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EFFECT OF DIFFERENT SOIL MOISTURE LEVELS AND NITROGEN SOURCES ON LETTUCE YIELD *(Lactuca sativa L.)* UNDER SURFACE AND DRIP IRRIGATION SYSTEMS IN CLAY LOAM SOILS

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ABSTRACT

A field experiment was conducted at El-Kanater Horticultural Research Station in the two seasons of 2013/14 and 2014/15 to study the effect of two soil moisture levels (25 % and 50 % of available soil moisture i.e. medium and dry) under drip and surface irrigation systems and three sources of N- fertilizers, namely urea (46.5% N), ammonium nitrate (33.5% N) and ammonium sulphate (20.5% N) at the rate of 50 kg N/fed., as well as their interactions on applied irrigation water, water use efficiency, growth, yield quality and chemical composition of lettuce (*Lactuca sativa L.*) cv. Balady .

Results indicate that surface irrigation system showed higher applied irrigation water under 25% and 50% of the available soil moisture than the drip irrigation system during 2013/14 and 2014/15 seasons. Drip irrigation system supported an increase of water use efficiency (23.84 and 22.57 kg/m^3) in the first and the second seasons, respectively . Ammonium sulphate application slightly increased the water use efficiency W.U.E (23.65 and 24.16 kg/m^3) in the two seasons, respectively. Results of the interaction indicate that the medium moisture (25 %) and Ammonium sulphate application under drip and surface irrigation systems increased all studied growth characters, yield and nutrient uptake of lettuce .

Keywords : Lettuce, soil moisture levels, nitrogen sources, growth ,yield .

INTRODUCTION

Lettuce (*Lactuca sativa*) is consider one of the most important vegetable crops for fresh consumption in Egypt. It is commonly grown on the clay loam and clay soils under irrigated conditions . Literature on 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%). Available water for agriculture in Egypt is becoming a major constraint in the next few years . Therefore, maximizing its use can be carried out through the efficiency of modern irrigation systems (Brown, 1999). Efficient water use by irrigation systems is becoming increasingly important especially in arid and semi-arid regions with limited water resources. In agricultural practice, the sufficient and balanced application of irrigation water and nutrients are important methodology to obtain maximum yield per unit area. lettuce yield increased in response to water and nitrogen Sanchez (2000). On the other hand, excessive application of irrigation water and nutrients result in some serious problems (Türkmen et al., 2004). To reach 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 use 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, 1996 and Tan, 1995) .

Nevertheless, the rate of water consumption for industrial and domestic needs is gradually increasing and rate of water consumption for agricultural irrigation is decreasing that necessitate a more efficient use of available water resources. (Önder *et al*., 2005). Consequently, on loam soil, greater cantaloupe (*Cucumis melo*) yields were obtained for weekly irrigations compared to daily irrigations, higher onion yield for daily irrigations compared with weekly irrigations, and irrigation frequency had little effect on carrot (*Daucus carota*) yield (Bucks et al., 1980). Little irrigation frequency effect was found on cabbage *(Brassica oleracea Capitata Group)* yield for intervals of 3, 6 and 12 day on clay loam (Bucks et al., 1974). Also, higher potato (*Solanum tuberosum*) yield was found for more frequent drip irrigation, but no consistent trend was found for lettuce (Sammis, 1980).

Practices management that sustain lettuce production and improve soil and water quality are needed. Total N fertilizer recommendation for lettuce varies between 63 and 84 kg / fed. . Optimal N supply for lettuce increased the N residue at harvest in the soil, and thus the risk of nitrate leaching (Brumm and Schenk 1993). N and water required for maximum yields, 88% and 77% of the applied N were not recovered in the above ground portions of the plants, indicating the potential of large nitrate-N leaching in the soil Sanchez (2000). Therefore, the object of this study was to investigate the effect of some soil moisture levels and nitrogen sources on growth and yield of lettuce under drip and surface irrigation systems .

MATERIALS AND METHODS

Field experiment was carried out at El-Qanater Horticultural Research station, Kalubiya, Governorate during 2013/2014 and 2014/2015 seasons. Seeds of lettuce (*Lactuca sativa* L.) cv. Balady were cultivated in October 10^{th} for both seasons. Seeds were successfully germinated in the proper time. After germination by about 35 – 40 days, seedlings (8-10 cm long). Were transplanted into experimental plots with area of about 12 m^2 each plot contained 5 rows with length of 4 m and width of 0.6 m at 20 cm in between both sides of the ridges which were 60 cm apart and 20 cm between plants.

The time of transplanting took place 15^{th} and 20^{th} of November in both seasons, respectively. Harvesting was carried out on 20 and 26 January in the first and the second season, respectively . Vegetative and yield characteristics were measured using ten plants from each plot. Plant height, total yield , fresh weight of plant were measured with harvesting . The experiment was arranged in a split-plot design, with two irrigation methods as main plots and two irrigation regimens as sub plots and three sources of nitrogen fertilizer as sub sub plots with three replications.

The soil on which the experiments were undertaken was a clay loam. Table 1 shows soil / water parameter and bulk density of the soil; Table 2 shows main properties of the soil. Meteorological data for the Agricultural Research Station are shown in Table 3.

Table (1): Field capacity wilting point, available water and bulk density of soilat various depths.

Depths	Field capacity (F.C.) %	Wilting point (WP) %	Available water (AW) %	Bulk density (BD) g/cm^3
0-15	37.9	18.1	19.8	1.27
15-30	36.1	17.6	18.5	1.30
30-45	33.5	16.9	16.6	1.31
45-60	32.5	16.2	16.3	1.34

FC: moisture at 33 kPa moisture tension. WP: moisture at 1.5 MPa moisture tension. AW = FC – WP

Table (2): Physical and chemical properties of the soil.

Parameter	Value	Parameter	Value
Particle size distribution (%):		EC (dS/m, soil paste extract)	1.1
Clay %	31.4	Saturation percent	67.5
Silt %	33.5	Cations and anions in soil paste extract (mmolc/L):	
Fine sand %	34	Na^+	4.1
Coarse sand %	1.1	K^+	0.41
Texture class	Clay loam	Ca^{++}	3.07
$CaCO_3$ g / kg	35.9	Mg++	2.63
Organic matter g / kg	17	CO_3^{-}	0
* Available K mg / kg	191.9	HCO_3^-	3.85
* Available P mg / kg	9.33	Cl^-	3.7
pH (1: 2.5 w/v soil water suspension)	7.9	$SO_4^=$	2.66

*** Extracts of NH_4 – acetate (for K), and sodium bicarbonate (for P).**

The study concerned the use of different irrigation levels and nitrogen fertilizer sources on Lettuce (*Lactuca sativa*) crop.

Irrigation treatments :

The investigation was designed to test two irrigation treatments as follows:

1- Irrigation when 25 % of available soil moisture is depleted (I_1).

2- Irrigation when 50 % of available soil moisture is depleted (I_2).

irrigation systems: 1- Surface irrigation. 2- Drip irrigation.

Nitrogen treatments :

The sources of nitrogen fertilizer were urea (46 % N), ammonium nitrate, (33.5 % N) and ammonium sulphate (20.6 % N) at the rate of 50 kg/fed. Nitrogen fertilizers were added as two equal batches, after transplanting by two weeks and after three weeks later.

The plot area was 20 m^2 planted in ridges, 70cm part, and 15cm between plants. All plots received P 13 kg/fed. ordinary superphosphate

(15.5% P_2O_5). In addition, plots received K as potassium sulphate (48% K_2O) 50 kg/fed. Both P and K were applied in one dose during preparation of soil before lettuce transplanting .

Table (3): Meteorological data in 2013/214 and 2014/215 seasons.

Month	2013/2014						
	T.max.	**T.min.**	**WS**	**RH**	**SS**	**SR**	**R. F**
October	30.0	18.4	1.0	65	11.3	417	0.0
November	27.2	14.6	0.8	67	10.5	326	0.0
December	23.0	11.5	0.7	63	10.1	268	0.0
January	20.9	8.5	3.0	56.1	6.6	280	0.3
	2014/2015						
October	30.7	17.1	3.3	47.2	7.3	417	0.0
November	22.2	10.2	2.58	62.0	8.4	432	0.0
December	27.2	14.2	2.58	60.0	9.5	514	0.0
January	32.8	18.1	2.63	56.0	10.5	572	0.0

T. max, T. min = maximum and minimum temperatures °C.
WS = wind speed (m / sec).
RH = relative humidity (%).
SS = actual sunshine duration (h/day)
SR = solar radiation (cal / cm² / day).
RF = rainfall (mm / month).

Drip irrigation system

The drip irrigation system used in the farm included an irrigation pump (2 hp) connected to sand and screen filters and a fertilizer injector tank. The conveying pipeline system consists of a main line that is made of PVC pipe of 76.2mm diameter connected to sub-main line of 50.8mm and manifold of 38.1mm. The drip lateral lines of 16mm diameter were connected to the manifold line. Each line is served by two lateral lines about 20cm apart . Lateral lines were equipped with build-in emitters of 4 l/h discharge and spaced 0.50 m apart on the lateral line.

Amount of applied irrigation water (AIW):

1-Drip irrigation system:

The amount of applied water was measured by a flow meter and was calculated according to (FAO, 1984) as the following equation**:**

$$AIW = \frac{Sp\ X\ S_l\ X\ ETc\ X\ Kr\ X\ I\ \mathrm{int}\,erval}{Ea}$$

Where:

AIW= applied irrigation water depth.
Sp= distance between plants in the same line (m).
S_l= distance between lines (m).
ET_c = water consumptive use.
K_r= reduction factor that depends on ground cover. It equals 0.7 for (FAO, 1979).
E_a= irrigation efficiency = K_1 x K_2 = 0.80

where:

K_1 = emitter uniformity coefficient = 0.90 for the experimental site.

K_2 = drip irrigation system efficiency = 0.89 for the experimental site.
$I_{interval}$ = irrigation intervals (days) = 1 day for the experimental site.

2-Surface irrigation system:

Depth of applied irrigation water was calculated according to the following equation:

$$AIW = \frac{ETc}{Ea}$$

Where:

ET_c: water consumptive use (mm/d)
E_a: application efficiency (fraction) = 0.6 for surface irrigation system.

Irrigation water applied (IWA):

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

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

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, $cm/sec.^2$ (981 cm/sec^2).
h= pressure head, causing discharge through the orifice, cm.

Water use efficiency (W.U.E):

Applied irrigation water is used to describe the relationship between production and the amount of water applied. It was determined according to(Jensen 1983). The following equation was used as follow:

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

Soil analysis:

Particle size distribution was conducted using the pipette method according to Klute (1986). Soil moisture constants were determined using the pressure membrane apparatus (Stackman 1966). Soil pH, electric conductivity (EC) and cationic and anionic compositions of the saturation extract of the soil were determined according to the standard methods described by Page *et al.* (1982).

Plant analysis:

Total nitrogen was determined by the micro-kjeldahl method according to Cottenie *et al*., (1982). Total phosphorus was determined in concentrated acid digest and measured using a spectrophotometer (Spectronic 20) to the method described by Murphy and Reily (1962). Total potassium content was determined in the acid digest using Atomic Absorption Spectrophotometer method for plant analysis according to method described by Jackson and Ulrish (1959) and Chapman and Pratt (1961). Total chlorophyll in fresh were determined using the methods described by Wettstein (1957).

Statistical analysis:

Data were statistically analyzed according to the analysis of variance as described by Waller and Duncan (1969).

RESULTS AND DISCUSSION

I. Soil water relations:

Applied irrigation water:

Results in (Table, 4) showed that seasonal applied irrigation water to lettuce plants were less under drip irrigation as compared with surface irrigation in both seasons. Under conditions of surface irrigation, the highest seasonal applied irrigation water was that of I_2 and the lowest was that of I_1. 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. Inanition, the high amount of water applied under surface system reflects the low system efficiency as compared with the drip system. 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 4.Monthly and seasonal applied irrigation water to lettuce by the two irrigation system in 2013/14 and 2014/15 growing seasons.

Months	Drip irrigation (m^3/fed)				Surface irrigation (m^3/fed)			
	2013/14		2014/15		2013/14		2014/15	
	I_1	I_2	I_1	I_2	I_1	I_2	I_1	I_2
November	130.7	160.5	132.2	168.1	224.6	246.3	229.8	263.5
December	339.0	433.3	329.0	440.0	389.3	555.5	399.4	584.2
January	381.3	453.4	393.0	478.2	467.8	710.2	488.1	767.5
Total	851	1047.2	854.2	1086.3	1081.7	1512.0	1117.3	1615.2

I_1 Irrigation when 50 % of available soil moisture is depleted.
I_2 Irrigation when 25 % of available soil moisture is depleted.

Monthly applied irrigation water

Results in Table (4) and Fig. (1) show that monthly applied water values began to raise during February then gradually increased to reach its maximum during January. Under drip system, maximum applied irrigation water values were affected by irrigation regimes. While under surface irrigation system, maximum applied irrigation water values were occurred also in June in the same seasons, respectively. In January the plants were fully developed thus the soil was subjected to greater loss of water 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 a maximum in January mainly due to increased demand for water by plants .

The monthly water consumption took a rather similar trend. This result reveals that the monthly water consumptive use starts small because plant seedlings need less water at their initial growth stage. Therefore, soil moisture losses are mainly by evaporation form soil surface at that time. With the advance in plant age, transpiration increased and consequently monthly consumptive use increased as plant foliage developed. Soil moisture depletion in the advanced growth phase is due to evapotranspiration (ET); and daily water consumptive use reaches its peak at the end of the growing season as the crop reaches the harvest stage.

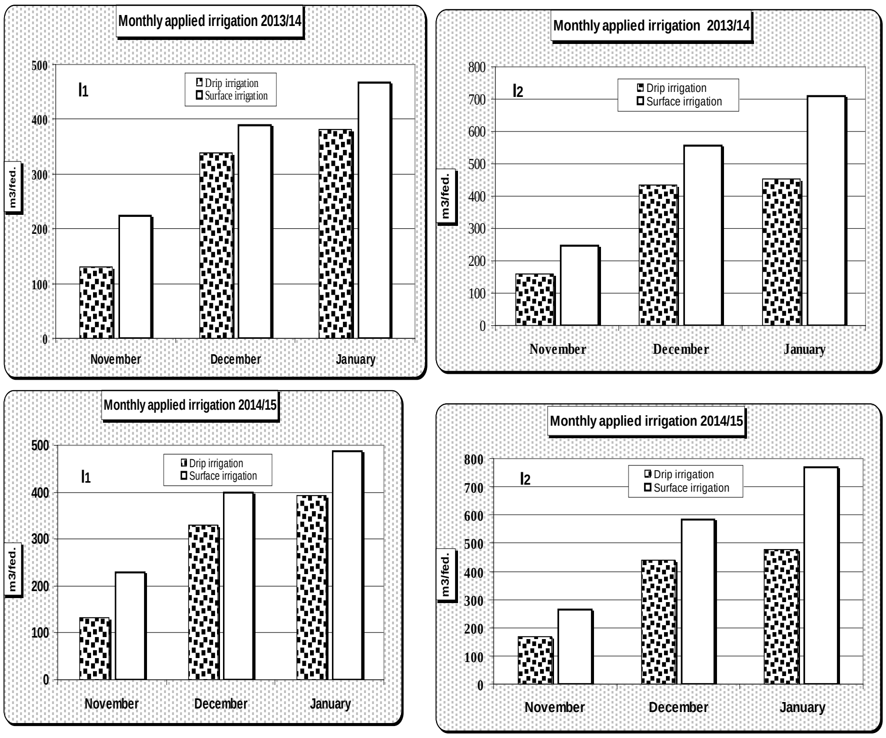

Fig.(1).Monthly applied irrigation water under surface and drip irrigation systems in 2013/14 and 2014/15 seasons.

I_1 Irrigation when 50 % of available soil moisture is depleted.

I_2 Irrigation when 25 % of available soil moisture is depleted

Water use efficiency (W.U.E):

Water use efficiency represented the amount of yield produced for every cubic meter of water used by the crop**.** Results in current study indicated that, there was significant effect of the irrigation systems on W.U.E value (Fig. 2.). The obtained values were significantly different under drip irrigation system than under surface system in 2013/14 and 2014/15 seasons,. The values of Water use efficiency for lettuce as affected by available soil moisture depletion The dry irrigation I_1 gave the highest water use efficiency. While under medium irrigation i.e., I_2 were lower. Fertilized treatments gave greater water use efficiency, than the unfertilized ones and ammonium sulphate gave the highest efficiency both seasons. There was an interaction between fertilizer treatments and moisture regimes : the ammonium sulphate and ammonium nitrate were similar under the dry regime season 2013/14 under surface irrigation.

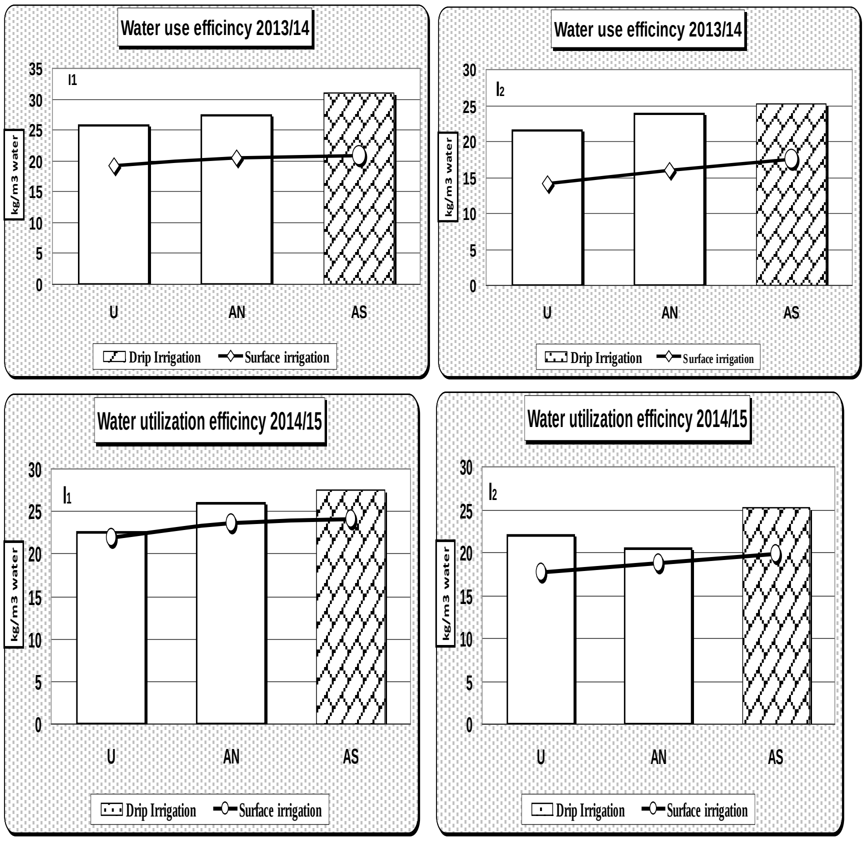

Fig. (2).Effect of irrigation systems, available soil moisture depletion and nitrogen fertilization on Water utilization efficiency (kg /m^3 water) during 2013/14 and 2014/15. seasons

I_1 Irrigation when 50 % of available soil moisture is depleted.
I_2 Irrigation when 25 % of available soil moisture is depleted.
U urea (46 % N) . - AN ammonium nitrate, (33.5 % N) .
AS ammonium sulphate (20.6 % N) .

2. Growth parameters:

Plant height

The main effects of irrigation system show that drip irrigation gave the higher value of plant height than surface irrigation. Excess water seemed to have encouraged plant growth in terms of height . The main effect of fertilizers show that the highest plant height was given by ammonium sulphate and the lowest was by urea. While with ammonium nitrate gave intermediate values. Shafshak and Abo Sedera (1990) and Eissa and Header

(1991) reported that height of lettuce was greater with ammonium sulphate than ammonium nitrate and some other sources.

Table (5): Effect of irrigation systems, available soil moisture depletion and nitrogen fertilization on plant height (cm) during 2013/14 and 2014/15 .

Irrigation treatment		Nitrogen fertilization							
		Season 2013/2014				Season 2014/2015			
Irrigation systems		U	AN	AS	Mean A x B	U	AN	AS	Mean A x B
Drip Irrigation	I_1	36.0f	42.0ce	45.0b	41.0B	38.0ef	42.7c	44.3bc	41.7B
	I_2	41.7de	44.3bc	47.3a	44.4A	39.7de	43.3bc	49.7a	44.2A
Mean (A X C)		38.8D	43.2B	46.2A	42.7A	38.8D	43.0C	47.0A	42.9A
Surface irrigation	I_1	36.0f	41.7de	44.0b-d	40.6B	37.0f	41.7cd	43.7bc	40.8B
	I_2	36.3f	41.0e	44.3bc	40.6B	36.3f	43.0c	46.0b	41.8B
Mean (A X C)		36.2E	41.3C	44.2B	42.5A	36.7E	42.3C	44.8B	
Grand mean (C)		37.5C	42.3B	45.2A		37.8C	42.7B	45.9A	
Means of irrigation treatments									
Mean (B x C)	I_1	36.0D	41.8B	44.5A	40.8B	37.5C	42.2B	44.0B	41.2B
	I_2	39.0C	42.7B	45.8A	42.5A	38.0C	43.2B	47.8A	43.0A

Notes : I_1 : Irrigation when 50 % of available soil moisture is depleted.
I_2 : Irrigation when 25 % of available soil moisture is depleted.
U : urea (46 % N) .
AN : ammonium nitrate (33.5 % N) .
AS : ammonium sulphate (20.6 % N)

Number of leaves / plant

The main effects of irrigation system show that drip irrigation gave the highest value of number of leaves/plant followed by surface irrigation (Table 6). Under drip irrigation shows that I_2 medium soil moisture regime gave the highest number of leaves of plant followed by I_1 dry while under surface irrigation system, in both seasons the two regimes of I_1 and I_2 were similar, without significant difference between them . The main effect of fertilizer treatments shows that the highest number of leaves among fertilized treatments was given by ammonium sulphate followed by ammonium nitrate and the least was given by urea. There were interactions caused by irrigation system on fertilizer treatments. ammonium sulphate, ammonium nitrate and urea were similar in the some cases I_2 the medium regime under surface irrigation system .

Table (6): Effect of irrigation systems, available soil moisture depletion and nitrogen fertilization on number of leaves/ plant during 2013/14 and 2014/15 .

Irrigation treatment		Nitrogen fertilization							
		Season 2013/2014				Season 2014/2015			
Irrigation systems		U	AN	AS	Mean A x B	U	AN	AS	Mean A x B
Drip	I_1	30.3g	32.7de	34.0d	32.3B	30.3g	32.3ef	34.0d	32.2B
Irrigation	I_2	41.0c	44.7b	49.0a	44.9A	41.0c	42.3b	44.7a	42.7A
Mean (A X C)		35.7C	38.7B	41.5A	38.6A	35.7C	37.3B	39.3A	37.4A
Surface	I_1	31.0fg	32.3ef	33.0de	32.1B	32.3ef	33.0de	33.3de	32.9B
irrigation	I_2	32.0ef	32.3ef	32.3ef	32.2B	31.3fg	33.0de	34.0d	32.8B
Mean (A X C)		31.5E	32.2DE	32.7D	32.2B	31.8E	33.0D	33.7D	32.8B
Grand mean (C)		33.6C	35.5B	37.1A		33.7C	35.2B	36.5A	
Means of irrigation treatments									
Mean	I_1	30.7F	32.5E	33.5D	32.2B	31.3F	32.7E	33.7D	32.6B
(B x C)	I_2	36.5C	38.5B	40.7A	38.6A	36.2C	37.7B	39.3A	37.7A

Notes : **I_1 : Irrigation when 50 % of available soil moisture is depleted.**
I_2 : Irrigation when 25 % of available soil moisture is depleted.
U : urea (46 % N) .
AN : ammonium nitrate (33.5 % N) .
AS : ammonium sulphate (20.6 % N) .

Fresh weight /plant

The main effect of irrigation system indicates a superiority of drip irrigation over surface irrigation in the first season, while surface irrigation showed superiority over drip irrigation in the second season (Table 7). Under drip irrigation soil moisture regimes results show that the greatest fresh weight of plant was given by I_2 and the lowest was that of the I_1. There was an interactive effect in season 1 for the two regimes of I_1 and I_2 were similar in their effect under conditions of ammonium sulphate fertilizer application.

The main effects of fertilizers show that the highest weight among fertilized treatments was that of AS , and the lowest was that of U. The results of the current study agree with those reported by Meleha (1992) who compared in a pot experiment ammonium sulphate with urea on barley under three water regimes (of 100 % , 75 % and 50 % of field capacity) and found superiority of ammonium sulphate regarding plant growth only under the wet regime (of 100 % field capacity) with no significant defferences between the two sources under other regimes. Shafshak and Abo Sedera (1990) reported also superiority of ammonium sulphate over ammonium nitrate for lettuce.

Table (7): Effect of irrigation systems, available soil moisture depletion and nitrogen fertilization on plant fresh weight (g /plant) during 2013/14 and 2014/15 .

Irrigation treatment		Nitrogen fertilization							
		Season 2013/2014				Season 2014/2015			
Irrigation systems		U	AN	AS	Mean	U	AN	AS	Mean
Drip Irrigation	I_1	498.7gh	556.7d	626.7a	560.7C	458.0j	529.3i	559.3h	515.6C
	I_2	536.0ef	593.3b	629.3a	586.2A	570.0gh	616.7f	652.7d	613.1B
Mean (A X C)		517.3E	575.0C	628.0A	573.4A	514.0F	573.0E	606.0D	564.3B
Surface irrigation	I_1	495.0h	526.7f	539.3e	520.3D	582.0g	630.0ef	640.7de	617.6B
	I_2	510.0g	576.7c	630.0a	572.2B	680.0c	722.0b	762.0a	721.3A
Mean (A X C)		502.5F	551.7D	584.7B	546.3B	631.0C	676.0B	701.3A	669.4A
Grand mean (C)		509.9C	563.3B	606.3A		572.5C	624.5B	653.7A	
Means of irrigation treatments									
Mean (B x C)	I_1	496.8E	541.7C	583.0B	540.5B	520.0F	579.7E	600.0D	566.6B
	I_2	523.0D	585.0B	629.7A	579.2A	625.0C	669.3B	707.3A	667.2A

Notes : **I_1 : Irrigation when 50 % of available soil moisture is depleted.**
I_2 : Irrigation when 25 % of available soil moisture is depleted.
U : urea (46 % N) .
AN : ammonium nitrate (33.5 % N).
AS : ammonium sulphate (20.6 % N) .

Yield per feddan

Yield per feddan in the current study was presented in. Table (8) The main effect of irrigation system indicated a superiority of drip irrigation over surface irrigation in the first season, while surface irrigation superiority over drip irrigation in the second season. Under drip irrigation soil moisture regimes the greatest yield was given by I_2 and the lowest was that of the I_1. However, there were interactive effect particularly in season 1 : superiority of the I_2 medium moisture regime over the I_1 dry regime, under N sources but under ammonium sulphate fertilization were alike. While in the second season, I_1 and I_2 were similar in their effect under conditions of ammonium nitrate .

The main effect of fertilizer treatments showed that the highest yield among the fertilized treatments was given by ammonium sulphate followed by ammonium nitrate; and the least was given by urea . However, there were interactions, under drip irrigation , ammonium nitrate resembled urea. While, ammonium sulphate and ammonium nitrate were similar in effect under conditions of surface irrigation in the second season. Shafshak and Abo-Sedera (1990) reported superiority of ammonium sulphate over ammonium nitrate in growing the leafy vegetable plant of spinach . Khalil *et al* (1985) on spinach , found that the maximum growth rate and total yield were obtained by short-interval irrigations (irrigation upon depletion of 25 % of available soil moisture).

Table (8): Effect of irrigation systems, available soil moisture depletion and nitrogen fertilization on yield of fresh matter (ton/fed.) during 2013/14 and 2014/15

Irrigation treatment		Nitrogen fertilization							
		Season 2013/2014				Season 2014/2015			
Irrigation systems		U	AN	AS	Mean	U	AN	AS	Mean
Drip Irrigation	I_1	20.94f	23.38cd	26.32a	23.55B	19.24g	22.23f	23.49ef	21.65D
	I_2	22.51de	24.92b	26.43a	24.62A	23.94e	22.23f	27.41cd	24.53C
Mean (A X C)		21.73D	24.15B	26.38A	24.08A	21.59C	22.23C	25.45B	23.09B
Surface irrigation	I_1	20.79f	22.12df	22.65de	21.85C	24.44e	26.46d	26.91d	25.94B
	I_2	21.42ef	24.15bc	26.46a	24.01AB	28.56c	30.32b	32.00a	30.30A
Mean (A X C)		21.10D	23.14C	24.56B	22.93B	26.50B	28.39A	29.46A	28.12A
Grand mean (C)		21.42C	23.64B	25.47A		24.05C	25.31B	27.45A	
Means of irrigation treatments									
Mean (B x C)	I_1	20.87D	22.75C	24.49B	22.70B	21.84D	24.35C	25.20C	23.80B
	I_2	21.97C	24.54B	26.45A	24.32A	26.25B	26.28B	29.71A	28.12A

Notes : I_1 : Irrigation when 50 % of available soil moisture is depleted.
I_2 : Irrigation when 25 % of available soil moisture is depleted.
U : urea (46 % N) .
AN : ammonium nitrate (33.5 % N) .
AS : ammonium sulphate (20.6 % N) .

3. Chemical composition:

Nitrogen uptake

The main effect of irrigation system and moisture regime treatment shows that the drip irrigation system gave the highest N-uptake followed by surface irrigation (Table 9**).** Under drip irrigation soil moisture regimes, the greatest N-uptake was given by I_2 and the lowest was that of the I_1. However, there were interactions particularly in season 1 : superiority of the I_1 dry moisture regime over the I_2 medium regime was particularly apparent, under ammonium sulphate fertilization. Increased soil moisture may have probably enhanced ammonification of soil organic N as reported by (Bremner 1965).

The main effect of fertilizer treatments shows that the highest uptake of N among the fertilized treatments was given by ammonium sulphate followed by ammonium nitrate and the least was that given by urea. There were interactions caused by irrigation system on fertilizer treatments superiority of the, ammonium nitrate over the ammonium sulphate under drip irrigation system I_2 in the second season . Dry conditions decreased uptake of N in soil since it decreased plant growth. 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 uptake of N in soil since it decreased plant growth Eissa and Header (1991**)** reported little differences in **N** uptake under low moisture contents . 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 and that ammonium sulphate gave greater **|** N uptake than urea.

Table (9): Effect of irrigation systems, available soil moisture depletion and nitrogen fertilization on uptake (N mg/plant) during 2013/14 and 2014/15 .

Irrigation treatment		Nitrogen fertilization							
		Season 2013/2014				Season 2014/2015			
Irrigation systems		U	AN	AS	Mean	U	AN	AS	Mean
Drip	I_1	1588g	1639f	1911d	1713C	1737f	1861d	2120b	1906B
Irrigation	I_2	1672f	1932d	2240a	1948A	1852d	2263a	2138b	2084A
Mean (A X C)		1630D	1786C	2076B	1830A	1795D	2062B	2129A	1995A
Surface	I_1	1438i	1584g	2164b	1729C	1242j	1521h	1810e	1524D
irrigation	I_2	1474h	1717e	2054c	1748B	1368i	1583g	2009c	1653C
Mean (A X C)		1456E	1650D	2019A	1739B	1305F	1552E	1910C	1589B
Grand mean (C)		1543C	1718B	2092A		1550C	1807B	2019.0A	
Means of irrigation treatments									
Mean	I_1	1513F	1611D	2037B	1721B	1490F	1691D	1965B	1715B
(B x C)	I_2	1573E	1825C	2147A	1848A	1610E	1923C	2073A	1869A

Notes : **I_1 : Irrigation when 50 % of available soil moisture is depleted.**
I_2 : Irrigation when 25 % of available soil moisture is depleted.
U : urea (46 % N) .
AN : ammonium nitrate (33.5 % N) .
AS : ammonium sulphate (20.6 % N) .

Phosphorus uptake.

The effects of irrigation treatments and fertilizer N sources on phosphorus uptake are shown in Table 10. Main effect of irrigation system and soil moisture shows significant difference between irrigation treatments a superiority of drip irrigation over surface irrigation . Under drip irrigation soil moisture regimes P uptake given by I_2 was higher than that of the I_1. However, there were interactions superiority of the I_2 medium moisture regime over the I_1 dry regime but under ammonium sulphate, in second season found I_1 and I_2 were similar under drip irrigation system . While in the first season, I_1 and I_2 were similar in their effect under conditions of ammonium sulpht and urea under surface irrigation system .

The main effect of fertilizer treatments shows that ammonium sulphate gave the highest P uptake followed by ammonium nitrate ,then urea. However, such a pattern of main effect did not occur under any of the two moisture regimes exhibiting a clear case of moisture /fertilizer interaction .Under the medium regime I_2 , ammonium nitrate surpassed ammonium sulphate under drip irrigation system in second season .

Table (10): Effect of irrigation systems, available soil moisture depletion and nitrogen fertilization on uptake P mg/plant during 2013/14 and 2014/15 .

Irrigation treatment		Nitrogen fertilization							
		Season 2013/2014				Season 2014/2015			
Irrigation systems		U	AN	AS	Mean	U	AN	AS	Mean
Drip Irrigation	I_1	185.7fg	204.6ef	244.5cd	211.6C	201.9fg	230.9de	273.1bc	**235.3B**
	I_2	212.3e	258.2bc	292.9a	254.5A	234.4d	303.9a	279.8b	**272.7A**
Mean (A X C)		199.0D	231.4B	268.7A	233.1A	218.1C	267.4A	276.5A	**254.0A**
Surface irrigation	I_1	169.1g	199.7ef	278.0ab	215.6C	145.3i	190.8g	233.4d	**189.8D**
	I_2	184.5fg	231.9d	268.7b	228.4B	173.3h	214.1ef	259.3c	**215.5C**
Mean (A X C)		176.8E	215.8C	273.4A	222.0B	159.3E	202.4D	246.4B	**202.7B**
Grand mean (C)		187.9C	223.6B	271.1A		188.7C	234.9B	261.4A	
Means of irrigation treatments									
Mean (B x C)	I_1	177.4E	202.1D	261.3B	213.6B	173.6D	210.9C	253.3B	212.6B
	I_2	198.4D	245.1C	280.8A	241.4A	203.8C	259.0AB	269.5A	244.1A

Notes : I_1 : Irrigation when 50 % of available soil moisture is depleted.
I_2 : Irrigation when 25 % of available soil moisture is depleted.
U : urea (46 % N) .
AN : ammonium nitrate (33.5 % N).
AS : ammonium sulphate (20.6 % N) .

Potassium uptake

In (Table 11) results indicated that, there was significant effect for the irrigation systems on K uptake values. Under drip irrigation soil moisture regimes, the greatest K uptake was given by I_2 and the lowest was that of the I_1. There was an interaction under conditions of ammonium sulphate and urea, I_1 and I_2 were similar in season1 under surface irrigation system.

The main effect of fertilizer treatments show that the highest K uptake among fertilized treatments was given by ammonium sulphat followed by ammonium nitrate then urea. There was significant interaction with urea and ammonium nitrate of similar in I_2 under drip irrigation system in second season. Increased irrigation by the I_2 in comparison with $I_{1,}$ caused increased in yield of lettuce. The extent in yield increase seemed considerable to a level which led to increased uptake of N, P and K. This occurred despite the decreased contents of some macronutrients. Increased soil moisture seemed to have facilitated availability of K since with increased irrigation there was an increase in K-uptake. Podstawka and Malicki (1997) found that irrigation increased P accumulation, although this reduced N accumulation. Das and Banerjee (1996) reported that fertilizing with equivalents of 83 kg K in combination with 160 kg N + 44 kg P/f caused highest uptake of N, P and K nutrients.

Table (11): Effect of irrigation systems, available soil moisture depletion and nitrogen fertilization on uptake K mg/plant during 2013/14 and 2014/15 .

Irrigation treatment		Nitrogen fertilization							
		Season 2013/2014				Season 2014/2015			
Irrigation systems		U	AN	AS	Mean	U	AN	AS	Mean
Drip	I_1	2182e	2084f	2573c	2280D	2366e	2350e	2872b	2529B
Irrigation	I_2	2297d	2581c	3151a	2677A	2529c	3042a	3012a	2861A
Mean (A X C)		2240D	2333C	2862B	2478A	2447D	2696B	2942A	2695A
Surface	I_1	1997gh	2036.g	2928b	2320C	1713i	1946g	2458d	2039D
irrigation	I_2	1982h	2323d	2909b	2405B	1875h	2142f	2837b	2284C
Mean (A X C)		1990F	2179E	2919A	2363B	1794F	2044E	2647C	2162B
Grand mean (C)		2115C	2256B	2891A		2120C	2370B	2794A	
Means of irrigation treatments									
Mean	I_1	2090E	2060F	2751B	2300B	2039F	2148E	2665B	2284B
(B x C)	I_2	2140D	2452C	3030A	2541A	2202D	2592C	2924A	2572A

Notes : **I_1 : Irrigation when 50 % of available soil moisture is depleted.**
I_2 : Irrigation when 25 % of available soil moisture is depleted.
U : urea (46 % N) .
AN : ammonium nitrate (33.5 % N) .
AS : ammonium sulphate (20.6 % N) .

Total Chlorophyll contents:

Chlorophyll analyses of the fresh leaves are shown in Table 12. The main effects of irrigation system show that drip irrigation gave the higher value than surface irrigation. Under drip irrigation data show that decreasing the soil moisture (by prolonging irrigation intervals) resulted in increase the concentration of total chlorophyll. While under surface the greatest concentration of total chlorophyll was given by I_2 and the lowest was that of the I_1. There was interaction with fertilizer treatment: where ammonium nitrate or urea was used, the I_1 dry and I_2 medium regimes were similar under drip irrigation in the second season.

However, there was an interaction with moisture regime plants supplied with U or AN were rather similar and U or AS in season 1 and 2, respectively under I_2 medium regimes under drip irrigation system . Shafshak (1987) reported that AS gave more chlorophyll contents over urea in spinach. N fertilization was reported to have increased concentration of chlorophyll in fresh leaves of spinach .

Table (12): Effect of irrigation systems, available soil moisture depletion and nitrogen fertilization on total chlorophyll mg/L during 2013/14 and 2014/15 .

Irrigation treatment		Nitrogen fertilization							
		Season 2013/2014				Season 2014/2015			
Irrigation systems		U	AN	AS	Mean	U	AN	AS	Mean
Drip Irrigation	I_1	278.3a	250.5bc	216.7de	248.5A	195.9ab	206.3a	186.7b	196.3A
	I_2	251.3bc	258.8b	201.1e	237.1B	198.1ab	156.6cd	198.5ab	184.4B
Mean (A X C)		264.8A	254.6A	208.9C	242.8A	197.0A	181.5BC	192.6AB	190.4A
Surface irrigation	I_1	150.5f	219.8d	250.9bc	207.1C	108.0e	141.3d	185.1b	144.8D
	I_2	204.9de	236.8c	259.5b	233.7B	146.7d	189.6ab	165.8c	167.3C
Mean (A X C)		177.7D	228.3B	255.2A	220.4B	127.3E	165.4D	175.4CD	156.1B
Grand mean (C)		221.2C	241.5A	232.1B		162.2C	173.5B	184.0A	
Means of irrigation treatments									
Mean (B x C)	I_1	214.4C	235.2B	233.8B	227.8A	151.9C	173.8B	185.9A	170.6A
	I_2	228.1B	248.8A	230.3B	235.4A	172.4B	173.1B	182.1AB	175.9A

Notes : **I_1 : Irrigation when 50 % of available soil moisture is depleted.**
I_2 : Irrigation when 25 % of available soil moisture is depleted.
U : urea (46 % N) ,
AN : ammonium nitrate, (33.5 % N)
AS : ammonium sulphate (20.6 % N) .

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تأثير مستويات مختلفة من الرطوبة الأرضية ومصادرالتسميد النيتروجيني على محصول الخس تحت نظامي الري الغمر و التنقيط في الأراضي الطينية الطميية

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مركز البحوث الزراعية – الجيزة – مصر

أجريت تجربة حقلية في محطة بحوث البساتين القناطر الخيرية خلال موسمي ٢٠١٤/٢٠١٣ و ٢٠١٥/٢٠١٤ لدراسة تأثير مستويين من رطوبة التربة (% ٢٥ و % ٥٠ استنزاف من الماء الميسر) و ثلاث مصادر من الأسمدة النتروجينية هي اليوريا (٤٦.٥٪ N)، و نترات الأمونيوم (٣٣.٥٪ N) وكبريتات الأمونيوم (٢٠.٥ ٪ N) بمعدل ٥٠ كجم نتروجين /فدان تحت نظام الري بالتنقيط ونظام الري السطحي و التفاعل بينهما وعلي كمية المياه المضافة و كفاءة استخدام المياه والنمو والمحصول والجودة والتركيب الكيماوي لنباتات الخس .

أوضحت أهم النتائج المتحصل عليها زيادة كمية مياه الري المضافة تحت نظام الري السطحي تحت ٢٥٪ ثم ٥٠٪ استنزاف من الماء الميسر ثم اتبع بالري بالتنقيط خلال موسمي ٢٠١٤/٢٠١٣ و٢٠١٥/٢٠١٤ . أعطي نظام الري بالتنقيط زيادة في كفاءة استخدام المياه (22.57 and 23.84) كجم/م٣ مياه في الموسم الأول والثاني علي التوالي . و بالنسبة لمصادر الأزوت فقد أعطت كبريتات الأمونيوم زيادة في كفاءة استخدام المياه (24.16 and 23.65) كجم/م٣ مياه في الموسمين علي التوالي.

تجمل الدراسة أن نظام الري بالتنقيط تفوق علي نظام الري السطحي وأن رطوبة التربة المتوسطة (استنفاد ٢٥٪ من الماء الميسر) و التسميد بكبريتات الأمونيوم تحت نظام الري بالتنقيط ونظام الري السطحي هام لزيادة صفات النمو الخضري والمحصول و امتصاص العناصر في الخس .