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Effect of Irrigation Scheduling and Intercropping Pattern on Growth, Yield, Quality of Green Onion, Lettuce and some Water Relations in North Nile Delta Region

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ABSTRACT

Two field trials were performed at Sakha Agricultural Research Station Farm, Kafr El- Sheikh Governorate, during the two winter seasons 2017/18 and 2018/19 to study the influence of irrigation scheduling; traditional watering (I1), irrigation at 1.2(I2), 1.0(I3) and 0.8(I4) of accumulative pan evaporation(APE) and four systems of sole and intercropping pattern; sole green onion *cv*. Giza 6(P1), sole lettuce *cv*. Balady(P2), 2green onion : 1 lettuce(P3) and 1 green onion : 2 lettuce(P4) in a split plot design with four replications. Data indicated that the highest values for seasonal applied water (AW) and water consumptive use (CU) were registered under irrigation treatment(I2). For water consumptive use efficiency (Ecu%), the highest values were recorded under treatment (I1). productivity of irrigation water (PIW) and water productivity (WP) were clearly impacted by irrigation treatments, intercropping patterns in addition crop type where the highest values also recorded I2 besides P4. The results also revealed that yield, yield component and quality parameters for green onion; plant height, fresh weight of leaves, plant weight, leaf area/ plant, chlorophyll content and total yield as well as lettuce; plant height, leaf area/ plant, chlorophyll content, plant weight, head weight, diameter and total yield increased with increasing irrigation applied water. On contrary, for crop pattern the highest values for yield component recorded under sole crop but the total yield recorded under 1:2green onion- lettuce planting pattern. For gross return and increasing income was attained I2 besides P4. Land equivalent ratio (LER) exhibited higher values with I1 besides P4.

Keywords: Irrigation treatments, planting crop pattern, green-onion crop, lettuce crop and water productivity

INTRODUCTION

Water considered a major part of farming and a vital component of different types of crops that consumed by human being. Where their food grains are vital to feed animals that very important for humans in each corner of the world. For centuries, humans have been interested with efficient use of water in production of crops so, the ability to grow crops and achieve their requires for water is essential for the modernization. In addition to without a good management, irrigated agriculture which is a main part of farming can be detrimental to the environment and endanger sustainability. Also, watering always played the greatest role in crop production that determines the growth, availability of plant nutrients and ultimately crop yields. So, farmers need to be learned for its production technology including judicious water management.

According to FAO Statistical yearbook (2018) for Egypt between 1995 and 2016 total population increased from 63.7 to 97.3 million and total renewable water resources deceased from 900 to 607 m^3/ per cap. One of the focal crises related with the Egyptian agriculture system is the low of cultivated area per farmers. In average 42.9% of the farmers own or work in field one faddan (0.42 Hectar) or less (Ahmed *et al.*,2009). In addition, irrigated agriculture is the main type of farming, the per capita from water for different needs is decreasing gradually to less than the water poverty edge (1000 m^3 per annum), farming uses about 85% of the total renewable water supply. In addition to, tremendous efforts should be implemented in this sector to rationalize water at the national level. So, optimal use of land and water is imperative to increase farmer's income, the need to follow process such as intercropping pattern is urgent. Intercropping is an agriculture system that utilize various crops to attain better final income with growing two or more crops in the same time.

Using of available water resources, for sustainable agriculture and to remove the negative effect of high or low irrigation, the main target of watering is to apply the water only when to irrigate and how match water apply to plant needs it with minimal water loss. Deficit irrigation supply means of decreasing water consumption and minimizing adverse effects on yield (Zhang *et al*., 2004).

Lettuce (Lactuca sativa L.) is one of the most important salad vegetables of the world due to its nutritional value, production potential and possibility to return profit. (Acharya *et al 2013)*. Lettuce for fresh consumption is an important field vegetable crop in Egypt.

It belongs to family Asteraceae and believed to have originated in Mediterranean region. Lettuce is rich in vitamins A and C and minerals like calcium, expectorant

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(Kalloo and Parthasarthy, 2003). Lettuce is primary cultivated salad crop which is commercialized internationally (Abu-Rayyan *et al*., 2004). It is the most important salad vegetable according to the highest consumption rate and economic importance throughout the world (Coelho *et al*., 2005).

Lettuce growth as well as yield and its components has been reported to increase in response to water application (Sanchez, 2000). On the contrary, increasing application of irrigation water results in some serious problems like soft rot (Turkmen *et al*., 2004).

Green-onion (Allium cepa L.) is one of the greatest important vegetable crops grown and used through the world and is grown under a wide range of climates. Soil water tension significantly affects both the total yield and the yield components. In this respect, Onion is a beneficial crop, and ranks second after tomato in the list of worldwide cultivated vegetables (FAO, database, 2012).

Water productivity (WP) exhibit a quantifiable benchmark to assess crop production in relation to available water resources (Bouman *et al*., 2005). WP can be defined in several ways depending on the temporal and spatial scales of concern and study objectives. Gebremedhin Gebremeskel Haile *et al., (2019)* showed that basin irrigation method and its corresponding factors from the irrigation interval treatments obtained higher performances with a total yield and an irrigation water productivity of 4.32 kg/m^3.

Lettuce growth and consequently yield has been reported to increase in response to water application (Sanchez, 2000). Conversely, excessive application of irrigation water results in some critical problems like soft rot (Turkmen *et al*., 2004). To make optimal use of available water resources, for sustainable agriculture and to eliminate the bad effect of high or low watering, the major target of watering is to apply the water only when the plant requires it with minimal water loss.

Intercropping patterns system importantly contributes to crop intensification and production by its effective utilization of resources as compared with pure sol cropping (Zhang and Li, 2003).

Ouda *et al* (2007) showed that applied irrigation using 1.0 pan evaporation coefficient attain high water use efficiency from 1:2 soybean/maize intercropping system and intercropping system at 1:2 soybean/maize pattern is the most productive system.

Badawy and Shalaby (2015) concluded that for the economic point of view, sugar beet which intercropped with 25cm- onion gave the highest gross income, followed by that at 50 cm, then the sole sugar beet, while that intercropped with 75 cm- onion or garlic gave the lowest income. It could be settled that intercropping system sugar beet with 25 cm – onion maximized the growers’ income.

Ahmed and Mahmoud (2015) studied three treatments of irrigation (I_1 =100, I_2 =85 and I_3 =70% of ETo) with three intercropping patterns (sole soybean, sole maize and soybean/ maize intercropping) and illustrated that the greatest WUE was found under soybean/maize intercropping and irrigated with I_1 treatment. However, WUE was relatively low under irrigation with I_3. Land equivalent ratios (LER) of all intercrops were greater than unity; denoting that higher productivity per unit area was obtained by growing maize and soybean crops together than by growing them sole.

Darwesh, *et al.* (2016) concluded that moderate water scheduling (65% accumulation pan evaporation) in sole crop and intercropping pattern not only does not decrease sunflower and forage cowpea yield, but led to increase yield component. As well as the irrigation water scheduling should be restricted when there is no difference in the crop yield. Given these findings, sunflower and cowpea mixed culture in 1:2 intercropping pattern is enforceable.

The target of this investigation is to evaluate the effect of intercropping lettuce with green onion under different irrigation scheduling, soil water status on growth, yield parameters and the water saving under such technique and computing lettuce with green onion - water relations, water productivity and productivity of irrigation water. as well as land equivalent ratio (LER) and monetary returns during lettuce and green onion production and total income and to recommend an effective irrigation water management strategy for lettuce with green onion intercropping grown in semi-arid regions, particularly under conditions of water lack.

MATERIALS AND METHODS

Two field trial were performed at Experimental farm of Sakha Research Station during the seasons of 17/2018 and 18/2019 to study the influence of intercropping lettuce with green onion under different irrigation scheduling treatments on yield of lettuce (*cv,* Balady), green onion (cv. Giza 6) and their water relationships. The site lies at Kafr EL Sheikh Governorate, which located at (31¯ 07° N Latitude, 30¯ 57° longitude) with an elevation of about 6 metres above mean sea level (MSL).

Table1. Some agro-meteorological data during the two seasons.

Months		T (c°)			RH(%)			U_2 km d^{-1}	Pan Evap. (mm/day)	R.F mm/ month
		Max.	Min.	Mean	Max.	Min.	Mean			
2017-2018	Oct.	28.70	24.00	26.35	81.10	54.70	67.90	73.20	3.27	---
	Nov.	23.70	19.90	21.80	84.70	58.60	71.65	53.50	2.06	9.3
	Dec.	21.30	18.40	19.85	88.20	64.80	76.50	42.90	1.47	5.60
	Jun.	18.90	13.60	16.25	89.40	64.40	76.90	44.90	2.63	36.40
2018-2019	Oct.	29.50	20.60	25.05	82.50	49.60	66.05	57.90	3.24	3.50
	Nov.	25.00	17.40	21.20	86.60	54.60	70.60	24.20	1.60	---
	Dec.	19.50	13.90	16.70	88.70	62.40	75.55	24.50	0.83	21.70
	Jun.	18.90	12.30	15.60	82.30	53.30	67.80	33.10	1.14	14.90

*** Source: Agro-meteorological station at Sakha station.**

Soil particle size distribution and bulk density were determined as described by Klute (1986). Field capacity, permanent wilting point and available water characters were determined according to James (1988). Chemical characteristics of soil were determined as described by Jackson (1973) and all data are presented in Table 2.

Table 2. Some soil-water characters, particle size distribution, bulk density, and some chemical soil properties (mean of 2017-18 and 2018-19 seasons)

Soil layer depth (cm)	Particle size distribution			Textural class	Bulk density (Kgm^{-3})	Soil- water constant		
	Sand%	Silt%	Clay%			F.C* (%,wt/wt)	P.W.P** (%,wt/wt)	A.W*** (%,wt/wt)
0-20	13.70	26.50	59.80	Clayey	1.14	42.12	21.42	20.70
20-40	18.30	29.40	52.30	Clayey	1.18	40.17	20.77	19.40
40-60	21.12	28.30	50.58	Clayey	1.19	39.16	20.88	18.28
Mean	17.71	28.06	54.23	Clayey	1.17	40.48	21.02	19.46

Chemical Soil characteristics

	p^H	EC dSm^{-1}	Soluble cations, $meqL^{-1}$				Soluble anions, $meqL^{-1}$			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
0-20	8.14	2.20	5.12	5.08	11.47	0.33	-	8.90	3.90	9.20
20-40	7.90	2.32	3.55	6.38	13.00	0.27	-	9.15	7.09	6.96
40-60	7.82	3.10	5.20	6.80	18.74	0.26	-	12.70	10.70	7.60
Mean	---	2.54	4.62	6.09	14.40	0.28	-	10.25	7.23	7.92

FC* = Field capacity, PWP = Permanent wilting point and AW*** = Available soil water**
Note SO4 was calculated by the difference between soluble cations and anion

The location of the trial was prepared for cultivation and divided in to was divided into 36 plots, each one, its area was 52.5 m^2 (7.5 X 7) = 1/80 fed., each plot isolated from the other to prevent horizontal water movement.

Lettuce (*cv*, Balady) and green onion (*cv*, Giza 6) a winter crops were transplanting on Oct., 25,2017 for two crops and start harvested January,8,2017 for lettuce and January, 2 ,2017 for green onion in first, and in second season planted on Oct., 22, 2018 for two crops and start harvested January, 12, 2019 for lettuce and January, 8, 2019 for green-onion, respectively.

Other different requirements for each crop were performed as recommendation the crop and area, otherwise the studied treatments. Nitrogen fertilizer as 300 kg ammonium sulfate (20.6% N) fed^{-1} for green onion and lettuce in two equal split application; i.e. applied 3 and 6 weeks after transplanting. The phosphates fertilizer as 250 kg single superphosphate (15.5 P_2O_5/ fed.) was applied in the two seasons during tillage preparation for two crops. The potassium sulphate (48% K_2O) as 50kg fed^{-1} in two equal split application; i.e. 4 and 8weeks after transplanting for two crops.

Experimental layout: -

The treatments under study

I-The main plot (irrigation scheduling): -

I_1 – Traditional watering

I_2 –Irrigation at 1.2 of accumulation pan evaporation (APE),

I_3– Irrigation at 1.0 (APE), and

I_4 – Irrigation at 0.8 (APE).

The obtainable water in the effective root zone (122 mm) was used to calculate the allowable depletion and for this horticulture crops we irrigation with 25% of allowable depletion 122mm*25% (30.5 mm). Therefore, irrigation water was applied when 38.2 mm (30.5 mm/0.8) of available water had evaporated from the pan in the treatment irrigation at 0.8 pan evaporation, 30.5 mm (30.5 mm/ 1.0) in the treatment irrigation at 1.0 pan evaporation and 25.4 mm (30.5 mm/ 1.2) in the treatment irrigation at 1.2 pan evaporation. Taking in consideration, pan coefficient and irrigation efficiency.

P- The sub-plots (four growing systems):

P_1- Planting pure stand of green onion was planted in ridges 60 cm width, spaced 5 cm between hills.

P_2- Planting pure stand of lettuce was planted in ridges 60 cm width, spaced 20 cm between hills (one plant in hill) on both sides of ridges.

P_3 - Planting (2: 1) ridges of green onion and lettuce respectively as in pure stand, i.e. 66.6% component population of green onion plus 50% component population of lettuce.

P_4- Planting (1: 2) ridges of green onion and lettuce respectively as in pure stand, i.e. 33.3% component population of green onion plus 100% component population of lettuce.

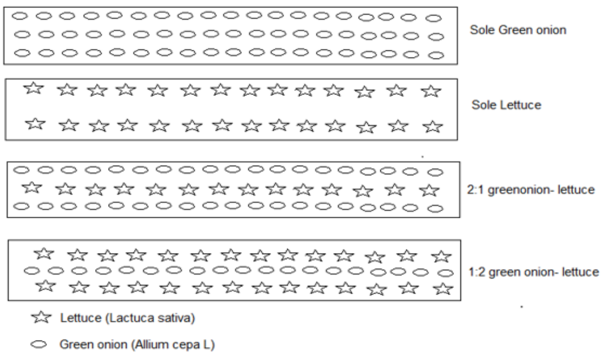

Fig .1. Schematic diagram show four systems of sole and intercrop system

Some irrigation relationships:

1- Irrigation water (I.W, m^3 & cm):

Irrigation water was measured and controlled by rectangular crested weir and water was distributed by spills inserted beneath the bank of each irrigated furrows set. Applied irrigation water discharge was calculated according to Michael, (1978) as follows:

$$Q = 1.84\ LH^{1.5}$$

Where:

Q = Water discharge, m^3sec^{-1},
L = width of weir, cm
H = the head above weir crest, cm

2- Water consumptive use, cm:

Soil moisture percentage was determined (on weight basis) just before and 48 hrs after each irrigation as well as at harvest to compute the actual consumed water as stated by Hansen *et al.*, (1979) as follows:

$$CU = S.M.D. = \sum_{i=1}^{i=4} \frac{\phi_2 - \phi_1}{100} \times D_{bi} \times D_i$$

Where:

CU =Water consumptive use (cm) in the effective root zone of 60 cm soil depth
S.M.D. = Soil moisture Depletion, cm.
i= Number of soil layers (1-4)
D_i = Soil layer thickness (15 cm)
D_{bi} = Bulk density (Kg gm^{-3}) of the concerned soil layer
ϕ_1 = Soil moisture percentage (wt/wt) before the next irrigation and
ϕ_2 = Soil moisture percentage (wt/wt), 48 hours after irrigation.

3- Consumptive use efficiency (Ecu, %):

The consumptive use efficiency (Ecu) was calculated as described by *Doornbos and Pruitt (1975)* as follows:

$$\mathbf{Ecu} = \frac{\mathrm{ETc}}{\mathrm{Aw}} \times 100$$

Where:
Ecu = Consumptive use efficiency%
ETc = Total evapotranspiration ~ consumptive use (m^{3}fed^{-1}).
Aw = Water applied to the field (m^{3}fed^{-1}).

4- Productivity of irrigation water (PIW, Kg m^{-3})

Productivity of irrigation water (PIW) was calculated according to Ali *et al* (2007).

$$PIW = \frac{\mathbf{Y}}{\mathbf{I}}$$

Where
PIW = productivity of irrigation water (Kg m^{-3}),
Y = yield kg fed^{-1}, and
I = irrigation applied water, m^3 fed^{-1} (Irrigation water + effective rainfall).
Note: effect rainfall = rianfall*0.7 (Novica, 1979).

5- Water productivity (WP, Kg m^{-3})

Water productivity is definite as crop yield per cubic metre of water consumption. Concept of water productivity in agricultural production system is focused on producing more food with the same water resources or, producing the same amount of food with less water resources. Water productivity was calculated according to Ali *et al*, (2007).

$$WP = {}^{Y}/_{ET}$$

Where:
WP= water productivity (kg m^{-3})
Y = yield (kg fed^{-1}).
ET = total water consumption through the growing season m^3 fed^{-1}.

- Studied plant parameters:

1-green onion:

At harvest a sample of 10 plants was select at random, from each plot to study:

1-Plant height (cm). 2-. Number of leaves
3- Fresh and dry weight of leaves, gm
4- Plant weight, gm 5- Leaf area /plant(cm^2)
7- Chlorophyll, (mgdm^{-2}) 8- Total yield, ton fed^{-1}

The plants in the two ridges were harvested, collected together. The yield was recorded in numbers /square meter for separately, and then it converted to record:

2-lettuce:

At harvest, a sample of 10 plants was chosen at random to calculate the following characters:

1- Plant height (cm). 2- Number of leaves
3- Leaf area /plant(cm^2).
4- Chlorophyll, (mgdm^{-2}). 5- Plant weight, gm
6- Head weight, gm
7- Head diameter, cm 8- Total yield, ton fed^{-1}

The plants in the two ridges of each experimental unit were harvested, collected together. The yield was recorded in numbers /square meter for separately, and then it converted to record:

3-Competitive relationships and yield advantages:

-Land equivalent ratio (LER):

This was determined according to *Willey (1979)*:

$$\mathbf{LER} = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where:
Yab = Mixture yield of a (when combined with b).
Yaa = Pure stand yield of crop (a).
Yba = Mixture yield of b (when combined with a).
Ybb = Pure stand yield of crop (b).

4-Economic evaluation: -

-Gross return (L.E.fed^{-1}):

Gross return from each treatment was calculated in Egyptian pounds (L.E.)/ton of green onion and (L.E.)/ton of forage cowpea seeds in both seasons as follows: -

one of green onion = 0.25 L.E. and one of lettuce = 1L.E. for first season and second season. Price of green onion and lettuce was obtained by market search.

Statistical analysis:

Data were statistically analyzed according to the technique of analysis of variance (ANOVA) as published by Gomez and Gomez (1984). Means of the treatments were compared using Least Significant Difference (LSD) at 5% level of significance as developed by Waller and Duncan (1969).

RESULTS AND DISCUSSION

1. Influence of irrigation and intercropping patterns on some studied water relations.

Applied water

Presented data in Table 3 clearly illustrated that the values of the studied parameters were influenced by the studied irrigation treatments and intercropping pattern treatments expect seasonal amount of applied water didn't affect by intercropping patterns in the two growing seasons. For seasonal applied water the highest values were recorded under irrigation treatment (I_2), irrigation with 1.2 EP and the values are 41.06 cm (1725.8 m^3 fed^{-1}) and 43.45 cm (1827.0 m^3 fed^{-1}) in the first and second season respectively. On the contrary, the lowest values for the same parameter were recorded under irrigation treatment (I_4), irrigation with 0.8 EP and the values are 32.02 cm (1344.0 m^3 fed^{-1}) and 34.98 cm (1469.0 m^3 fed^{-1}) in the first and second season respectively. Generally, the seasonal amount of applied water can be decreased in order $I_2 > I_1 > I_3 > I_4$ in the two growing seasons. Increasing the values of seasonal amount of applied water under irrigation treatment I_2 comparing with the other irrigation treatmentsI_1, I_3 and I_4 this may be due to decreasing irrigation intervals between watering and hence, increasing number of irrigations, therefore, increasing the seasonal applied water amount. These results are in a great harmony with those reported by Ouda *et al* (2007) and Darwesh, *et al.* (2016).

Water consumptive use, CU (cm)

Concerning with, (CU) the values were clearly influenced by both watering in addition also intercropping treatments. Regarding the impact of irrigation treatment on water consumptive use, the highest values were recorded under (I_2) and the values are 34.63 and 35.71 cm in the first and second season respectively. On the contrary, were recorded under irrigation treatment (I_4) and the values are 27.03 cm and 28.50 cm in the first and second growing season respectively. Generally, the values of CU can be decreased in order $I_2 > I_1 > I_3 > I_4$ in the two growing seasons and the values are (34.63 and 35.71), (33.64 and 33.53), (31.89 and 34.02) and (27.03 and 28.50), respectively.

Increasing the values of CU under I_2 comparing with the other irrigation treatmentsI_1, I_3 and I_4 this may be due to increasing amount of applied water and hence, increasing availability of plant nutrients and hence its uptake by plants. So, forming strong plants with thick vegetative cover therefore, increasing the exposed surface area to the sunlight and hence increasing transpiration from plant surface under the conditions of this treatment. These results were harmony with results by Moshira El-Shamy *et al.* (2015) and Ahmed and Mahmoud (2015).

On the other hand, for intercropping patterns on the values of CU in the two growing seasons, the highest values were recorded under intercropping pattern (P_2) but the lowest values were recorded under (P_1) treatment. The values of CU can be descended in order $P_2 > P_4 > P_3 > P_1$, this may be due to under the conditions of intercropping pattern treatment (P_2), the vegetative cover was thick. So, exposed area to sunlight was big. Therefore, the losses by evaporation from plant surface was high under the condition of this treatment and hence, increasing the values of CU in comparison with the other treatments. These results are in the same line with those obtained by Darwesh, *et al.* (2016)

Consumptive use efficiency (Ecu), %

Concerning, (Ecu%), the values were clearly affected by irrigation treatments in the two growing seasons, where the highest values were recorded under I_1, but the lowest values were recorded under irrigation treatment I_3. Regarding the effect of intercropping patterns on Ecu% data in the same table showed slight effect for intercropping patterns on Ecu%. There finding in agreement with those reported by El-Shamy *et al.* (2015).

Table 3. Seasonal applied water ($m^3 fed.^{-1}$), Consumptive use (cm), consumptive use efficiency (Ecu) in the two growing seasons.

Irrigation scheduling	Planting patterns	Applied water, season: m^3 fed.$^{-1}$		Applied water, season: cm		CU, cm		Ecu, %	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
I_1	P_1	1605.0	1709.0	38.22	40.69	32.5	34.87	85.03	85.69
	P_2	1669.0	1811.0	39.74	43.11	34.39	36.18	86.53	83.92
	P_3	1684.0	1835.0	40.10	43.69	33.45	35.50	83.41	81.25
	P_4	1710.0	1765.0	40.71	42.02	34.20	35.55	84.0	84.60
Mean I_1		1667.0	1780.0	39.69	42.38	33.64	35.53	84.76	83.84
I_2	P_1	1725.8	1827.0	41.06	43.45	33.52	35.25	81.64	81.12
	P_2	1725.8	1827.0	41.06	43.45	35.85	36.08	87.73	8.04
	P_3	1725.8	1827.0	41.06	43.45	34.05	35.67	82.93	82.09
	P_4	1725.8	1827.0	41.06	43.45	35.08	35.85	85.44	82.51
Mean I_2		1725.8	1827.0	41.06	43.45	34.63	35.71	84.34	82.19
I_3	P_1	1626.0	1716.5	38.71	40.87	30.80	32.54	79.57	79.62
	P_2	1626.0	1716.5	38.71	40.87	33.25	35.85	85.90	87.71
	P_3	1626.0	1716.5	38.71	40.87	31.55	33.50	81.50	81.96
	P_4	1626.0	1716.5	38.71	40.87	31.94	34.18	82.51	83.63
Mean I_3		1626.0	1716.5	38.71	40.87	31.89	34.02	82.38	83.24
I_4	P_1	1344.8	1469.0	32.02	34.98	26.01	27.45	81.23	87.47
	P_2	1344.8	1469.0	32.02	34.98	28.08	29.85	87.70	85.33
	P_3	1344.8	1469.0	32.02	34.98	26.56	27.95	82.94	79.90
	P_4	1344.8	1469.0	32.02	34.98	27.45	28.75	85.73	82.19
Mean I_4		1344.8	1469.0	32.02	34.98	27.03	28.50	84.41	81.47
Mean I		1590.9	1698.1	37.87	40.42	31.80	33.44	83.97	82.69

I_1: Traditional irrigation, I_2: Irrigation at 1.2 of APE, I_3: Irrigation at 1.0 of APE. and I_4: Irrigation at 0.8 of APE.
P_1: sole green onion, P_2: sole lettuce, P_3: 2:1 green onion / lettuce planting pattern and P_4: 1:2 green onion / lettuce planting pattern

The linear regression equations between applied water, cm over all planting pattern on consumptive use, cm are shown in Fig. (2), these equations reveled that the relationship between applied water quantities and plants water consumed, cm is most reliable in the two seasons.

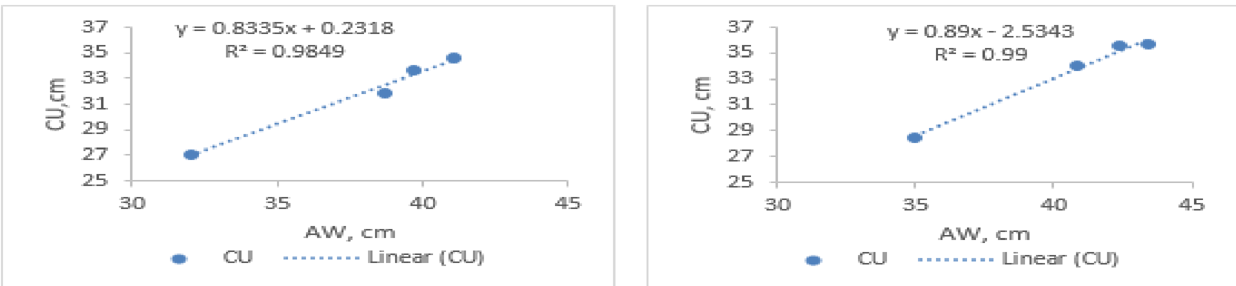

Fig. 2. Correlation between applied water, cm and water consumed, cm overall planting systems in the two growing seasons.

Productivity of irrigation water PIW and water productivity WP, kg m^{-3}, kg m^{-3}.

Presented data in Table (4) showed that the values of both (PIW) and (WP) were clearly influenced by irrigation treatments, intercropping patterns and crop type.

Concerning, the impact of irrigation treatments (irrigation scheduling) on both (PIW) and (WP). The highest values were recorded under I_2 under the two studied crops, but the values under lettuce crop are higher than those recorded under green onion crop, this might be due to increasing the total yield of lettuce in comparison green onion crop. but, the lowest values for the two parameters (PIW)and (WP) were recorded under irrigation treatment I_4 for the two crops. Generally, the mean values of WP were higher than those for PIW because of decreasing the values of consumed water comparing the applied water.

Supposedly, the values of both PIW and WP were higher under irrigation treatment I_4 (water stress conditions) comparing with other irrigation treatments (non-stress ones), as results of decreasing the values of both applied and consumed water but, recording the highest values for the two calculate parameters under irrigation treatment I_2 might be due to increasing yield for two crops in this treatment comparing than decreasing water applied and consumed in other treatments. These results were agreement with those reported with Similar results were reported by Ouda *et al* (2007).

Regarding the effect of crop pattern treatments on the two parameters (PIW)and (WP), generally in 2:1 and 1:2 lettuce/green onion systems WIP and WP, were recorded with lettuce with green onion that were use the same unit of water consumed, Hence, cubic metre of irrigation water under I_3 (irrigation at 100% of APE) produced 1.99 and 1.82 kg of lettuce in addition 7.81 and 7.38 kg of green onion for PIW in the first and second growing seasons, respectively.

Likewise, for WP 2.47 and 2.25 kg of lettuce plus 9.34 and 8.74 kg of green onion in the first and second growing seasons, and the same trend for I_1, I_2 and I3 irrigation scheduling. These findings were in the same line with the reported by Darwesh *et al. (2016),* they found that planting pattern in 1:1 and 1:2 sunflower/cowpea systems WIP and WP, were recorded with sunflower plus cowpea that were use the same unit of water consumed.

Table 4. Seasonal productivity of irrigation water, PIW (kgm^{-3}) and water productivity (WP, $kg\ m^{-3}$) for green onion and lettuce crops in the two growing seasons.

Irrigation scheduling	Planting patterns	Green onion crop				lettuce crop			
		PIW, $kg\ m^{-3}$		WP, $kg\ m^{-3}$		PIW, $kg\ m^{-3}$		WP, $kg\ m^{-3}$	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
I_1	P_1	3.10	2.83	3.64	3.31	---	---	---	---
	P_2	---	---	---	---	9.84	8.90	11.37	10.60
	P_3	2.10	1.91	2.52	2.34	5.74	5.18	6.88	6.37
	P_4	1.19	1.14	1.41	1.35	9.21	8.52	10.96	10.09
Mean I_1		2.13	1.96	2.52	2.33	8.26	7.53	9.74	9.02
I_2	P_1	3.02	2.83	3.71	3.49	---	---	---	---
	P_2	---	---	---	---	10.27	9.23	11.77	11.12
	P_3	2.14	1.97	2.57	2.40	6.11	5.45	7.37	6.64
	P_4	1.17	1.11	1.37	1.35	9.53	8.96	11.17	10.88
Mean I_2		2.11	1.97	2.55	2.41	8.64	7.88	10.10	9.55
I_3	P_1	2.91	2.68	3.66	3.39	---	---	---	---
	P_2	---	---	---	---	9.71	8.98	11.31	10.24
	P_3	1.94	1.80	2.39	2.20	5.05	4.63	6.20	5.65
	P_4	1.11	0.97	1.35	1.16	8.68	8.53	10.52	10.21
Mean I_3		1.99	1.82	2.47	2.25	7.81	7.38	9.34	8.70
I_4	P_1	2.50	2.34	3.08	2.98	---	---	---	---
	P_2	---	---	---	---	9.27	8.14	10.56	9.53
	P_3	1.70	1.56	2.05	1.95	5.34	4.58	6.44	5.73
	P_4	0.94	0.84	1.10	1.02	8.42	7.42	9.82	9.04
Mean I_4		1.71	1.58	2.08	1.98	7.68	6.71	8.94	8.10
Mean I									

I_1: Traditional irrigation, I_2: Irrigation at 1.2 of APE, I_3: Irrigation at 1.0 of APE. and I_4: Irrigation at 0.8 of APE.
P_1: sole green onion, P_2: sole lettuce, P_3: 2:1 green onion / lettuce planting pattern and P_4: 1:2 green onion / lettuce planting pattern

1. Effect of irrigation treatments and intercropping pattern on green onion crop:

Presented data in Tables (5 &6) showed that yield and all yield components were affected by irrigation treatments, intercropping pattern and the interactions between the two abomination studied factors. Concerning, irrigation treatments, all the studied parameters such as, plant height, no of leaves, fresh weight of leaves, dray weight of leaves, plant weight, leaf area/ plant, chlorophyll content and total yield were highly significantly affected by irrigation treatments in the two growing seasons. Generally, the effect of irrigation treatments on the abovementioned studied parameters can be decreased in order $I_2 > I_1 > I_3 > I_4$ in the two growing seasons. Increasing the abovementioned studied parameters under irrigation treatment I_2 comparing with I_1 control treatment; traditional practice for local farmers in the studied area) and other stressed treatments I_3 and I_4. this might due to the amount of applied water is suitable for growing plants without extravagance for water to make leaching for nutrients or water stress to affect badly in nutrients uptake by plants and forming weak plants and that reflects badly on yield and its attributes. These results are in a great harmony with those reported by Darwesh, *et al.* (2016)

Regarding, the impact of intercropping patterns on the above-mentioned studied parameters. All the studied parameters were significant and highly significantly affected by intercropping patterns. Generally, the effect of intercropping patterns on the abovementioned studied parameters can be decreased in order $P_1 > P_3 > P_4$ in the two growing seasons. Increasing the values under the conditions of intercropping pattern treatment P_1 comparing with P_3 and P_4 increasing pant populations under P_1 and hence increasing yield. Decreasing the values under P_3 and P_4 may be due to increasing cooperation rate between onion plants and lettuce ones.

Concerning, the interaction between irrigation and intercropping pattern treatments, on the abovementioned studied significantly and highly significantly by the interactions except, No of leaves fresh and dry weight for leaves and leaf area/ plant in the second seasons. These finding are in a great agreement with those obtained by Darwesh, *et al.* (2016)

Table 5. Effect of irrigation scheduling and planting patterns on plant height, cm, No of leaves, Fresh weight of leaves, gm and Dry weight of leaves, gm of green onion in the two growing seasons.

Irrigation scheduling	Planting patterns	Plant height, cm		No of leaves		Fresh weight of leaves, gm		Dry weight of leaves, gm	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
	P_1	43.75	43.50	8.00	7.75	13.75	12.75	9.50	9.00
I_1	P_3	42.75	41.00	7.50	7.25	12.50	12.00	8.75	8.25
	P_4	42.50	40.00	7.00	6.25	11.50	10.75	8.50	8.00
Mean I_1		43.00	41.50	7.50	7.08	12.58	11.83	8.92	8.42
	P_1	44.25	45.75	8.25	8.00	14.25	13.50	9.75	10.25
I_2	P_3	44.00	44.00	7.25	7.25	13.25	13.25	9.00	10.00
	P_4	41.50	42.00	6.50	7.25	13.75	12.75	10.25	9.50
Mean I_2		43.25	43.92	7.33	7.50	13.75	13.17	9.67	9.92
	P_1	40.00	42.00	6.25	6.50	11.50	11.50	8.50	8.50
I_3	P_3	39.25	40.75	6.25	6.50	12.25	11.25	8.50	8.25
	P_4	37.25	37.50	6.25	6.25	10.25	10.25	8.50	8.00
Mean I_3		38.83	40.08	6.25	6.42	11.33	11.00	8.50	8.25
	P_1	37.25	39.00	5.50	5.25	9.50	8.75	7.25	6.25
I_4	P_3	37.25	36.00	5.00	4.50	9.25	8.50	6.50	5.75
	P_4	33.00	32.50	4.75	4.50	8.50	8.25	6.00	5.25
Mean I_4		35.83	35.83	5.08	4.75	9.08	8.50	6.58	5.75
Mean I		40.22	40.33	6.54	6.44	11.69	11.13	8.42	8.08
$LSD_{0.05}$		1.128	0.969	0.770	0.759	0.737	0.574	0.822	0.385
	I	***	***	**	***	***	**	**	**
F test	P	**	***	**	**	**	**	*	**
	I*P	**	***	NS	NS	**	NS	NS	NS

I_1: Traditional irrigation, I_2: Irrigation at 1.2 of APE, I_3: Irrigation at 1.0 of APE. and I_4: Irrigation at 0.8 of APE.
P_1: sole green onion, , P_3: 2:1 green onion / lettuce planting pattern and P_4: 1:2 green onion / lettuce planting pattern
***, **, *** and NS: significant at $p \leq 0.05$, 0.01, 0.001or not significant, respectively. Means separated at $P \leq 0.05$, LSD test.**

Table 6. Effect of irrigation scheduling and planting patterns on plant weight, gm, leaf area /plant,cm^2, chlorophyll, (mgdm^{-2}) and total yield, tonfed^{-1}of green onion in the two growing seasons.

Irrigation scheduling	Planting patterns	Plant weight, gm		Leaf area /plant(cm^2)		Chlorophyll, (mgdm^{-2})		Total Yield (tonfed^{-1})	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
	P_1	48.5	46.25	28.50	28.50	70.25	68.75	4.975	4.851
I_1	P_3	48.00	45.00	26.75	26.50	68.50	66.25	3.550	3.496
	P_4	44.75	44.00	25.00	24.75	66.50	65.75	2.034	2.009
Mean I_1		47.08	45.08	26.75	26.58	68.41	66.91	3.51	3.45
	P_1	53.50	48.5	28.75	28.75	69.75	70.00	5.222	5.170
I_2	P_3	53.25	46.50	27.25	26.50	70.50	68.50	3.688	3.607
	P_4	51.75	42.25	25.75	24.75	68.50	67.75	2.019	2.025
Mean I_2		52.83	45.75	27.25	26.67	69.58	68.75	3.64	3.60
	P_1	47.75	42.75	25.25	25.25	65.25	63.50	4.732	4.637
I_3	P_3	47.50	41.75	25.00	24.00	65.50	62.25	3.168	3.090
	P_4	45.25	38.50	23.50	21.75	64.00	62.00	1.810	1.677
Mean I_3		46.83	41.00	24.58	23.67	64.92	62.58	3.24	3.13
	P_1	41.50	38.00	22.25	20.25	59.00	56.00	3.361	3.438
I_4	P_3	38.25	38.25	20.25	19.00	56.50	53.75	2.286	2.295
	P_4	34.25	34.25	18.50	17.75	53.25	51.50	1.266	1.234
Mean I_4		38.00	36.83	20.33	19.00	56.25	53.75	2.30	2.32
Mean I		46.19	42.17	24.72	23.98	64.79	63.00	3.17	3.13
$LSD_{0.05}$		1.619	1.231	0.994	1.081	0.952	1.502	117.1	76.45
	I	***	***	***	***	***	***	***	***
F test	P	***	**	***	***	***	***	***	***
	I*P	**	**	*	NS	*	*	**	**

I_1: Traditional irrigation, I_2: Irrigation at 1.2 of APE, I_3: Irrigation at 1.0 of APE. and I_4: Irrigation at 0.8 of APE.
P_1: sole green onion, P_3: 2:1 green onion / lettuce planting pattern and P_4: 1:2 green onion / lettuce planting pattern
***, **, *** and NS: significant at $p \leq 0.05$, 0.01, 0.001or not significant, respectively. Means separated at $P \leq 0.05$, LSD test.**

2. Effect of irrigation treatments and intercropping pattern on Lettuce crop.

Presented data in Tables (7 &8) showed that lettuce yield and all yield components were affected by irrigation treatments, intercropping pattern and the interactions between the two abomination studied factors. Concerning, irrigation treatments, all the studied parameters such as, plant height, no of leaves, leaf area/ plant, chlorophyll content, plant weight, head weight, head diameter and total yield were highly significantly affected by irrigation treatments in the two growing seasons. Generally, the effect of irrigation treatments on the abovementioned studied parameters can be decreased in order $I_2 > I_1 > I_3 > I_4$ in the two growing seasons. Increasing the abovementioned studied parameters under irrigation treatment I_1 (control treatment; traditional practice) comparing with and other stressed treatments I_2, I_3 and I_4.

this might due to the amount of applied water is suitable for growing plants without extravagance for water to make leaching for nutrients or water stress to affect badly in nutrients uptake by plants and forming weak plants and that reflects badly on yield and its attributes. These results are in agreement with those reported by Sanchez, (2000).

Concerning, the intercropping patterns effect of the above-mentioned studied parameters. All the studied parameters were significant and highly significantly affected by intercropping patterns. Generally, the effect of intercropping patterns on the abovementioned studied parameters can be decreased in order $P_2 > P_3 > P_4$ in the two growing seasons. Increasing the values under the conditions of intercropping pattern treatment P_1 comparing with P_3 and P_4 increasing pant populations under P_1 and hence increasing yield. Decreasing the values under P_3 and P_4 may be due to increasing cooperation rate between lettuce and onion plants ones. These results are in the same line with those reported by Darwesh, *et al.* (2016)

Concerning, the interaction between intercropping pattern and irrigation treatments, on the abovementioned studied significantly and highly significantly by the interactions except, Chlorophyll, head weight and diameter in the two growing season and plant weight in the first seasons. These finding are in a great agreement with those obtained by El-Shamy *et al.* (2015) and Darwesh, *et al.* (2016).

3. Gross return (L.E., fed^{-1}) and land equivalent ratio (LER):

Data in Table 9 illustrated that watering treatments and planting pattern had impact gross return, for watering treatments the highest values were noticed under watering treatment I_1. On the contrary, the lowest values were noticed under watering I4 for all sole and pattern system in the two growing seasons, respectively. Meanwhile, planting pattern showed effect in gross return under overall irrigation scheduling in the two growing seasons. Comparing return from sole crop and pattern;1-2 green onion / lettuce giving approximately 200% comparing sole green onion and 125% comparing sole lettuce. These results observations were stated by El-Shamy *et al.* (2015).

This a ratio is a method used to measure the effectiveness of intercropping pattern. It is the most widely used index for calculating the advantages of intercropping systems on combined yield of both crops. It is defined as the relative land area under sole crops required producing yields achieved in intercropping. Data in same Table illustrated that, the values of land equivalent ratio were affected by watering treatment and intercropping systems in the two growing seasons. On other hand, the effect of watering treatment on land equivalent ratio, the highest values in the two growing seasons were noticed under irrigation treatment I1 and the values are 1.32 and 1.35. Meanwhile, the lowest values were recorded under irrigation treatment I3 and the values are 1.23 and 1.25 in the first and second growing seasons, respectively. those obtained by *Aou Khadra et al. (2013)* who explain that LER values were greater than one at any intercropping pattern.

Table 7. Effect of irrigation scheduling and planting patterns on plant height, cm, No of leaves, leaf area /plant, cm^2 and chlorophyll, ($mgdm^{-2}$) of lettuce in the two growing seasons.

Irrigation scheduling	Planting patterns	Plant height, cm		No of leaves		Leaf area /plant(cm^2)		Chlorophyll, ($mgdm^{-2}$)	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
	P_2	42.75	41.00	43.00	41.25	12.25	11.37	44.00	41.65
I_1	P_3	39.50	39.00	38.75	38.50	10.63	10.38	39.57	36.92
	P_4	40.50	39.50	40.50	41.50	11.88	11.75	41.35	39.70
Mean I_1		40.92	39.83	40.75	40.42	11.58	11.16	41.64	39.42
	P_2	41.00	40.75	42.00	41.25	12.13	11.63	43.50	41.87
I_2	P_3	37.50	38.75	38.00	39.00	10.75	10.62	39.81	37.25
	P_4	35.25	39.00	42.00	41.00	11.50	11.00	41.43	39.12
Mean I_2		37.92	39.50	40.66	40.41	11.46	11.08	41.58	39.41
	P_2	37.50	35.25	39.00	35.00	11.00	10.50	38.45	3.60
I_3	P_3	35.25	33.50	37.00	29.25	10.00	9.50	34.15	32.00
	P_4	37.50	37.25	39.00	36.00	10.75	10.63	38.23	36.65
Mean I_3		36.75	35.33	38.33	33.42	10.58	10.21	36.94	24.08
	P_2	36.25	34.50	35.50	33.00	9.50	9.23	34.55	33.18
I_4	P_3	32.50	32.75	32.00	27.75	7.20	6.93	32.63	28.27
	P_4	26.75	25.25	35.00	32.00	8.13	8.40	33.75	31.38
Mean I_4		31.83	30.83	34.17	30.92	8.28	8.19	33.64	30.94
Mean I		36.86	36.37	38.48	36.29	10.48	10.16	38.45	33.47
$LSD_{0.05}$		1.224	2.005	1.618	1.358	1.070	0.958	1.418	1.799
	I	***	***	***	***	***	***	***	***
F test	P	***	**	**	**	**	**	**	**
	I*P	**	**	*	**	*	**	NS	NS

I_1: Traditional irrigation, I_2: Irrigation at 1.2 of APE, I_3: Irrigation at 1.0 of APE. and I_4: Irrigation at 0.8 of APE.
P_2: sole lettuce, P_3: 2:1 green onion / lettuce planting pattern and P_4: 1:2 green onion / lettuce planting pattern
***, **, *** and NS: significant at $p \leq 0.05, 0.01, 0.001$or not significant, respectively. Means separated at $P \leq 0.05$, LSD test.**

Table 8. Effect of irrigation scheduling and planting patterns on plant weight, gm, Head Weight, gm, head diameter, cm and total yield, ton fed^{-1} of lettuce in the two growing seasons.

Irrigation scheduling	Planting patterns	Plant weight, gm		Head Weight, gm		Head Diameter, cm		Total Yield, tonfed^{-1}	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
I_1	P_2	437.5	437.5	413.8	398.5	9.09	9.03	17.72	16.86
	P_3	407.5	383.7	378.8	363.8	7.42	7.23	10.54	9.95
	P_4	422.5	417.5	402.0	383.7	8.41	8.61	16.46	16.38
Mean I_1		422.5	412.9	398.2	382.0	8.31	8.29	14.91	14.40
I_2	P_2	430.0	421.3	392.5	388.7	9.09	8.92	16.43	16.11
	P_3	402.0	383.8	375.0	365.0	7.53	7.35	9.67	9.50
	P_4	402.0	408.8	388.8	387.5	8.13	8.35	15.75	15.07
Mean I_2		411.33	404.6	385.4	380.4	8.25	8.25	13.95	13.56
I_3	P_2	386.3	388.8	387.5	367.5	8.18	8.16	15.82	15.42
	P_3	365.0	357.5	351.2	342.5	7.27	6.98	8.22	7.95
	P_4	376.3	373.8	377.5	357.5	7.91	7.67	14.11	14.65
Mean I_3		375.9	373.4	372.1	355.8	7.79	7.60	12.72	12.67
I_4	P_2	312.5	306.0	285.0	281.2	7.25	7.11	12.46	11.95
	P_3	265.0	292.8	255.0	237.5	6.00	5.92	7.18	6.73
	P_4	288.8	283.8	273.0	253.8	7.25	6.89	11.32	10.91
Mean I_4		288.8	294.4	271.0	257.5	6.83	6.64	10.32	9.86
Mean I		374.6	371.3	356.7	343.9	7.80	7.70	12.98	12.62
$LSD_{0.05}$		13.63	15.37	12.76	18.39	0.502	0.325	441.3	295.1
F test	I	**	***	**	***	**	**	***	***
	P	**	***	**	***	**	**	***	***
	I*P	NS	*	NS	NS	NS	NS	**	**

I_1: Traditional irrigation, I_2: Irrigation at 1.2 of APE, I_3: Irrigation at 1.0 of APE. and I_4: Irrigation at 0.8 of APE.
P_2: sole lettuce, P_3: 2:1 green onion / lettuce planting pattern and P_4: 1:2 green onion / lettuce planting pattern
***, **, *** and NS: significant at $p \leq 0.05, 0.01, 0.001$or not significant, respectively. Means separated at $P \leq 0.05$, LSD test.**

Table 9. Effect of irrigation scheduling and intercropping pattern green onion with letuuce on land equivalent ratio (LER) and gross return (L.E., fed.$^{-1}$) in two growing seasons.

Irrigation scheduling	Planting patterns	Gross return (L.E. fed^{-1})		Increasing income (L.E. fed^{-1}) comparing with sole green onion		Increasing income (L.E. fed^{-1}) comparing with sole lettuce		Land equivalent ratio	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
I_1	P_1	25644	26221	----	----	----	-----	----	-----
	P_2	40502	38537	----	----	----	-----	----	-----
	P_3	44354	45353	18710	19132	3852	6816	1.30	1.31
	P_4	50321	50648	24677	24427	9819	12111	1.34	1.38
I_2	P_1	24401	26649	----	----	----	----	----	-----
	P_2	38209	38238	----	----	----	----	----	-----
	P_3	41369	44144	16968	17495	3160	5906	1.30	1.29
	P_4	48932	48846	24531	22197	10732	10208	1.33	1.26
I_3	P_1	24774	27116	----	----	----	----	----	-----
	P_2	39194	39660	----	----	----	----	----	-----
	P_3	40952	40740	14420	13624	1758	1080	1.19	1.19
	P_4	47496	50081	22722	22965	6544	10421	1.27	1.31
I_4	P_1	20246	22618	----	----	----	----	----	-----
	P_2	39872	37984	----	----	----	----	----	-----
	P_3	42035	39052	21789	16434	2163	1068	1.26	1.23
	P_4	48437	47449	28191	24832	8565	8397	1.29	1.27

I_1: Traditional irrigation, I_2: Irrigation at 1.2 of APE, I_3: Irrigation at 1.0 of APE. and I_4: Irrigation at 0.8 of APE.
P_1: sole green onion, P_2: sole lettuce, P_3: 2:1 green onion / lettuce planting pattern and P_4: 1:2 green onion / lettuce planting pattern

CONCLUSION

Our results exhibited that moderate watering treatment (irrigation at 1.2 of accumulative pan evaporation (APE) in intercropping pattern and sole crop not only does not reduce lettuce and green onion yield, but led to high quality. Hence the watering treatment should be restricted when there is no difference in the crop yield. Given these findings, green onion-lettuce mixed culture in 1:2 intercropping system is enforceable. Therefore, under limited water and soil sources it could be recommended that using intercropping pattern with moderate water scheduling. It is still necessary to have more studies for better understanding of intercropping systems interacted with irrigation scheduling.

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تاثير جدولة الري والتحميل علي نموانتاجية وجودة البصل الأخضر و الخس وبعض العلاقات المائيه بمنطقة شمال دلتا النيل

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أقيمت تجربتان حقليتان بمحطة البحوث الزراعية بسخا - كفر الشيخ لمنطقة شمال الدلتا خلال موسمى 18/2017 ، 19/2018م لمعرفة تأثير جدولة الرى وتحميل البصل الأخضر علي الخس وأثر ذلك علي العائد المحصولي من وحدة الماء المضاف والجودة وكذالك بعض العلاقات المائية لمحصولي البصل الأخضر والخس وكان التصميم الاحصائى المستخدم هو القطع المنشقة مرة واحدة فى 4 مكررات. وكانت المعاملات:- القطع الرئيسية (جدولة الري):- - الري التقليدي(I_1) - الري عند فقد 1.2 من البخر تجميعي من وعاء البخر(I_2). - الري عند فقد 1.0 من البخر تجميعي من وعاء البخر(I_3). - الري عند فقد 0.8 من البخر تجميعي من وعاء البخر(I_4). القطع التحت ريئسية (نظم التحميل):- زراعة 100% خس فقط (P_1) زراعة 100% بصل أخضر فقط (P_2) زراعة البصل الاخضر و الخس 1:2 مع الحفاظ علي الكثافة النباتية للمحصولين 66.6% البصل الاخضر و50% الخس.(P_3) زراعة البصل الاخضر و الخس :21 مع الحفاظ علي الكثافة النباتية للمحصولين 33.3% البصل الاخضر و100% الخس.(P_4) وكانت اهم النتائج:- أظهرت النتائج أن أعلى القيم للماء المضاف وكذلك الماء المستهلك سجلت تحت معاملة الري عند فقد 1.2 من البخر تجميعي من وعاء البخر(I_2) . بالنسبة لكفاءة استخدام للمياه (٪ ECu) تم تسجيل أعلى القيم تحت المعامله (I_1). العائد المحصولى من وحدة المياه المضافةPIW والمستهلكهWP تأثرت بشكل واضح بمعاملات الري ونظام التحميل ونوع المحاصيل وكانت أعلى القيم المسجلة تحت معاملة الري (I_2) ونظام التحميل 2:1 بصل أخضر-خس. كشفت النتائج أيضا لكل من المحصول ومكوناته لمحصول ومعايير الجودة للبصل الأخضر متأثرة بجدولة الري في الموسمين كارتفاع النبات و عدد الأوراق و الوزن الطازج للأوراق و الوزن الجاف للأوراق و الوزن الكلي للنبات و مساحة الورقة / النبات و محتوى الكلوروفيل والمحصول الكلي وكذلك بالنسبة للخس كإرتفاع النبات و عدد الأوراق و مساحة الورقة / النبات و محتوى الكلوروفيل و وزن النبات ووزن الرأس و قطر الرأس والوزن الكلي أعطت اعلي القيم تحت معاملة الري I_2 . من ناحية أخرى بالنسبة لنظم التحميل تم تسجيل أعلى قيم لمكونات المحصول تحت النظام المفرد ولكن المحصول الكلي سجلت أعلي القيم تحت نظام التحميل 2:1 بصل أخضر-خس. العائد الإجمالي وزيادة الدخل تم تحقيقه تحت نظام التحميل 1-2 بصل أخضر-خس وجدولة الري I_2. أظهرت النتائج بالنسبة لقيم المكافئ الأرضى (LER) فأن أعلي القيم سجلت تحت المعامله I_1 ونظام التحميل 2:1 بصل أخضر-خس. وعليـــه فتوصي الدراسة بتحميل البصل الأخضر مع الخس بنظام 2:1 بصل أخضر / خس وريهم كل حوالي من 12-16 يوم وذلك لتعظيم الاستفادة من وحدتي الأرض والمياه وكذلك العائد المحصولي في منطقة شمال دلتا النيل. كما توصي الدراسة بإجراء مزيد من الدراسات الحقلية للمحصولين في المنطقة موضع الدراسة.