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Comparative study on the effect of changing the system of surface irrigation to drip irrigation system in the old cultivated lands of the lettuce (*lactuca sativa*) crop spraying with organic acids

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Abstract

Two field experiments were conducted at El-Kanater Horticultural Research Station during two successive winter seasons of 2013/2014 and 2014/15. This study aimed to determine the effect of the changing of surface irrigation to drip one as well as spraying the plants with organic acids (humic and folvic acid of 3 ml/L) on seasonal applied irrigation water, consumptive use, yield, vegetative growth and leaf mineral content of Lettuce (*Lactuca sativa*). Results for surface irrigation system showed that higher applied rate of irrigation water (1637.4 & 1642.4 m^3/fed.) Than the drip irrigation system (1064.3 & 1098.1 m^3/fed.) during 2013/2014 and 2014/2015 seasons, respectively. Therefore drip irrigation system showed that seasonal applied irrigation water decreases with 35.1 and 33.2 % from surface irrigation system in 2013/2014 and 2014/2015 seasons, respectively. Drip irrigation system supported an increase of water productivity 32.0 and 32.15 kg/m^3 irrigation water. Therefore drip irrigation showed increases in Water utilization efficiency by 86.8 and 78.8 % and increases yield by 22.3 and 19.5 % over surface irrigation in 2013/14 and 2014/15 seasons respectively. The increase in all morphological characters, yield and nutrient uptake of lettuce by the drip irrigation and foliar spray with humic + fulvic acids.

Key wards: Lettuce, irrigation system, organic acids, growth, yield

Introduction

Head lettuce (*Lactuca sativa* L.) is the world's most used salad crop. It is one of the important leafy vegetable crops which are eaten fresh and is a major and extensively grown cool season vegetable best adopted to temperate locations **(Rubatzky and Tamaguchi, 1997).** Lettuce for fresh consumption is an important field vegetable crop in Egypt. It is commonly grown on the clay loam and clay soils under irrigated conditions but knowledge of the water consumptive use and the influence of different water regimes on the yield and nitrogen uptake by lettuce are still insufficient. Water is consumed plentifully for agricultural purposes in Egypt and in the world (approximately 80%). Water for agriculture in Egypt is becoming a major constraint therefore maximizing its use can be carried out through the efficiency of modern irrigation systems **(Brown, 1999).** Nevertheless, the rate of water consumption for industrial and domestic needs is gradually increasing and it for agricultural irrigation is decreasing **(Önder *et al*., 2005**) that necessitate a more efficient use of available water resources. Efficient water use by irrigation systems was becoming increasingly important especially in arid and semi-arid regions with limited water resources. In agricultural practices, the sufficient and balanced application of irrigation water and nutrients are important methodology to obtain maximum yield per unit area. **Sanchez (2000)** demonstrated that lettuce yield was increased in response to water and nitrogen. On the other hand, excessive application of irrigation water and nutrients result in some serious problems **(Türkmen *et al*., 2004).** To make optimal use of water resources, contribute to sustainable agriculture and to decrease or to eliminate the negative effects of irrigation to the ecology, the main objective of irrigation is to apply the water only as a plant needs for optimal us and to apply it on time to the active root zone depth with minimal water loss. Drip irrigation is considered to have many advantages over other types of irrigation **(Thompson and Doerge, 1996a and Tan, 1995).** Humic substances are generated through organic matter decomposition and employed as soil amendment in order to improve soil structure and soil microorganisms **(Halime *et al*., 2011).**

Zaky *et al*. (2006) found that the number of shoots/plant, average leaf area, total yield, average pod fresh weight and P content were increased by application of humic acid as a foliar fertilizer at a rate of 1 g/l. **Sladky, (1959).** A foliar application of Fulvic Acid yielded a greater stem length, greater fresh weight, dry stem weight and root weight

The main objective of this study was to identify the effects of transition from surface irrigation to drip irrigation and spray with humic and folvic acid on yield, vegetative growth, chemical composition, applied irrigation water and water use efficiency as well as investigate the mechanism of action of humic and folvic acid.

Materials and Methods

The present work was conducted at El-Kanater Hort. Res. Station during the two successive winter growing seasons of 2013/2014 and 2014/2015. The main target of this investigation was to study the effect of changing the irrigation system from surface to the modern irrigation system (Drip irrigation) in clay loamy soil on vegetative growth, yield, chemical content and some both crop water relations of lettuce plants under foliar spraying with humic acid (HA) and /or folvic acid (FA) solutions at the rate of (3 ml/l). The leaf surfaces of plants were totally wetted with (HA) and (FA) solutions in order to accomplish faster and more effective absorption of (HA) and (FA) during late afternoon or evening hours **(Hull *et al.*, 1975).**

Lettuce plants were sprayed with foliar treatments three times, 15 days after sowing and repeated each 15 days interval with different concentrations of HA and FA utilizing a hand-held sprayer. Seeds of head lettuce (*Lactuca sativa* L.) cv. Balady were sown in October 10th for both seasons. Seeds were successfully germinated in the proper time. After germination by about 40 – 45 days, seedlings (8-10 cm long) were transplanted in the field on 15th and 20th of November in both seasons, respectively. The experimental plots area was about 12 m^2. Each plot contained 5 rows, 4 m long and 0.6 m width and the plants were spaced at 20 cm apart on both sides.

The drip irrigation system used in the farm included water pump (2 hp) connected to both sand and screen filters as well as a fertilizer injector tank. The conveying pipeline system consists of a PVC main line 76.2 mm diameter connected to sub-main line of 63 mm and manifold of 38.1mm. Each line is served by two lateral lines about 30cm apart. Lateral lines were connected to the manifold line and equipped with build-in emitters of 4 L/h discharge and spaced 0.50 m apart. The experiment treatments were arranged in a split-plot design in complete randomized block system with three replicates. Irrigation methods were rested in the main plots and four foliar applications occupied the sub plots. Routine cultured practices, similar to those used in lettuce commerce of production were done as needed. Plant height, total yield , fresh weight of plant were measured using ten plants from each plot in harvesting time 20 and 25 January in the first and second seasons, respectively .

The experimental soil was clay loamy in texture and bulk density as well as water-soil characteristic is shown in Table 1. Meteorological data for the Agricultural Research Station are shown in Table 2.

Table 1. Physical properties of the experiment soil.

Parameter		Value
Particle size distribution (%):		
Clay	%	31.4
Silt	%	33.5
Fine sand	%	34.0
Coarse sand	%	1.1
Texture class		**Clay loam**

Some soil - water parameters and bulk density

Depth	Field capacity (FC)		Wilting Point (WP)		Available water (AW)		Bulk density (BD) g/cm^3
	% by weight	Cm	% by weight	cm	% by weight	cm	
0-15	37.9	7.22	18.1	3.45	19.8	3.77	1.27
15-30	36.1	7.04	17.6	3.43	18.5	3.61	1.30
30-45	33.5	6.58	16.9	3.32	16.6	3.26	1.31
45-60	32.5	6.53	16.2	3.26	16.3	3.28	1.34
Total		27.37		13.46		13.92	

FC: moisture at 33 KPa (0.33 bar) moisture tension.
WP: moisture at 1.5 MPa (15 bar) moisture tension.
AW = FC-WP

Irrigation treatments (main plots)

1- Surface irrigation.
2- Drip irrigation.

Foliar applications (sub-plots)

1- Foliar spray with water (control).
2- Foliar spray with humic acid (HA) compound at a rate of 3 ml/l of water.
3- Foliar spray with folvic acid (FA) compound at a rate of 3 ml/l of water.
4- Foliar spray with humic acid (HA) + folvic acid (FA) (1:1 ratio) at the rate of 3 ml/l of water.

Table 2. Meteorological data for the experimental site during 2013/2014 and 2014/2015 seasons.

Month	T.max.	T.min.	WS	RH	SS	SR	R. F
	2013/2014						
October	30.3	18.1	2.0	66	11.3	417	0.0
November	26.7	15.8	1.9	73	10.5	326	0.2
December	23	9.7	1.1	68	10.1	268	0.1
January	22	9.1	1.4	68	6.6	280	0.3
	2014/2015						
October	30.9	18.2	1.7	59	10.5	417	0.2
November	26	14.6	1.7	64	9.5	432	0.1
December	21.5	9.9	1.3	66	8.4	514	0.3
January	20.8	9.1	1.8	67	7.3	572	0.9

T. max, T. min = maximum and minimum temperatures °C.
WS = wind speed (m / sec^{-1}).
RH = relative humidity (%).
SS = actual sunshine duration (h/day^{-1})
SR = solar radiation (cal / cm^2 / day^{-1}).
RF = rainfall (mm / $month^{-1}$).

Amount of applied irrigation water (AIW):

Drip irrigation system:

The applied amounts of irrigation water were equal to ETo calculated using Penman Monteith equation, by CROPWAT computer model **(FAO 1992)**, using **(Doorenbos and Pruitt 1977)** equation and the Kc values illustrated in FAO-24 **(Allen *et al*., 1998)**

Surface irrigation system:

Submerged flow orifice with fixed dimension was used to measure the amount of water applied, according to **(Michael, 1978)** as

$$Q = CA\sqrt{2gh}$$

Where:

Q = discharge through orifice, (1/sec).
C = coefficient of discharge, (0.61).
A = cross-sectional area of the orifice, cm^2.
G = acceleration due to gravity, (981 cm/$sec.^2$).
H = pressure head, causing discharge through the orifice, cm

Water utilization efficiency (W.Ut.E):

It was determined according **(Jensen 1983)** as

$$W.Ut.E = \frac{\text{yield (kg)/fed.}}{\text{Seasonal applied water } (m^3\text{/fed.})}$$

Chemical composition of plant: Total nitrogen was determined by the micro-kjeldahl method according to **Cottenie *et al.*, (1982).** Total phosphorus was determined in concentrated acid digest using a spectrophotometer according to the method **Murphy and Reily (1962)**. Total potassium content was determined in the acid digest using Atomic Absorption Spectrophotometer according to **Jackson and Ulrich (1959)** and **Chapman and Pratt (1961).** Chlorophyll "A", Chlorophyll "B" and caroteniods in fresh were determined using the methods described by **Wettsteine (1957).**

Soil physical analysis: Particle size distribution was conducted using the pipette method and bulk density according to **Klute (1986)**. Soil moisture constant was determined using the pressure membrane apparatus, considering the saturation percent "SP" at KPa tension. Field capacity "FC" and wilting point WP at 0.33 and 15 bar, respectively. Available water is the difference between FC and WP **(Stackman 1966).**

Statistical analysis:

The analysis of variance was carried out according to **(Gomez and Gomez 1984)** using MSTAT computer software, after testing the homogeneity of the error according to Bartlett's test. Means of the different treatments were compared using the least significant difference (LSD) at 5% level.

Results and Discussion

I. Soil water relations:

1.1. Applied irrigation water:

Results show that seasonal applied irrigation water to lettuce plants were less under drip irrigation as compared with surface irrigation in both seasons. The applied seasonal irrigation water were 1059 and 1637 m^3/fed in the first season and 1066 and 1642 m^3/fed in the second one for drip and surface systems, respectively (Table, 3). Therefore surface irrigation system showed that seasonal applied irrigation water increases of 35.4 and 35.1 % over drip irrigation system in 2013/14 and 2014/15 seasons, respectively. Such result might be reasonable, since the exposed surface area under surface system provides high evaporation opportunity from the relatively wet rather than dry soil surface as in drip irrigation. Also, the high amount of water applied under surface system reflects the low system efficiency as compared with the drip one. The seasonal water use values were obtained from the sum of water for all irrigations per treatment, from November until January in each season. The obtained results were in harmony with those reported by **Kucukyumuk *et al*. (2012)**

Table 3. Monthly and seasonal applied irrigation water to Lettuce plants by the two irrigation system in 2013/2014 and 2014/2015 growing seasons.

Season	Drip irrigation				Surface irrigation			
Month	2013/2014		2014/2015		2013/2014		2014/2015	
	m^3/ day	m^3/ month	m^3/ day	m^3/ month	m^3/ day	m^3/ month	m^3/ day	m^3/ month
November	11.3	168.9	11.3	169.4	15.16	227.4	16.8	252.6
December	14.4	447.1	14.8	458.7	22.10	685.1	19.3	597.5
January	22.2	443.0	17.5	437.9	23.38	724.9	31.7	792.3
Seasonal (m^3/fed.)		**1059**		**1066**		**1637**		**1642**

1.2. Monthly applied irrigation water.

Results in Table 3 and Fig. 1 show that monthly applied water values began to raise during November then gradually increased to reach its maximum during January under drip irrigation and surface irrigation system in both seasons. In January the plant were fully developed thus the water soil was subjected to greater depletion in January compared with the other two months. In the two seasons, monthly water consumption started low when plants were small and increased gradually with increasing plant growth reaching the maximum in January mainly due to increased demand for water by plants. Thus, the increase in evapotranspiration from the beginning of the growth season till harvesting maturity can be explained on the basis of the plants coverage**. Ibrahim (1981)** concluded that the increase in evaportanspiration by maintaining soil moisture at a high level is attributed to excess available water in the root zone .

1.3. Water utilization efficiency (W.Ut.E):

Water utilization efficiency represented the amount of yield produced per cubic meter of water used by the crop**.** Results in current study indicated that, there was significant effect of the irrigation systems on W.Ut.E value (Fig, 2). The obtained values were significantly different under drip irrigation system (32.16 and 33.12 kg/m^3) than under surface system (17.13 and 17.98 kg/m^3) in 2013/14 and 2014/15 seasons, respectively. Therefore, drip irrigation show increases in Water utilization efficiency of 87.7 and 84.2 % over surface irrigation in 2013/14 and 2014/15 seasons, respectively. Decreasing the total seasonal water application negatively affected the crop water use efficiency. Comparing between surface irrigation and drip irrigation from the point of view of the recorded crop water use efficiency, it is clear that the drip irrigation system has an advantage in the beneficial use of water. This is because of higher values of crop water use efficiency recorded with drip irrigation than that recorded by the surface irrigation system. This may be due to the uniform distribution of moisture in the effective root zone in the soil profile observed with drip irrigation.

The main effects of foliar spray with humic and/or fulvic treatments showed a significant increase in water utilization efficiency in first and second season. The highest value was given by (HA+FA) treatment and the lowest one was by the control. Mean values were as follows: HA + FA gave water utilization efficiency of (30.44 and 30.66) followed by HA which gave (26.71 and 27.14) then FA (22.14 and 23.34) and the lowest was by the control (19.29 and 21.1) kg fresh matter /m^3 irrigation water in 2013/14 and 2014/15 seasons, respectively. (Humic + Fulvic acid) treatment also slow down leaf senescence, and leaf function was maintained for a longer period. During exposure to dry winds, the evapotranspiration rate of sprayed plants was higher than that of the unsprayed control. This seemed to be due to reduction in function of the leaves of control plants which were obviously damaged. That stomatal conductance and transpiration could be decreased by humic substances has been reported recently **(Mei and Yang 1983; Molho *et al*. 1981)**.

2. Growth parameters:

2.1. Plant height

The main effect of irrigation system on plant height was recorded in Table 5. Such results show that there was no significant increase in plant height in both seasons of study. However, the highest values were connected with using drip irrigation system.

The main effect of foliar spray with organic acids treatments shows significant increase in plant height only in the second season which the highest value was given by HA+FA and the lowest one was by the control . Mean values were as follows: HA+FA gave the highest plant height of 46.7 followed by HA which gave 42.8, then FA which gave 42.7 cm. Therefore HA+FA showed increases over control amounting to 23.5 %. However, there was significant interaction caused by irrigation and foliar spray treatments. This was manifested when drip irrigation gave plants of greater height, an increase of about 10.6 % on surface irrigation under condition of HA+FA in the second season .

2.2. Number of leaves/ plant The main effect of irrigation system on number of leaves/ plant was presented in Table 4. The increase in number of leaves/plant was significant by drip irrigation system and the lowest was by surface irrigation system in 2013/14 and 2014/15 seasons. Values of mean number of leaves/ plant were as follows : drip irrigation system gave the highest number of leaves/ plant (61.5 and 60.8), and surface irrigation system gave (46.7 and 46.3) in seasons 2013/14 and 2014/15, respectively. Therefore drip irrigation showed increases of 31.7 and 31.3 % over surface irrigation in both seasons, respectively.

However, there were interactions particularly in season 2013/14 drip irrigation and surface irrigation system were similar in effect under conditions of Foliar spray with water (control) .

Data in Table 4 reveal that effect of the tested organic acids was mostly significant on number of leaves/ plant in the two seasons of study. In addition, higher values of number of leaves/ plant were recorded due to foliar application of the assessed organic acids, comparable with the control. In this respect, and humic acid + fulvic acid seemed to be superior in this respect.

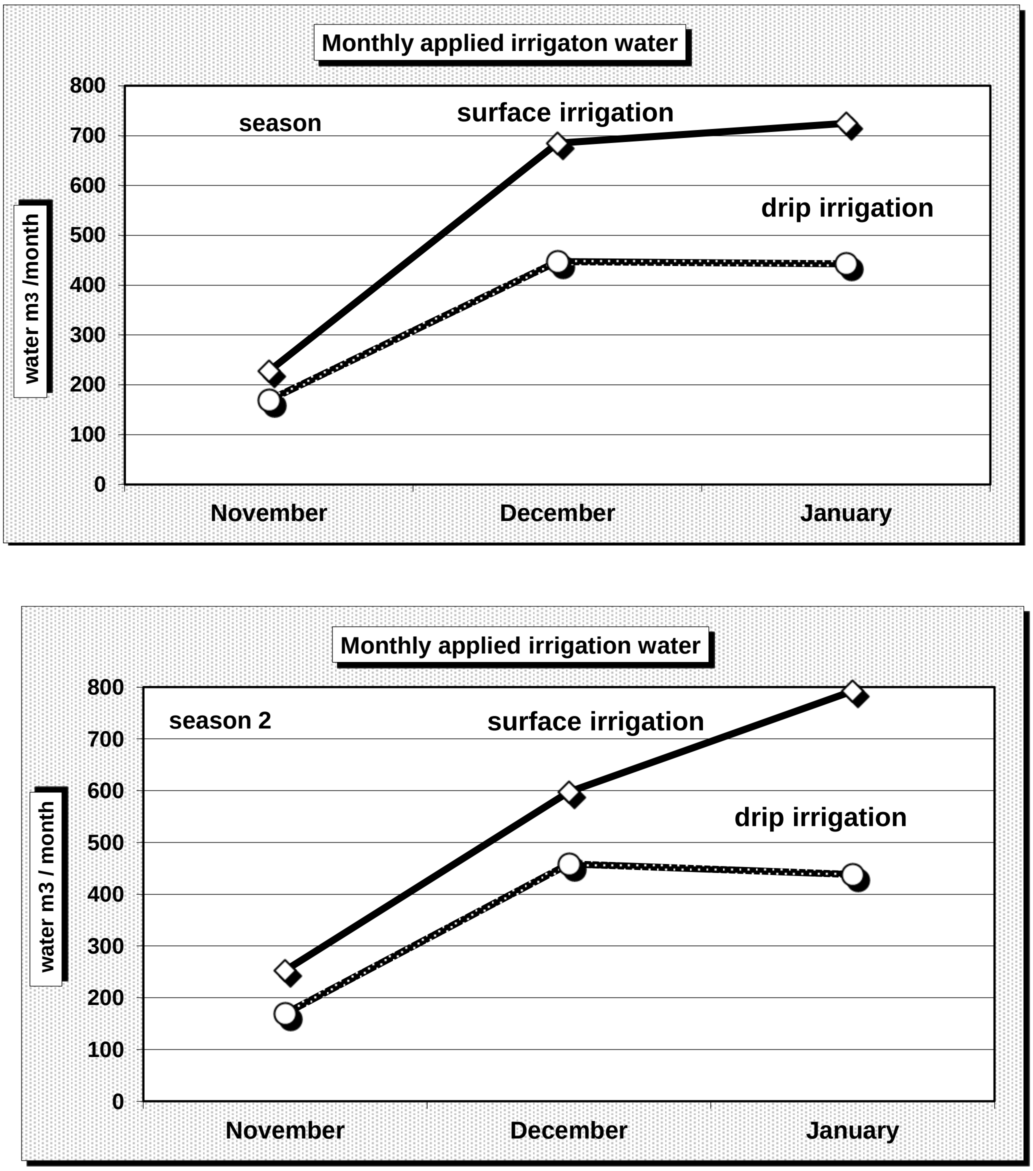
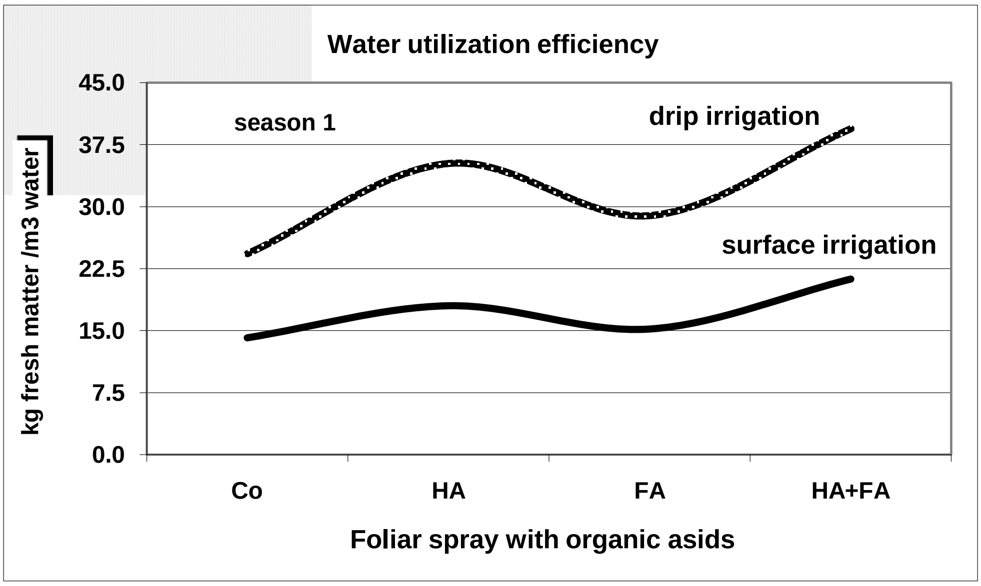


Fig. 1 Monthly applied irrigation water under surface and drip irrigation systems in 2013/14 and 2014/15 seasons.



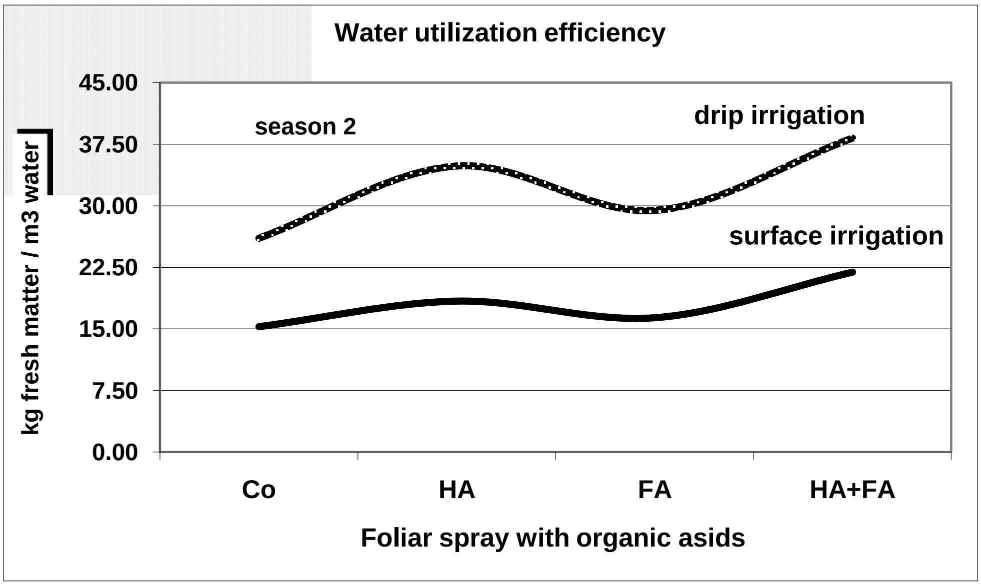


Fig. 2 Effect of irrigation systems and foliar spray with organic acids on water utilization efficiency (kg /m^3 water) during 2013/14 and 2014/15 seasons.

HA : Humic acid rate of 3 ml/l.
FA : Fulvic acid rate of 3 ml/l.
HA+FA: Humic acid + Fulvic acid (1:1) rate of 3 ml/l
Co. : Foliar spray with water (control)

As for the effect of the interaction there were interactions particularly in season 2013/14 Humic acid and the control were similar in effect under conditions of surface irrigation system. According to the results of vegetative growth measurements, differences were determined among all treatments, but a clear relationship could not be identified. It is clear that transition from surface irrigation to drip irrigation system has positive effects on vegetative growth of lettuce plants. Plants spend most of their energies while taking water from the soil by their roots **Kocacaliskan, (2005).** These results are confirmed by those recorded by **Kamari-Shahmaleki *et al*. (2012), Ferrara and Brunetti (2010) and Pouzeshi *et al*. (2011).** Formation of complex between humic acid and mineral ions, catalysis of humic acid by the enzymes in plant, influence of humic acid on respiration and photosynthesis, stimulation of nucleic acid metabolism and hormonal activity of humic acid are amongst effective assumptions that has been expressed to describe the effect of humic acid on plants growth parameters **Turkmen *et al*. (2004). Abdel Fatah *et al*. (2008)**, who observed that application of humic acid improved growth.

Research done with tomato plants revealed that plants treated with fulvic acid had significant beneficial effects on roots and stem weight, surpassing the benefits of those plants treated with humic acid **(Sladky, 1959).** A foliar application of Fulvic Acid yielded a greater stem length, greater fresh weight, dry stem weight and root weight.

Table 4. Effect of irrigation systems and foliar spray of organic acids on plant height (cm) and number of leaves/ plant during 2013/14 and 2014/15 .

Irrigation systems (A)	Plant height (cm)									
	Organic acids (B)									
	Season 2013/2014					Season 2014/2015				
	Co	HA	FA	HA+FA	Mean	Co	H	F	H+F	Mean
Drip irrigation	38. 7	45.7	44.0	46.3	**43. 7**	38.3	43.3	43.0	49.0	**43.4**
Surface irrigation	37. 7	44.0	43.0	45.0	**42.4**	37.3	42.3	42.3	44.3	**41.6**
Mean	**38.2**	**44.8**	**43.5**	**45. 7**		**37.8**	**42.8**	**42. 7**	**46. 7**	
LSD at 5%	A N.S B N.S AB N.S					A N.S B 4.7 AB 4.4				

Irrigation systems (A)	Number of leaves/ plant									
	Organic acids (B)									
	Season 2013/2014					Season 2014/2015				
	Co	HA	FA	HA+FA	Mean	Co	H.	F.	H.+F.	Mean
Drip irrigation	44.3	64. 7	58. 3	78. 7	**61.5**	48.0	62.3	59.0	74.0	**60.8**
Surface irrigation	38. 7	44.3	40. 7	63.3	**46.7**	39.3	47.0	44.0	54. 7	**46.3**
Mean	**41.5**	**54.5**	**49.5**	**71.0**		**43. 7**	**54. 7**	**51.5**	**64.3**	
LSD at 5%	A 2.5 B 11.6 AB 7.2					A 12.3 B 11.5 AB 7.3				

HA : Humic acid rate of 3 ml/l.
FA : Fulvic acid rate of 3 ml/l.
HA+FA : Humic acid + Fulvic acid (1:1) rate of 3 ml/l
Co : Foliar spray with water (control)

2.3. Fresh weight /plant

The main effect of irrigation system on fresh matter per lettuce plant is shown in Table 5. The results showed a non-significant differences in fresh matter per lettuce plant in 2013/14 and 2014/15 seasons.

The main effect of foliar spray with organic acids treatments shows there were a significant increase in fresh matter per lettuce plant in first and second season. The highest effect was given by HA+FA and the lowest was by the control . Mean values in seasons 2013/14 and 2014/15 were as follows: HA+FA gave the highest height of (1034 and 975) followed by HA which gave (837.5 and 850) then FA which gave (701.7 and 731.7) and the lowest value was by the control (635.9 and 683.1) g /plant in the first and second seasons, respectively.

As for the effect of interaction, there was significant interaction effect caused by irrigation with affected foliar spray treatments. However, both fulvic and the control treatments were similar in the their effect under conditions of surface irrigation in the second season. **Zaky *et al*. (2006)** on bean found that number of shoots/plant, average leaf area, total yield and P content were increased by application of humic acid as a foliar fertilizer at a rate of 1 g/l.

2.4. Yield of fresh matter per feddan. The results in Table 5 reveal that lettuce yield was significantly affected due to the irrigation system in both 2013/2014 and 2014/2015 seasons. The highest yield

34.30 and 35.30 ton/fed. were obtained from drip irrigation , while the surface irrigation bear yield to 28.05 and 29.54 ton/fed., respectively, in first and second seasons. Therefore drip irrigation showed increases of 22.3 and 19.5 % over surface irrigation in 2013/2014 and 2014/2015 seasons, respectively. The increase in all morphological characters by drip irrigation systems might be attributed to the favorable effect of drip irrigation in maintaining soil moisture at rang suitable for plant growth with out stress for the growth of lettuce plant, minimizing the irrigation water losses, and maximizing the yield of fresh matter .

Regarding the effect of foliar spray with organic acids, data in Table 5 show that lettuce yield was significantly increased with the tested organic acids, as compared with the control, and such trend was true in the two seasons of study. The main effect of foliar spray with organic acids show that the highest yield was given by (HA + FA) treatment followed by HA; and the least was given by FA treatment. Values of mean yields (in ton/ fed) in 1st and 2nd seasons were as follows : HA+FA (38.37 and 39.0), HA (33.49 and 34.23) and FA (27.33 and 29.60). In the 1st season, the increase percentages in yield reached, 31.2,7.1 and 50.3% due to foliar spray with humic, fulvic and humic + fulvic acids reached, respectively comparable with control. The corresponding increase percentages in 2nd season comprised 27.8, 10.2 and 45.2 %, as compared with control, respectively.

Table 5. Effect of irrigation systems and foliar spray of organic acids on plant fresh weight (g /plant) and yield of fresh matter (ton/fed.) during 2013/14 and 2014/15 .

Plant fresh weight (g /plant)

Irrigation systems (A)	Organic acids (B)									
	Season 2013/2014					Season 2014/2015				
	Co	HA	FA	HA+FA	Mean	Co	HA	FA	H.+F.	Mean
Drip irrigation	670.0	938.3	773.3	1140	**880.4**	739.5	956.7	816.7	1050	**890.7**
Surface irrigation	601.8	736.7	630.0	928.7	**724.3**	626.7	743.3	646.7	900.0	**729.2**
Mean	**635.9**	**837.5**	**701.7**	**1034**		**683.1**	**850.0**	**731.7**	**975.0**	
LSD at 5%										
	A N.S					A N.S				
	B 115.3					B 70.7				
	AB N.S					AB 43.7				

Yield of fresh matter (ton/fed.)

Irrigation systems (A)	Organic acids (B)									
	Season 2013/2014					Season 2014/2015				
	Co	HA	FA	HA+FA	Mean	Co	HA	FA	HA+FA	Mean
Drip irrigation	25.90	37.52	30.80	41.99	**34.30**	28.62	38.27	32.33	42.00	**35.30**
Surface irrigation	23.13	29.47	24.87	34.75	**28.05**	25.08	30.20	26.87	36.00	**29.54**
Mean	**24.51**	**33.49**	**28.83**	**38.37**		**26.85**	**34.23**	**29.60**	**39.00**	
LSD at 5%										
	A 5.40					A 4.00				
	B 4.00					B 1.84				
	AB 2.47					AB N.S				

Notes:

HA : Humic acid rate of 3 ml/l.
FA : Fulvic acid rate of 3 ml/l.
HA+FA : Humic acid + Fulvic acid (1:1) rate of 3 ml/l
Co : Foliar spray with water (control)

However, regarding the effect of the interaction, data show that both fulvic and the control were similar in their effect under conditions of surface irrigation in the first season. **Yildirim, (2007); and Karakurt *et al.* (2009)** reported that the foliar sprays of these substances promote growth, and increases yield and quality in a number of plant species at least partially through increasing nutrient uptake, serving as a source of mineral plant nutrients and regulator of their release **Atiyeh *et al.* (2002). Cimrin and Yilmaz (2005)** stated that application of humic acid increased head weight of lettuce (*Lactuca sativa* L. *var longifolia*) by increasing the availability of phosphorus and nitrogen. **Ayas and Gulser (2005)** concluded that increased nitrogen uptake caused by humic acid application was the main reason of enhanced vegetation growth of spinach. The positive effects of the humic substances were also observed on the studies such as dry matter yield increases on corn and oat seedling.

3. Chemical composition:

3.1. Nitrogen content (mg/plant)

The main effect of irrigation system shows that the drip irrigation system gave the highest N-uptake followed by surface irrigation Table 6**.** Mean values in both 2013/14 and 2014/15 seasons were as follows : drip irrigation (1536 and 1164 mg N/plant), surface irrigation (1201and 1019 mg N/plant), respectively. Therefore drip irrigation showed increases of 27.9 and 14.2 % over surface irrigation in 2013/14 and 2014/15 seasons, respectively.

Foliar spray with organic acids treatments showed greater N-uptake than the control treatment. Regarding the main effect of foliar spray for the organic acids treatments, the highest was given by (HA+FA) treatment followed by HA then by FA. Mean values of N-uptake in plants (mg N/plant) were as fellows; (HA+FA = 1896 and 1258), (HA = 1657 and 1227), (FA = 1197 and 1013) , and (Co = 958 and 868) in seasons 2013/14 and 2014/15 respectively.

There was an interaction caused by irrigation, with affecting response to foliar spray organic acids. Under conditions of the surface irrigation there were no significant differences between fulvic acid foliar spray and the control in second season. The above results assert the importance having soil moisture niether too high nor too low in order to obtained high N uptake. Dry conditions decreased up take of N in soil since it decreased plant growth . **Eissa and Header (1991)** reported little differences in **N** uptake under low moisture contents and **Meleha (1992)**, reported that keeping soil at 100 % of its water holding capacity resulted in greater N uptake by barley as compared with 75 % or 50 % water holding capacity. Increased soil moisture may have probably enhanced ammonification of soil organic N **(Bremner, 1965). Ayas and Gulser (2005)** reported that HA application was the main reason of enhancing nitrogen uptake in spinach.

3.2. Phosphorus content (mg/plant).

The main effect of irrigation system on P-uptake by plants (mg P/plant) is shown in Table 6. The results show a no significant differences between both irrigation systems on P-uptake by plants in 2013/14 and 2014/15 seasons.

The main effect of foliar spray with organic acids treatments shows that

there was a significant increase in P-uptake by plants in first and second seasons. The highest value was given by HA+FA and the lowest was by the control.

Mean values in seasons 2013/14 and 2014/15 were as follows: HA+FA gave P-uptake by plants of (237 and 158) followed by HA which gave (192 and 143) then FA which gave (134 and 115) and the lowest was by the control (109 and 102) mg P/plant in 2013/14 and 2014/15 seasons, respectively.

There was an interaction caused by irrigation, affecting response to foliar spray organic acids. Under conditions of the surface irrigation there were significant differences between foliar spray for humic acid + fulvic acid and for humic acid in second season**.**

The enhanced uptake of phosphorous in plants with application of humic substances is mainly due to the increased availability of phosphate in the soil **(Zalba and Peinemann, 2002)**. In many soils a large part of total phosphorous is insoluble (calcium phosphate precipitation) and thus unavailable to the plants. The major mechanism involved in the effect of humic acid increasing phosphorus recovery is the interference on calcium phosphate precipitation **(Satisha and Devarajan, 2005).** The effect of HA on the availability of P and micronutrients has been given particular attention because of observed increases in uptake rates of these nutrients following application of HA **Ayuso *et al*., (1996). Abdel-Rezzak and EI-Sharkawy (2013)** reported that the humic acid, significantly increased in concentration of phosphorus in garlic cloves.

3.3. Potassium content (mg/plant).

The main effect of the irrigation system shows that surface irrigation gave the lowest K-uptake, while the highest was given by drip irrigation in Table 6**.** Average values of K-uptake by plants (mg K/plant) were as follows: drip irrigation (1711 and 1173) and surface irrigation (1176 and 964) in seasons 2013/14 and 2014/15, respectively. Therefore drip irrigation showed increases of 45.5 and 21.7 % over surface irrigation in first season and second season, respectively. There was an interaction in season 2013/14 and 2014/154 the drip irrigation and surface irrigation were similar in effect under conditions of the control foliar spray with water. The main effect of foliar spray with organic acids treatments show that the highest K uptake among foliar spray treatments was given by HA+FA followed by H then F and the lowest was by control. Mean K uptake in season 1 and 2 (mg/ plant) were: HA+FA (2138 and 1346), HA (1736 and 1282), FA (1267 and 1065) and Co (2115 and 2120). **Fernández- Escobar *et al.*, (1999)** found that application of HA stimulated accumulation of K in leaves. These results may be due to the role of humic acid in the modulation of nutrient uptake via an interaction with plasma membrane H+ -ATP. In their study the contemporary presence of humic substances caused stimulation of the nutrient uptake capacity and of the plasma membrane H+ -ATP activity with the same pattern observed for nutrient uptake. The stimulation of plasma membrane H+ -ATP activity was also reported by several other authors **Canellas *et al.*, (2002)** and is considered as an important action of humic substances on plant nutrient acquisition.

Table 6. Effect of irrigation systems and foliar spray of organic acids on uptake N, P and K mg/plant during 2013/14 and 2014/15.

Uptake N mg/plant

Irrigation systems (A)	Organic acids (B)									
	Season 2013/2014					**Season 2014/2015**				
	Co	**HA**	**FA**	**HA+FA**	**Mean**	**Co**	**HA**	**FA**	**HA+FA**	**Mean**
Drip irrigation	1067	1783	1313	1983	**1536**	893	1348	1115	1300	**1164**
Surface irrigation	848	1331	1081	1545	**1201**	843	1106	910	1215	**1019**
Mean	**958**	**1657**	**1197**	**1896**		**868**	**1227**	**1013**	**1258**	
LSD at 5%	A 156 B 158 AB N.S					A 132 B 135 AB 83				

Uptake P mg/plant

Irrigation systems (A)	Organic acids (B)									
	Season 2013/2014					**Season 2014/2015**				
	Co	**HA**	**FA**	**HA+FA**	**Mean**	**Co**	**HA**	**FA**	**HA+FA**	**Mean**
Drip irrigation	116	225	154	265	**190**	103	151	131	162	**137**
Surface irrigation	102	159	114	210	**146**	101	135	99	153	**122**
Mean	**109**	**192**	**134**	**237**		**102**	**143**	**115**	**158**	
LSD at 5%	A N.S B 50 AB N.S					A N.S B 18 AB 11				

Uptake K mg/plant

Irrigation systems (A)	Organic acids (B)									
	Season 2013/2014					**Season 2014/2015**				
	Co	**HA**	**FA**	**HA+FA**	**Mean**	**Co**	**HA**	**FA**	**HA+FA**	**Mean**
Drip irrigation	705	2167	1421	2552	**1711**	606	1453	1204	1429	**1173**
Surface irrigation	559	1306	1113	1724	**1176**	554	1112	926	1263	**964**
Mean	**632**	**1736**	**1267**	**2138**		**580**	**1282**	**1065**	**1346**	
LSD at 5%	A 173 **B 232** **AB 146**					A 136 B 138 AB 86				

HA : Humic acid rate of 3 ml/l.
FA : Fulvic acid rate of 3 ml/l.
HA+FA : Humic acid + Fulvic acid (1:1) rate of 3 ml/l.
Co : Foliar spray with water (control)

3.4. Contents of Chlorophyll (A + B) and Carotenoids mg/l .

Chlorophyl and carotenoids analyses of the fresh plant leaves are shown in Table 7. Data show that decreasing the applied irrigation water (by drip irrigation system) resulted in an increase in the concentration of chlorophyll a,b, and caroteniod . Plants of the surface irrigation gave the lowest values of chlorophyll a and b, and carotenoids (111.4 and 110.3) , (59.5 and 59.4), (91.8 and 94.7) mg/l , while plants of the drip irrigation system gave the highest (115.6 and 114.2) , (63.6 and 63.1), (94.9 and 99.4) mg/l, in both growing seasons, respectively).

Foliar spray with organic acids had a favourable effect on the concentration of chlorophyll and caroteniods. The main effect of Foliar spray with organic acids shows that the lowest values for chlorophyll "a" chlorophyll "b" , and caroteniods (109.7 and 108.2) , (58.4.6 and 58.3) and (86.6 and 90.8) mg/ l respectively were obtained in the control foliar spray with water. The highest mean values (115.9 and 114.5), (64.1 and 763.1) and (97.6 and 103.2) mg/ l of the same 3 respective components were obtained in plants supplied with HA+FA. Plants supplied with HA and FA or HA+FA were rather similar with respect to chlorphyll a.

Regarding the interaction effect, there was no such effect with respect to chlorphyll b. i.e. all organic acids showed similar contents under all irrigaton system. There were interactions regarding chlorophyll a and carotenoids. The interaction regarding chlorophyll a is shown when HA+FA superiority over FA under drip irrigation in first and second seasons. There was an interaction in season 1 and 2 the drip irrigation and surface irrigation were similar in effect under conditions of the control foliar spray with water. The interaction regarding carotenoids is shown when under the surface irrigation combined with humic acid + fulvic acid similar with fulvic acid in first season. **Abdel Fatah *et al*. (2008)**, who observed that application of humic acid improved growth parameters and K promotes photosynthesis and transport assimilates of the carbohydrates to the storage organs. **Cangi *et al*. (2006)** indicated that foliar spraying of humic acid and amino acids on asparagus plants increase uptake of macro and micro elements in shoot and rhizome has increased carbohydrates production, chlorophyll and carotenoids in edible stems. Enhancing the quantitative and qualitative characteristics as a result of increased respiration, photosynthesis and total protein in the plants, due to humic acid and folic acid application has also been reported by **Nardi *et al*. (2002)**. **Fernández-Escobar *et al.* (1999)** found that application of HA stimulated chlorophyll content in leaves.

Table 7. Effect of irrigation systems and foliar spray of organic acids on chlorophyll a, b and Carotenoids mg/l during 2013/14 and 2014/15.

Chlorophyll A mg/l

Irrigation systems (A)	Organic acids (B)									
	Season 2013/2014					Season 2014/2015				
	Co	HA	FA	HA+FA	Mean	Co	HA	FA	HA+FA	Mean
Drip irrigation	112.0	116.7	115.5	118.3	**115.6**	108.0	116.3	114.9	117.6	**114.2**
Surface irrigation	107.4	112.9	111.6	113.6	**111.4**	108.3	110.8	110.6	111.5	**110.3**
Mean	**109.7**	**114.8**	**113.6**	**115.9**		**108.2**	**113.6**	**112.8**	**114.5**	

LSD at 5%	Season 2013/2014	Season 2014/2015
A	3.2	2.8
B	3.7	3.8
AB	2.5	2.4

Chlorophyll B mg/l

Irrigation systems (A)	Organic acids (B)									
	Season 2013/2014					Season 2014/2015				
	Co	HA	FA	HA+FA	Mean	Co	HA	FA	HA+FA	Mean
Drip irrigation	58.3	65.2	64.3	66.8	**63.6**	58.2	65.0	63.1	66.0	**63.1**
Surface irrigation	58.4	59.3	58.7	61.4	**59.5**	58.5	59.9	58.8	60.2	**59.4**
Mean	**58.4**	**62.3**	**61.5**	**64.1**		**58.3**	**62.5**	**61.0**	**63.1**	

LSD at 5%	A 4.0	A 3.6
	B 2.2	B 3.7
	AB 1.3	AB 3.3

Carotenoids mg/l

Irrigation systems (A)	Organic acids (B)									
	Season 2013/2014					Season 2014/2015				
	Co	HA	FA	HA+FA	Mean	Co	HA	FA	HA+FA	Mean
Drip irrigation	88.8	98.0	93.4	99.3	**94.9**	89.4	104.2	97.5	106.5	**99.4**
Surface irrigation	84.4	94.0	92.9	95.8	**91.8**	92.2	94.1	92.5	99.9	**94.7**
Mean	**86.6**	**96.0**	**93.1**	**97.6**		**90.8**	**99.2**	**95.0**	**103.2**	
LSD at 5%	A 2.9 B 4.9 AB 3.1					A N.S B 4.4 AB 2.8				

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دراسة مقارنة علي تأثير تغيير نظام الري بالغمر إلى نظام الري بالتنقيط في الأراضي الزراعية القديمة لمحصول الخس مع الرش بالأحماض العضوية .

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مركز البحوث الزراعية – الجيزة – مصر

أجريت تجربة حقلية في محطة بحوث البساتين القناطر الخيرية في المواسم الشتوي لعامي 2014/2013 و 2015/2014 لدراسة تأثير تغيرنظام الري بالغمر الي نظام الري بالتنقيط في الاراضي القديمة مع الرش بالأحماض العضوية الهيوميك 3ملي/لتر والفولفيك بمعدل 3 ملي/لتر والخلط بينهما 1:1 (تم الرش بعد الشتل بأسبوعين كل 15 يوم). وتاثير هذه المعاملات علي كمية المياه المضافة و الزيادة الإنتاجية من وحدة المياه والنمو والجودة، والمحصول والتركيب الكيماوي لنباتات الخس من الصنف البلدي .

اوضحت أهم النتائج المتحصل عليها زيادة مياه الري المضافة تحت نظام الري السطحي 35.1٪ و 33.2٪ في الموسمين علي التوالي وكانت كميات المياه المضافة هي (1637.4 و 1642.4 م3 / فدان) تحت نظام الري السطحي و (1064.3 و 1098.1 م3 / فدان) تحت نظام الري بالتنقيط خلال عامي 2014/2013 و 2015/2014 على التوالي . أعطي نظام الري بالتنقيط زيادة في إنتاجية الخس من وحدة المياه (32.0 و 32.15 كجم / م3 مياه) و زيادة في المحصول بلغ 22.3 و 19.5 % عن الري بالغمرفي الموسم الأول و الثاني على التوالي. كما كانت المعاملة بالرش (الهيوميك + الفولفيك) هي الاكثر زيادة في كل الصفات النمو الخضري والمحصول والمحتوي الكيماوي لنباتات الخس .