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FULL LENGTH ARTICLE

Impact of different water regimes based on class-A pan on growth, yield and oil content of *Coriandrum sativum* L. plant

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Abstract This experiment was carried out to study the effect of five irrigation levels on growth, yield and chemical composition of coriander plants. The amount of irrigation water was equal to 40%, 60%, 80%, 100% and 120% of the potential evapotranspiration (ETP) values based on class-A pan. The irrigation water was applied by drip irrigation system. The results of this experiment showed that the vegetative growth parameters were improved as a result of applying higher irrigation levels compared to lower levels. Irrigation water use efficiency (IWUE) was increased by reducing the irrigation levels. Increasing the irrigation level from 40% to 120% increased the volatile oil percentage as well as fruit and volatile oil yields/hill and per fed. The results of GC analysis of volatile oil showed that the main components of volatile oil were linalool, ß-cymene, limonene, nerol, borneol and geraniol. However, the irrigation treatments did not affect oil composition. The chemical analysis of the coriander herb indicated that increasing the irrigation rate from 40% to 120% of ETP gradually decreased nitrogen, phosphorus and carbohydrate percentages in the dried herb of coriander plants. However, there was no clear trend for potassium percentage.

1. Introduction

Because of the great importance of coriander (*Coriandrum sativum* L.) plants as natural sources for producing the volatile oil which has several uses in pharmaceutical and food industries, more investigations for improving the growth and productivity of this plant are still needed. Irrigation is a very important factor affecting the growth and yield of medicinal and aromatic plants. Irrigation also may affect the volatile oil composition. From another point of view, water is characterized as such no alternative source can substitute it and it is not a commercial

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resource or commodity. It is known that Egypt is a downstream country of the Nile River. Based on this fact, the great challenge for the coming decades will be the task of increasing the productivity of water units (Abdin and Salem, 2009). Irrigation as an environmental factor has an important role in plant growth and is essential to increase yield and quality of plants (Singh and Goswamy, 2000). Deficit irrigation, one of the environmental stresses, is the most significant factor restricting plant growth and crop productivity in the majority of agricultural fields of the world (Abedi and Pakniyat, 2010). Identifying growth stages of a particular cultivar under local conditions of climate and soil fertility allows irrigation scheduling to maximize crop yield and most efficient use of scarce water resources (Mahal and Sidhu, 2006).

There are different methods to estimate the irrigation requirements. One of them is using potential evapotranspiration based on class A Pan (Halepyati et al., 1996; Ruhi et al., 2006). Prolonging the irrigation intervals reduced the growth and yield of various medicinal and aromatic plants (Eid et al., 1995; Hammam, 1996 on *Pimpinella anisum* plant). Irrigation of coriander plants at higher levels resulted in the highest vegetative growth characters and yield component compared to the lower levels (Osman, 2000; Osman and El-Feky, 2005). The seed yield and weight of 100 seeds of fennel were increased under more frequent irrigation based on Cumulative-pan-Evaporation (Sharma and Prasad, 1990). Reducing the irrigation level reduced the seed yield of *C. sativum* (Tomar et al., 1994; Kumar et al., 2008). Increase in irrigation water increased dry matter and yield however water soluble carbohydrate was decreased (Islam et al., 2012).

Water deficit severely affected all growth parameters and yield attributes with the exception of the number of branches per caraway plant. Moreover, the seed yield and its components significantly decreased under moderate and severe water deficit (Laribi et al., 2009). Application of three irrigations at the branching, flowering and seed formation stages produced a significantly greater seed yield than all the other moisture regimes except for omitting irrigation at the seed formation stage. In addition, the water use efficiency was the highest when irrigation was omitted at the seed formation stage followed by the application of three irrigations at branching, flowering and seed formation (Kumar et al., 2008). Otherwise, the lower WUE was associated with a higher amount of irrigation water (Kamkar et al., 2011).

The volatile oil of various medicinal and aromatic plants was affected as a result of applying different irrigation treatments. Limited water supply is an important factor affecting growth and metabolic activities of plant species. It has a generally negative effect on plant growth and development. However, there are reports on the positive effect of limited water supply, as far as the biosynthesis of secondary metabolites, enzyme activities and solute accumulation are concerned (Singh-Sangwan et al., 2001). Deficit irrigation can change plant behavior regarding the biosynthesis of primary and secondary metabolites. In addition, drought influences the essential oil biosynthesis (Laribi et al., 2009; Bettaieb et al., 2011; Bourgou et al., 2011) and therefore affects the composition of essential oil.

Increasing the irrigation intervals increased the volatile oil percentage; however the volatile oil yield was in an opposite manner (Afify et al., 1993; Eid et al., 1995; Hammam, 1996). On the other hand, Mohamed (2000) on *Carum carvi* L. plants found that both essential oil percentage and oil yield were increased with decreasing the irrigation intervals. Increasing irrigation level from 70% (ETP) to 110% (ETP) significantly increased the essential oil yield of *C. sativum* L. plant (Osman and El-Fiky, 2005). On the other hand, the maximum volatile oil yield of coriander was obtained when the lowest irrigation rate was applied compared to the highest irrigation rate (Osman, 2000). Irrigation water also affected not only the volatile oil percentage but also oil composition of coriander fruits (Hassan et al., 2012). The chemical constituents of medicinal and aromatic plant herbs were also affected by irrigation treatments (El-Shafie et al., 1994; Hammam, 1996; Osman, 2000).

From the previous literature, it will be beneficial to determine the optimum irrigation level of coriander plants in order to increase the productivity of water unit. Therefore, the aim of this study was to estimate the optimum irrigation level, potential evapotranspiration (ETP) value based on class-A pan, which maximizes the productivity as well as quality of coriander plants under experimental conditions.

2. Materials and methods

Two field experiments were carried out at Aly Mubarak Experimental Farm of the South Tahrir Research Station, Elbehara Governorate during winter seasons of 2007/2008 and 2008/2009. The farm represents the newly reclaimed sandy soil of El-Bustan area. The soil was sandy in texture and its physical properties were (90.9% sand, 3.6 silt, 5.5 clay) and chemical characteristics of the soil were EC; 0.38, pH; 8.16, soluble cations; 1.25, 0.60, 1.60 and 0.20 meq L^{-1} for the Ca^{+2}, Mg^{+2}, Na^{+} and K^{+} and soluble anions were 1.18, 180 and 0.75 meq L^{-1} for HCO_3^{-}, Cl^{-}, and SO_4^{-2}, respectively.

The coriander seeds were obtained from the experimental farm of Medicinal and Aromatic plants Department, Agriculture Research Center, Ministry of Agriculture, Egypt. The soil was prepared and divided into plots; each of them was 1.6 × 50 m and contained three rows (30,000 hills/fed.). The seeds were sown in the first of November in both seasons in hills. The distances between hills were 50 cm. Three weeks later, the plants were thinned out and two plants per hill remained.

Five irrigation treatments of evapotranspiration potential (ETP) based on class A pan were applied and arranged in a complete randomized block design with five replicates, and treatments were as follows: irrigation with amounts of water equal to 40%, 60%, 80%, 100% and 120% of evapotranspiration potential (ETP).

2.1. Soil water relationships

Potential evapotranspiration (ETP) was obtained by class-A pan evaporation method according to Doorenbos and Pruitt (1975) and the values are presented in Table 1.

$$\mathrm{ETP} = E\mathrm{pan} \times K\mathrm{pan}$$

where:

E pan = Pan evaporation (mm/day).
K pan = Pan coefficient.

K pan values depend on the relative humidity, wind speed and site conditions. The K pan value of 0.75 was used for

Table 1 *E* pan and ETP in (mm/month) during 2007/2008 and 2008/2009 seasons measured by class-A pan.

Month	*E* pan		ETP	
	2007/2008	2008/2009	2007/2008	2008/2009
Nov.	10.18	8.60	7.63	6.45
Dec.	6.60	7.45	4.95	5.59
Jan.	6.49	6.71	4.87	5.03
Feb.	6.35	6.27	4.76	4.70
Mar.	6.83	10.91	5.12	8.18
Total	36.45	39.94	27.33	29.95
M^3/fed.	1530.90	1677.48	1047.86	1257.90

the experimental site as an average of 50 years for the experimental location.

2.2. Amount of applied irrigation water (AIW)

The amount of applied water (mm) is presented in Table 2 and measured by flow water and was calculated according to Vermeiren and Jobling (1980) by the following equation:

$$\text{AIW} = \frac{\text{ETP} \times K\text{r} \times I\text{interval}}{\text{Ea}} + \text{LR}$$

where:

AIW: Applied irrigation water depth (mm).
ETP: Potential evapotranspiration (mm/day) values obtained by class A pan evaporation method.
*K*r: Reduction factor that depends on ground cover. It varied from 0.7 at the beginning of the growing season to 0.1 for the rest of the season.
Ea: Irrigation efficiency values measured at the site = $K_1 \times K_2$ = 0.85 where
K_1: Emitter uniformity coefficient = 0.90 for the drip system at the site.
K_2: Drip irrigation system efficiency = 0.94.
I interval: Irrigation intervals (days) = 1 day at the site.
LR: Leaching requirements (no additional water for leaching was added during growing seasons due to the low EC values irrigation water and soil profile).

2.3. Irrigation water use efficiency (IWUE)

IWUE (kg m^{-3}) = Yield (kg/fed)/Total applied water (m^3/fed).Irrigation water use efficiency IWUE, i.e. yield/unit of applied water was determined according to Howell et al. (1990).

Surface drip irrigation system consists of an irrigation pump connected to sand and screen filter and a hydraulic fertilizer injection pump was used. Drip irrigation efficiency parameters based on drip system efficiency and emission uniformity were taken into consideration however; it ranged between 94% and 90% based on the actual discharge rate of 3.8 L h^{-1} along the drip lines. Coriander plants were chemically fertilized with ammonium sulfate (20.6% N) at 300 kg fed^{-1}, calcium super-phosphate (15.5% P_2O_5) at 200 kg fed^{-1} and potassium sulfate (48% K_2O) at 100 kg fed^{-1} according to the recommended dose of Medicinal and Aromatic Plants Department, Agriculture Research Center, Ministry of Agriculture, Egypt.

The plants were harvested on the first of April in the two experimental seasons (before fruits were fully ripe but sufficiently hard and greenish yellow in color or semi-dry) and the growth parameters i.e. plant height, branch number, fresh and weight of herb/plant and yield components i.e. number of umbels/plant, weight of 100 seeds, fruit yield/plant and fed were determined.

2.4. Essential oil percentage determination

The volatile oil percentages in representative air-dried fruits samples (25 g) obtained from each replicate of every treatment during the two seasons were determined by a water distillation method described in British Pharmacopea (1963), using the following equation:Volatile oil% = oil volume in the graduated tube (mL)/sample weight (g) × 100.

2.5. Essential oil composition

Analysis of the oil was carried out using GC–MS. The apparatus was a Schimadzu QP-5000 GCMS equipped with a Mass detector. The chromatograph was fitted with a DB-5-Ms. 30 m × 0.250 mm × 05 µm film thickness fused silica capillary column. Helium was used as the carrier gas with a flow rate of 1.8 mL/min for coriander and 1.7 mL/min for cumin. An initial temperature of 40 °C was held for 2 min, then programmed to rise from 40 to 210 °C at rate of 4 °C/min. The interface temperature was 210 °C, injector temperature was 190 °C, the final temperature was 175 °C for 3 min and the run time was 38.75 min. Det-gain 1.50 kV.

2.6. Chemical analysis

Samples of herb from each replicate were dried in an electric oven at 70 °C then finally ground to study the following chemical analysis:

Table 2 Amount of applied irrigation water (AIW) in cm of different ETP levels during the two experimental seasons.

ETP (%)	40	60	80	100	120	40	60	80	100	120
	2007/2008 Season					2008/2009 Season				
Nov.	3.35	5.03	6.71	8.39	10.06	2.84	4.25	5.67	7.09	8.51
Dec.	2.17	3.26	4.35	5.44	6.53	2.46	3.69	4.92	6.15	7.38
Jan.	2.14	3.21	4.28	5.35	6.42	2.21	3.32	4.42	5.53	6.64
Feb.	2.09	3.14	4.18	5.23	6.27	2.07	3.10	4.14	5.17	6.20
Mar.	2.25	3.37	4.50	5.63	6.75	3.60	5.39	7.19	8.99	10.79
Total	12.00	18.01	24.02	30.04	36.57	13.18	19.75	26.34	32.93	39.52
M^3/fed.	504.0	756.4	1008.8	1261.7	1535.9	553.6	829.5	1106.3	1383.1	1659.8

– Nitrogen percentage was determined by micro-Kjeldahl method, phosphorus was spectrophotometrically determined and potassium was determined by flame photometer as described by A.O.A.C. (1995).
– The total carbohydrates percentage of the dried herb was determined according to Dubois et al. (1956).

2.7. Statistical analysis

Data of this experiment were statistically analyzed using Irristat Program and an analysis of variance (ANOVA) was performed. Means were compared using revised L.S.D. test at 0.05 levels.

3. Results and discussion

3.1. Vegetative growth

Data presented in Table 3 clearly show that different irrigation treatments significantly affected the vegetative growth of coriander plants. The plant height was gradually increased with increasing the irrigation level and reached its maximum value with an irrigation treatment of 120% of potential evapotranspiration (ETP). However, there were no significant differences concerning the effect of different irrigation treatments on the number of branches per coriander plant during the two seasons. The heaviest fresh and dry weights of herb (40.66 and 14.66 g) and (40 and 15.66 g) were obtained by applying treatment of irrigation at 120% of ETP in the two experimental seasons, respectively. On the other hand, the irrigation treatment at 40% of ETP resulted in the lowest values in this respect during the two seasons (Table 3).

From the previous results, it could be concluded that the growth characters of coriander were improved as a result of increasing the amount of irrigation water applied. The growth reduction can be considered as a morphological adaptation of the plant to deficit irrigation to reduce transpiration and to induce a lower consumption of water (Banon et al., 2003). One of the first signs of water shortage is the decrease in turgor which causes a decrease in both growth and cell development, especially in the stem and leaves. The growth of cells is the most important process that is affected by water stress and the decrease in the growth of cells leads to decrease in the plant height. Decreasing the dry weight under water deficit could be a result of a reduction in the chlorophyll content as our data indicated, and consequently, photosynthesis efficiency, as reported by Khalid (2006). Water is a very important factor affecting the growth of the coriander plant since when the water content of the plant decreases, its cells shrink and the cell walls relax which results in lower turgor pressure and the subsequent concentration of solutes in the cells as well as cell expansion. Because leaf expansion depends mostly on cell expansion, the principles that underlie the two processes are similar. The smaller leaf area transpires less water, effectively conserving a limited water supply from the soil over a longer period (Taiz and Zeiger, 2002). Such results might be reasonable, since Doorenbos and Pruit (1975) mentioned that more frequent irrigation periods gave chance for a more luxuriant use of soil moisture, which ultimately resulted in greater foliage and increase of transpiration. Growth reduction as a result of water deficit has been widely reported (Osman 2000; Sánchez-Blanco et al., 2004; Osman and El-Fiky, 2005; Leithy et al., 2006; Kumar et al. 2008; Bettaieb et al., 2011; Ekren et al., 2012; Hassan et al. 2012).

3.2. Fruit yield

Increasing irrigation level from 40% to 120% of ETP increased the number of umbels/hill. The results also indicate that both fruit yields per hill and fed were significantly increased with increasing the irrigation level. The highest fruit yields per hill and per feddan (30.71 g and 921.30 kg) and (31.20 g and 936 kg) were obtained by using irrigation level

Table 3 Vegetative growth characters of coriander as affected by different water regimes based on class-A pan during the two experimental seasons.

ETP (%)	Plant height (cm)	Branch number	Herb FW. (g)	Herb DW. (g)
2007/2008 Season				
40	67.92b	5.33a	30.00d	10.00d
60	68.22b	5.66a	31.66cd	11.00c
80	70.24ab	6.00a	35.66bc	12.00b
100	71.80ab	6.33a	37.66ab	12.66b
120	73.11a	6.60a	40.66a	14.66a
2008/2009 Season				
40	67.95b	5.00a	31.00b	10.00a
60	68.76b	5.33a	35.33ab	10.66b
80	71.00ab	5.66a	36.33a	11.66b
100	71.61ab	6.00a	38.00a	12.00b
120	74.35a	6.33a	40.00a	15.66a

ETP means evapotranspiration potential.
Means followed by different letters were significantly different according to revised L.S.D. test at 0.05 level.

Table 4 Fruit yield components of coriander as affected by different water regimes based on class-A pan during the two experimental seasons.

ETP (%)	Number of umbels/plant	Fruit yield (g/hill)	Fruit yield (kg/fed.)	Weight of 100 seeds (g)	IWUE
2007/2008 Season					
40	75.30c	24.08c	722.40d	0.83c	1.40a
60	76.30c	25.26c	757.80c	0.83c	1.00b
80	78.30bc	26.52bc	795.60c	0.96bc	0.79c
100	81.00ab	28.90ab	867.00b	1.02ab	0.69d
120	82.00a	30.71a	921.30a	1.13a	0.59e
2008/2009 Season					
40	73.00b	24.13d	723.90d	0.91c	1.30a
60	74.00b	25.62cd	768.60cd	0.92bc	0.93b
80	77.66a	26.67bc	800.10c	1.06bc	0.72c
100	79.66a	28.44b	853.20b	1.01ab	0.62d
120	80.33a	31.20a	936.00a	1.16a	0.56e

ETP means evapotranspiration potential.
IWUE means irrigation water use efficiency.
Means followed by different letters were significantly different according to revised L.S.D. test at 0.05 levels.

at 120% of ETP in both seasons, respectively (Table 4). The heaviest 100 seeds followed the same direction of seed yield in both seasons. Irrigation water use efficiency (IWUE) was increased by reducing the irrigation levels in both seasons (Table 4). The maximum IWUE (1.40 and 1.30) were obtained by 40% of ETP treatment, while the lowest values in this respect (0.59 and 0.56) were recorded by using 120% treatment in both seasons, respectively. The lower WUE associated with a higher amount of irrigation water could be due to a greater loss of water by ET than the corresponding increase in seed yield (Kamkar et al., 2011).

Increasing fruit yield of coriander plants by increasing irrigation level could be explained through the effect of frequent irrigation on stimulating the vegetative growth as shown in Table 3. This stimulation may reflect in increasing plant fruit yield and consequently fruit yield/fed. The higher physiological activity and better growth of crop plants with frequent irrigation might have enhanced the supply of photosynthates from source to sink, consequently increasing the production of yield attributes with more frequent irrigation.

3.3. Volatile oil content

Data presented in Table 5 show that the highest essential oil percentage was obtained by applying the treatment of 120% of ETP while, the treatment of 40% of ETP recorded the lowest values in this concern in both seasons. At the same time, the volatile oil yield per hill and fed were gradually increased with increasing irrigation rate and the maximum values were obtained at 120% of ETP in the two seasons. The irrigation treatment at 40% of ETP resulted in the lowest volatile oil yield/fed. (10.69 and 8.68 L) meanwhile; the highest volatile oil yield/fed. (25.05 and 24.89 L) was obtained by irrigation treatment at 120% of ETP in both seasons, respectively (Table 5).

These results may be due to the water stress in lower rates, which reduces the rate of metabolic process for secondary products which lead to biosynthesis of volatile oil; however, in the presence of frequent irrigation water the accumulation of products may be increased. In addition, the increment in volatile oil yield could be explained through the increment in fruit yield as a result of using higher irrigation levels. These results are in accordance with the results of Hammam (1996) on *P. anisum*, Mohamed (2000) on *C. carvi*, Osman (2000) and Osman and El-Fiky (2005) as well as Hassan et al. (2012) on coriander plants and support the others obtained by Khalid (2006) and Ekren et al. (2012) who revealed that the essential oil content was affected by different water treatments.

Table 6 The main components of fruit volatile oil of coriander as affected by different water regimes based on class-A pan.

Main components	Component (%)				
	ETP (%)				
	40	60	80	100	120
Limonene	19.75	19.67	19.82	19.01	19.73
ß- Cymene	26.30	26.12	26.50	26.58	26.26
Linalool	37.69	37.90	37.72	38.1	37.80
Nerol	7.90	7.80	7.65	7.65	7.87
Borneol	2.21	2.40	2.15	1.99	2.22
Geraniol	2.00	2.23	1.98	1.98	2.02

ETP means evapotranspiration potential.

3.4. Volatile oil composition

The results of GC analysis of volatile oil showed that the main components of volatile oil were linalool, ß-Cymene, limonene, nerol, borneol and geraniol Table 6. These results support the other findings of Mostafa et al. (1986) and El-Deeb et al. (1993). However, the irrigation treatments did not affect the oil composition of coriander as the percentages of peaks of the main components were very slightly affected Table 6.Unlike our data, other studies stated that the irrigation treatments affected the volatile oil composition (Khalid 2006; Ekren et al., 2012) and that may have occurred because they applied water stress treatments.

3.5. Chemical composition

The results of chemical analysis of dry herb of coriander were tabulated in Table 7. Increasing the irrigation rate from 40% to 120% of ETP gradually decreased the nitrogen percentage, however the phosphorus percentage takes an opposite trend of nitrogen. The phosphorus percentage was gradually increased with increasing the irrigation level during the two experimental seasons. In addition, there was no clear trend for potassium as a result of applying different irrigation treatments. The decrease of nitrogen percentage could be explained through the dilution effect, which may have occurred as a result of increasing the corresponding produced dry matter obtained by increasing the irrigation level (Table 3).Similar results were reported by Afify et al. (1993) and Al-Humaid and Mazrou (1998). On the other hand, Osman (2000) found an opposite

Table 5 Essential oil content of coriander fruits as affected by different water regimes based on class-A pan during the two experimental seasons.

ETP (%)	Volatile oil (%)	Oil yield (mL/hill)	Oil yield (L/fed.)	Volatile oil (%)	Oil yield (mL/hill)	Oil yield (L/fed.)
	2007/2008 Season			2008/2009 Season		
40	1.48	0.35d	10.69d	1.20	0.28e	8.68e
60	1.54	0.38d	11.67d	1.59	0.40d	12.22 d
80	2.00	0.53c	15.91c	1.97	0.52c	15.76c
100	2.44	0.70b	21.15b	2.49	0.70b	21.24b
120	2.72	0.83a	25.05a	2.66	0.82a	24.89a

ETP means evapotranspiration potential.
Means followed by different letters were significantly different according to revised L.S.D. test at 0.05 levels.

Table 7 Chemical composition of coriander herb as affected by different water regimes based on class-A pan during the two experimental seasons.

ETP (%)	Elements (%)			Carbohydrates	Elements (%)			Carbohydrates
	N	P	K	(%)	N	P	K	(%)
	2007/2008 Season				2008/2009 Season			
40	2.86a	0.24b	1.56a	22.66a	2.79a	0.24b	1.00c	25.43 a
60	2.67ab	0.26b	1.64a	20.27ab	2.68a	0.28b	1.06bc	23.00 b
80	2.37b	0.29b	1.57a	13.59b	2.61a	0.29b	1.63ab	21.42 b
100	2.29b	0.63a	1.31a	11.59c	2.37b	0.61a	1.59a	13.33 c
120	1.53c	0.66a	1.44a	9.41c	1.77c	0.64a	1.80a	8.30 d

ETP means evapotranspiration potential.
Means followed by different letters were significantly different according to revised L.S.D. test at 0.05 levels.

trend. Concerning the total carbohydrate percentage, increasing the irrigation level significantly decreased the total carbohydrate percentages during the two seasons. The irrigation treatment at 40% of ETP resulted in the highest carbohydrate percentages (22.66% and 25.43%) whereas the lowest values in this respect (9.41% and 8.30%) were obtained by applying the highest irrigation level of 120% of ETP in the two experimental seasons, respectively (Table 7).

Deficit irrigation had a negative effect on NPK of rosemary plants. As a result of vegetative growth reduction, the absorption of nutrient elements could be decreased (Pascale et al., 2001). As a result of vegetative growth promotion by higher irrigation levels, the absorption of nutrient elements could be increased and the metabolic processes can also be promoted. However, water deficit reduced photosynthesis rate (Pascale et al., 2001). The reduced yield obtained at low frequency may have resulted from deficiency of nutrients rather than of water, and that high irrigation frequency could compensate for nutrient deficiency (Silber et al., 2003). The carbohydrate percentage was positively correlated with deficit irrigation. Carbohydrates as the main organic solutes involved in plant osmotic adjustment may lead to a decrease in leaf osmotic potential to maintain turgor and this is also an important adaptive mechanism in plants subjected to deficit irrigation (Hessine et al., 2009). These results support the findings of Osman (2000), Díaz-López et al. (2012) however; an opposite trend was obtained by Hammam (1996).

From the results of our experiment it could be concluded that applying 120% of ETP irrigation level resulted in promoting the vegetative growth and gave the highest fruit as well as oil yields of coriander plants. Therefore, it can be recommended under the experimental conditions.

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