	3.61	3.14	3.64	3.72	3.61	3.29
2304 m^3/fed	2.56	2.81	3.60	3.16	3.63	3.76	3.70	3.32
(B) Mean of Fertilization	2.53	2.74	3.56	3.11	3.60	3.67	3.60	
		A		B		AB		
New L.S.D. at 5%		0.02		0.03		0.05		
New L.S.D. at 1%		0.03		0.04		0.07		

Fertilizations (B)

1= Control	2= Biofertilizer	3= 100% NPK
4= Biofertilizer. + 25 % NPK	5= Biofertilizer. + 50 % NPK	6= Biofertilizer. + 75 % NPK
7= Biofertilizer. + 100 % NPK		

Table 10. Effect of irrigation rates, biofertilizer and chemical fertilizers and their combination on the phosphorus (%) of stevia plants for two cuts during 2010 and 2011 seasons.

Fertilization / Irrigation	1	2	3	4	5	6	7	(A) Mean of Irrigation
				First season				
1248 m^3/fed.	0.25	0.33	0.50	0.47	0.54	0.60	0.55	0.46
1632 m^3/fed.	0.28	0.36	0.54	0.50	0.57	0.65	0.56	0.49
2016 m^3/fed.	0.30	0.35	0.56	0.51	0.58	0.65	0.59	0.51
2304 m^3/fed	0.29	0.38	0.58	0.49	0.59	0.65	0.59	0.51
(B) Mean of Fertilization	0.28	0.36	0.54	0.49	0.57	0.64	0.57	
		A		B		AB		
New L.S.D. at 5%		0.010		0.017		0.029		
New L.S.D. at 1%		0.014		0.024		0.039		
				Second season				
1248 m^3/fed.	0.26	0.28	0.49	0.46	0.51	0.57	0.52	0.44
1632 m^3/fed.	0.29	0.35	0.51	0.47	0.56	0.62	0.54	0.48
2016 m^3/fed.	0.29	0.36	0.53	0.49	0.57	0.64	0.58	0.49
2304 m^3/fed	0.33	0.38	0.56	0.49	0.58	0.65	0.59	0.51
(B) Mean of Fertilization	0.29	0.34	0.53	0.48	0.55	0.62	0.56	
		A		B		AB		
New L.S.D. at 5%		0.010		0.013		0.024		
New L.S.D. at 1%		0.015		0.019		0.032		

Fertilizations (B)

1= Control 2= Biofertilizer 3= 100% NPK
4= Biofertilizer. + 25 % NPK 5= Biofertilizer. + 50 % NPK 6= Biofertilizer. + 75 % NPK
7= Biofertilizer. + 100 % NPK

Table 11. Effect of irrigation rates, biofertilizer and chemical fertilizers and their combination on the potassium (%) of stevia plants for two cuts during 2010 and 2011 seasons.

Fertilization / Irrigation	1	2	3	4	5	6	7	(A) Mean of Irrigation
				First season				
1248 m^3/fed.	1.70	1.76	2.06	1.75	2.07	2.14	2.14	1.95
1632 m^3/fed.	1.75	1.85	2.23	2.13	2.28	2.36	2.38	2.14
2016 m^3/fed.	1.83	1.89	2.55	2.13	2.61	2.67	2.67	2.34
2304 m^3/fed	1.83	1.88	2.58	2.19	2.61	2.66	2.65	2.34
(B) Mean of Fertilization	1.78	1.85	2.36	2.05	2.39	2.46	2.46	
		A		B		AB		
New L.S.D. at 5%		0.03		0.05		0.08		
New L.S.D. at 1%		0.05		0.07		0.11		
				Second season				
1248 m^3/fed.	1.74	1.77	2.04	1.99	2.05	2.14	2.13	1.98
1632 m^3/fed.	1.78	1.83	2.29	2.11	2.30	2.35	2.39	2.15
2016 m^3/fed.	1.82	1.68	2.53	2.15	2.73	2.68	2.71	2.33
2304 m^3/fed	1.81	1.87	2.56	2.15	2.65	2.68	2.70	2.35
(B) Mean of Fertilization	1.79	1.79	2.36	2.10	2.43	2.46	2.48	
		A		B		AB		
New L.S.D. at 5%		0.05		0.06		0.11		
New L.S.D. at 1%		0.07		0.09		0.14		

Fertilizations (B)

1= Control 2= Biofertilizer 3= 100% NPK
4= Biofertilizer. + 25 % NPK 5= Biofertilizer. + 50 % NPK 6= Biofertilizer. + 75 % NPK
7= Biofertilizer. + 100 % NPK

Table 12. Effect of irrigation rates, biofertilizer and chemical fertilizers and their combination on the total sugars (%) of stevia plants for two cuts during 2010 and 2011 seasons.

Fertilization / Irrigation	1	2	3	4	5	6	7	(A) Mean of Irrigation
				First season				
1248 m^3/fed.	12.76	13.89	18.40	16.42	19.54	19.73	18.55	17.04
1632 m^3/fed.	12.57	13.72	17.67	16.13	19.29	19.28	18.26	16.70
2016 m^3/fed.	12.32	13.51	16.84	15.41	18.43	18.68	17.40	16.08
2304 m^3/fed	12.02	12.35	15.56	14.18	16.41	16.66	16.18	14.76
(B) Mean of Fertilization	12.41	13.37	17.12	15.54	18.42	18.58	17.60	
		A		B		AB		
New L.S.D. at 5%		0.12		0.11		0.19		
New L.S.D. at 1%		0.17		0.15		0.25		
				Second season				
1248 m^3/fed.	12.63	13.74	18.04	16.27	19.63	19.92	18.78	17.00
1632 m^3/fed.	12.34	13.62	17.80	16.19	19.34	19.69	18.45	16.78
2016 m^3/fed.	12.23	13.39	16.77	15.17	18.38	18.62	17.56	16.02
2304 m^3/fed	11.76	12.73	15.41	15.05	16.43	16.59	16.20	14.88
(B) Mean of Fertilization	12.24	13.37	17.00	15.67	18.44	18.70	17.75	
		A		B		AB		
New L.S.D. at 5%		0.08		0.13		0.22		
New L.S.D. at 1%		0.11		0.18		0.30		

Fertilizations (B)

1= Control **2= Biofertilizer** **3= 100% NPK**
4= Biofertilizer. + 25 % NPK **5= Biofertilizer. + 50 % NPK** **6= Biofertilizer. + 75 % NPK**
7= Biofertilizer. + 100 % NPK

Refernces

Abd El-Ghani, Neama M. (2007) Physiological studies on rosemary and chamomile plants. M. sc. Thesis, Fac. Agric., Cairo Univ., Egypt.

Abdou, M.A. and El-Sayed, A.A. (2002) Effect of planting date and biofertilization treatment on growth and yield characters of *Carum carvi* L. Proc. 2nd hort. Sci. Conf., 10-12 Sept. 202, Kafr El-Sheikh, Tanta Univ., Egypt. 341- 352.

Ahmad H. Al-Fraihat, Sati Y. Al-Dalain and Mohammad Abu Darwish (2010). Effect of organic and biofertilizers on growth, herb yield and volatile oil of marjoram plant grown in Ajloun region, Jordan. per 2nd International Symposium on Medicinal Plants, Their Cultivation and Aspects of Uses, Al-Balqa' Applied University, Jordan.211-223.

Al-Fayyad, M.; Alali, F.; Ahmad, A. and Abdelmajeed, T. (2002). Drtermination of colchicines content in *Colchicum hierosolymitanum* and *Colchicum tunicatum* under cultivation. Natural Product Letters. 16 (6): 395-400.

Ashorabadi, E. S.; Matin, A. and Lebaschi, M. H. (2003). Investigation of physiological growth indices in fennel (*Foeniculum vulgare*). Iranian, Journal of Medicinal and Aromatic Plants Research; 19 (2): 157-182.

Attia, D. M. G. (2003). Physiological studies on guar plants in sandy soil. M. Sc. Thesis, Fac. Agric. El-Arish, Sues Canal Univ., Egypt.

Attia, Elham M. and Abdel-Azeem H. M. Hoda (2005). Effect of biofertilization on yield and active materials in *Lawsonia inermis* L. plants at Maryout. per 6th Arabian Conference For Horticulture, Ismailia, Egypt. 39-49.

Chalapathi, M. V.; Thimmegowda, S.; Rao, G. G. E.; Devakumar, N. and Chandraprakash, J. (1999). Influence of fertilizer levels on growth, yield and nutrient uptake of raton crop of stevia (*Stevia rebaudiana*). J. of Medicinal and Aromatic Plant Sci., 21(4): 947-949.

Dadarwal, L.R.; Yadav, L.S. and Sindhu, S.S. (1997). Biofertilizer-fertilizer Production Technology: Prospects In. Biotechnological Approaches: In. Soil Microorganisms for Sustainable Crop Production. pp: 323- 337. Scientific Publisher, Jodhpur, India (C.F. Proceeding of Training Course on Bio-Organic Farming Systems for Sustainable Agriculture. July, 1997, Cairo, Egypt).

Earanna, N. (2007). Response of *Stevia rebaudiana* to biofertilizers. Karnataka J. of Agric. Sci., 20 (3) 616-617.

El-Leithy, A.S.; M.A. Salem; E.A.E. El-Ghalban and N.M. Abd El-Ghani (2007). Effect of irrigation intervals and biofertilization on growth, yield, oil production and chemical constituents of rosemary (*Rosmarinus officinals*, L.) plants. J. Product.& Dev., 12 (2) 645-665.

El-Kouny H. M. (2002). Effect of Organic Fertilizer in Different Aplication Rates Under Salinity Stress Goudvion on Soil and Plant. International Symposium and Optimum Resources Utilization in Salt-Affected Ecosystems in Arid and Semi-arid Regions, 8- 11 April 2002, Cairo , Egypt, Le Meridian, Heliopolis Hotel, Abst. Book, pp.33.

El-Mansi, A. A., El-Ghamriny, E. A. , Arisha, H. M. E. and Abou El-Khair E. E. (1999). Effect of cultivar,irrigation intervals and water quantity on garlic under drip irrigation system in sandy soil.3- Storageability. Zagazig J. Agric. Res., 26 (6):1695-1705.

El-Mogy, E. M.; Yousef, R.M.M.and Soliman, S.G.I. (2008). Response of basil plants to drip irrigation rates and organic fertilizers in sandy soil conditions. J. Agric. Sci., Mansoura Univ., 33 (3) 2111-2131.

El-Sakov, G.V.; Gorelova A.P. and Mironova R.A. (2001). Role of fertilizers in cultivating medicinal crops North of the arctic circle. Agrokhimiya, (2): 40-45.

Fayez, M.; Emam N. F. and Makboul H. E. (1985). The possible use of nitrogen fixing *Azospirillum* as biofertilizer for wheat plants Egypt. J. Microbiofertilizerl., 20(2): 190-206.

Glala, A. A. (1997). Studies on the effect of irrigation and preceding crops on growth ,yield and quality of onion (*Allium cepa* L.) M. Sc. Thesis, Fac. Agric.,Ain Shams Univ., Cairo, Egypt.

Hsiao, T.C. and Acevedo, E. (1974). Plant response to water deficits, water use efficiency and drought resistance. Agric. Meteorogy, 14: 2, 92-98.

Kamel, H.; Juan, P.M.; Mhemmed G.; Ali A.; Abdelaziz S. and Chedly A. (2009). Effect of water stress on growth, osmotic adjustment, cell wall elasticity and water-use efficiency in *Spartina alterniflora*. Environmental and Experimental Botany., 67, 312–319.

Khalil, M.A. and Yousef R.M.M. (2005). Effect of some conventional and controlled release nitrogen fertilizers under the effect of some amendments on caraway. Egypt . J. of Appl. Sci., 20 (8b) 632-646.

Kolb, N., Herrera J. L., Ferreyra D. J. and . Uliana, R. F. (2001). Analysis of sweet diterpene glycosides from *Stevia rebaudiana* improved

HPLC method. J. Agric. Food Chem., 49: 4538 – 4541.

Koriem, S. E. O., El-Koliey M. M. A., and Wahba M.F.(1994). Onion bulb production from "Shandwell" sets as affected by soil moisture stress. Assuit J. Agric. Sci., 25 (5) :185-193.

Kozera, W. and Nowak, K. (2004). The effect of fertilization on milk thistle (*Silybum marianum*) yield and its chosen features. Annales, Universitayis Mariae curie Skodowska Sectio-E, Agricultura, 59(1):369-374.

Kuntal, D. and Raman D. (2010). Influence of biofertilizers on stevioside content in *Stevia rebaudiana* grown in acidic soil condition. Archives of Applied Science Research, 2 (4): 44-49.

Kuntal, D.; Shivananda R.D. and Hegde T. N.L. (2007). Effect of bio-fertilizers on biomass yield of *Stevia rebaudiana.* Biomed., 2 (30 278-282.

Lee, K.; Yang, M.; Supanjani and Smith, D.L. (2005). Fertilizer effect on the yield and terpene components from the flower heads of *Chrysanthemum boreale*, M. (Compositae). Agronomy for Sustainable Development, 25 (2): 205-211.

Leithy, S. ; El-Meseiry T.A. and Abdallah E.F. (2006). Effect of biofertilizer, cell stabilizer and irrigation regime on rosemary herbage oil yield and quality. J. Appl. Sci. Res., 2(10): 773-779.

Mahfouz, S.A. and Shams-Eldin M.A. (2007). Effect of mineral vs. biofertilizer on growth, yield and essential oil content of fennel (*Foeniculum vulgare* Mill). International Agrophysics, 21 (4) 361-366.

Mazumdar, B. C. and K. Majumder (2003). Methods of Physiochemical Analysis of Fruits. Daya Publishing House Delhi, India.

Niakan, M.; Khavarynejad, R.A. and Rezaee, M.B. (2004). Effects of different rates of NPK fertilizer on the leaf fresh weight, dry weight, leaf area and oil content of *Mentha piperita,* L. Iranian Journal of Medicinal and Aromatic Plants Research, 20 (2): 131-148.

Soliman, S.G.I. ; Harridy I. M. A. and Ismail E. G. (2009). Response of French basil plants (*Ocimum bacilicum*) to nitrogen fixed bacteria. J. Agric. Sci. Mansoura Univ., 34 (5) 5137-5150.

Sperenat, M. (1990). Nitrogen Fixing Organisms. P.5. Chapman and Hall London.

Thomas, A.; Swati, B. and Singh, D.B. (2002). Influence of different levels of nitrogen and potassium on growth and yield of turmeric (*Curcuma longa* L.). Journal of Spices and Aromatic Crops, 11(1):4-77.

Veerendra, P.S.; Singh R.K.; Prakashl J.; Singh A.K. and Biradar S.I. (2011). Effect of spacing and bio fertilizers on yield and quality parameters of stevia (*Stevia rebaudiana* Bertoni). International J. of Agricultural Science, 7 (2) 325-329.

Vijaya, T. and Ramkrishnaiah G. (2006). Studies on effect of VAM fungi and nitrogen fixing bacteria on growth and biochemical aspects of *Stevia rebaundiana* (Bert.): An emerging nutraceutical plant. INCOB : 56.

Xie-Youchao, C.F.; Li R.; Zhang W.; Qiu C. and Chen W. (2000). The effects of fertilizer on growth and leaf yield in Ginkgo leaf producing plantation. Journal of Jiangsu Forestry Science and Technology. 27 (6): 9-12.

Yousef, R. M. M. ; Hamouda A.M. A. and Ghaly G. Nawal (2008). Effect of irrigation and organic fertilization on growth and productivity of *Majorana hortensis* in sandy soils. J. Agric. Sci., Mansoura Univ., 33 (11) 8039-8056.

الملخص العربي

تأثير معدلات الري وبعض معاملات التسميد علي النمو الخضري والتركيب الكيماوي لنبات الاستيفيا

صفاء مصطفي محمد*, إيمان مختار على أبو الغيط*, أحمد سعيد محمد يوسف*,
أشرف محمد محمد خليل**, كمال السيد عطية **
* قسم البساتين (الزينة) – كلية الزراعة – جامعة بنها
**قسم بحوث النباتات الطبية والعطرية– معهد بحوث البساتين – مركز البحوث الزراعية

أجريت تجربتان حقليتان لدراسة تأثير الري والتسميد الحيوي والكيماوي علي النمو الخضري والتركيب الكيماوي لنبات الاستيفيا بمزرعة محطة بحوث البساتين بالقصاصين، محافظة الإسماعيلية، علي الاستيفيا خلال موسمي 2010و 2011.

وزعت المعاملات بنظام القطع المنشقة مرة واحدة بثلاث مكررات حيث وزع العامل الأول وهو البلوت الرئيسي وهو أربع معدلات الري في القطع الرئيسية (1248, 1632, 2016 و2304م^3 للفدان) بينما العامل الثاني تحت البلوت وهو سبع معاملات من التسميد الحيوي و الكيماوي في القطع المنشقة (كنترول, سماد حيوي, (24:12:18 kg/fed) 100% NPK, سماد حيوي + 25 % NPK, سماد حيوي + 50 % NPK , سماد حيوي + 75 % NPK و سماد حيوي + 100 % NPK) .

وقد أظهرت معدلات الري تأثير جيد وهام على النمو الخضري و محتوي الاستفيوسيد في أوراق النباتات خاصة مع معدل الري العالي.

كما كان للتركيزات المختلفة من التسميد الحيوي و التسميد الكيماوي كان لها تأثير علي ارتفاع النبات، عدد الفروع، الوزن الجاف للعشب، محتوي الاستفيوسيد, النيتروجين، الفسفوروالبوتاسيوم حيث ازداد تدريجيا بزيادة التسميد الحيوي و التسميد الكيماوي.

من ناحية أخري وجد أن كفاءة استخدام المياه ازدادت بانخفاض معدل الري في كلا الموسمين .لكن ازدادت بزيادة التسميد الحيوي و التسميد الكيماوي .

وبالنسبة لتأثير معدلات الري و التركيزات المختلفة من التسميد الحيوي و التسميد الكيماوي كان لها نفس الأثر علي النسبة المئوية لكل من الاستفيوسيد, النيتروجين ,الفسفور والبوتاسيوم في الأوراق الجافة حيث ازدادت النسب المئوية تدريجيا بزيادة معدلات الري حتى 2304م^3 للفدان واستخدام سماد حيوي +75 % NPK . ومن جانب اخر وجد ان محتوي الاوراق الجافة من السكريات الكلية قد ازداد بإنخفاض معدل الري في كلا الموسمين لكن هذا المحتوي قد ازداد بزيادة التسميد الحيوي و التسميد الكيماوي.

الكلمات الدالة المرشدة علي البحث : الاستيفيا– الاستفيوسيد– الري– التسميد الحيوي– التسميد الكيماوي