J.Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 7 (2):135 -146, 2016

EFFECT OF IRRIGATION SCHEDULING ON SUNFLOWER/ FORAGE COWPEA INTERCROPPING PATTERN, GROWTH, YIELD AND ITS COMPONENTS.

Darwesh, R.Kh. [1]**; Mona A.M. EL-Mansoury**[1] **and Moshira A .El-Shamy** [2]**.**
[1] **Soils, water & Environment, Res. Inst.(SWERI), A.R.C., Egypt**
[2] **Crop intensification Res. Department, Field Crops Res. Institute, A.R.C., Giza, Egypt.**

ABSTRACT

A field experiment was conducted at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate, during the two growing seasons 2013 and 2014 to study the effect of irrigation scheduling; irrigation at 50 (I_1), 65(I_2) and 80% (I_3) of accumulative pan evaporation (APE) and four systems of sole and intercropping pattern; 1: 1 (P_1), 1: 2 (P_2) rows for sunflower *cv.* Sakha 53, forage cowpea *cv.* balady, sole sunflower (P_3) and sole cowpea (P_4) in a split plot design with three replications. The important findings could be concluded as follows:

The highest values of water applied and consumptive use were recorded under I_1 in the two growing seasons and the values were 57.9 and 59.1 cm for water applied and 48.89 and 50.25 cm for water consumed in the first and second season, respectively. On the other hand, the highest mean values of water productively (WP) and productivity of irrigation water (PIW) were recorded under I_3 (lowest water applied and consumed) for two crops in the two seasons and the value tended to reduce, gradually, with increasing the irrigation water applied, for planting pattern in 1:2 sunflower/cowpea intercropping pattern gave the highest PIW under I_3 where the values were 0.368 and 0.352 kg m^{-3} of sunflower plus 0.746 and 0.714 kg m^{-3} in 2013 and 2014 growing seasons, respectively. Likewise, WP takes the same trend in the two growing seasons.

Results showed also, all characteristics of sunflower and cowpea were significantly affected by irrigation scheduling and intercropping systems in both seasons. For sunflower; plant height, stem diameter, head diameter, weight of seeds plant^{-1},100-seed weight, seed yield fed^{-1} and oil % gave the highest values under irrigation scheduling I_2 and the 1: 2 planting pattern. All of the evaluated growth, yield and yield components traits for cowpea plants; plant height , stem diameter , number of leaves plant^{-1} , dry seed yield , dry matter yield ,dry matter % , crude protein % and crude fiber % exhibited higher figures under irrigation scheduling (I_2) and the 1 : 2 planting pattern (P_2). Land equivalent ratio (LER) exhibited higher values with I_3 irrigation scheduling and 1:2 sunflower/ cowpea planting pattern. The highest total income was attained with the 1: 2 planting pattern and I_2 irrigation scheduling.

Keywords: - *Irrigation scheduling, planting pattern, sunflower crop, cowpea crop and water productivity*

INTRODUCTION

Water is an essential component of agriculture and a major part of grain crops, fruits and vegetables consumed by humans, their food grains fed to animals that are used as human feeding and food / vegetation to sustain animals to work in human many parts of the world. For centuries humans have been concerned with efficient use of water in production of crops. The ability to grow crops and manage their needs for water is vital for the civilization. Greater efficiencies of water use in agriculture, recycling of water through water treatment plants in industries can play a catalytic role in saving this valuable resource. Without appropriate management, irrigated agriculture which is a major part of agriculture can be detrimental to the environment and endanger sustainability.

In Egypt, irrigation uses more than 85% of the total renewable water supply. So, tremendous efforts should be implemented in this sector to rationalize water at the national level. One of the most effective ways for irrigation is to determine crop water need with accumulation pan evaporation is essential for maximizing the productivity from each unit of applied water.

Sunflower is one of the four most important oil crops in the world, its moderate cultivation requirements and high oil quality, its acreage has increased in both developed and developing countries (Demir *et al*., 2006).

Goksoy *et al.* (2004) found that seasonal evapotranspiration (ETC) of sunflower and water use efficiency WUE decreased by increasing available soil moisture depletion (ASMD) percentage.

In this field total yield produced, water requirements of sunflower are comparatively high compared to most crops. Despite its high water use, the crop has the ability to withstand short periods of severe soil water deficit of up to 15 atmosphere tensions. Long intervals of water deficit, particularly at sensitive growth stages cause significant reduction in seed yield (Beyazgul *et al*, 2000) by limiting evapotranspiration (ET) through stomata closure, reduced assimilation of carbon and decreased biomass production (Demir *et al*., 2006).

Cowpea (*Vigna unguiculata. L.)* has been introduced to Egyptian agriculture as promising double purpose forage and seed crop for green canopy or using it in animal diets as dry seed as well as it is a primary source of protein for humans and animals. It is a high nutritive value and known in Africa for human consumption. Forage cowpea as summer crop will compete with other summer dominant crops, likely, it has a wide range of compatibility with other crop species in intercropping systems. At the same time, cowpea is solid. Therefore, cowpea intercropping may offer a potential method of incorporating such crop in the Egyptian agricultural structure.

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

Abou kheira (2009) indicated that, deficit irrigation significantly affected yields, where kernels yield decreased by 28.39, 36, and 41% in deficit – irrigated late vegetative and early flowering, late flowering and early pegging and pod formation growth stages respectively, compared with full irrigation treatments.

Intercropping, during more efficient of water, solar energy and nutrients can significantly enhance crop productivity compared to the growth of sole crops (Yildirim and Guvenc, 2005).

Productivity of component crops in multiple cropping systems depend on several factors, including planting date, planting density, cultivated varieties, soil management and agriculture practices (fertilization, irrigation etc.) Tsubo *et al*., 2003.

The intercropped crops, for example, may extract water from different soil horizons and therefore more completely capture this growth resource (Zegada-Lizarazu et al., 2006).

The relative performance of the crop components in the intercropping depends on planting pattern, time of planting, fertilizer application, compatibility of component crop species and pest (Olowe *et al*., 2006).

Nawar and Al- Kafoury (2002) found that increasing plant spacing of sunflower to 30 cm between hills and 60kgN fed^{-1} increased LER value and more than one, sunflower was dominant crop, whereas soybean was dominated. Nofal and Attalla (2006) indicated that the highest pods yield was found when yellow maize hybrid was planted in 2:2 pattern and the highest values of land equivalent ratio LER of maize and soybean. In general, LER increased by both crops.

The objectives of this study; effects of different irrigation schedules on sunflower and cowpeas sole and intercropping pattern, soil water status, growth, yield parameters and the water saving under such technique and computing sunflower and cowpea- water relations as well as water productivity and productivity of irrigation water and to recommend an effective irrigation water management strategy for sunflower and cowpea intercropping grown in semi-arid regions, particularly under conditions of water scarcity.

MATERIALS AND METHODS

A field experiments were carried out at Sakha Agricultural Research Station Farm, during the two growing seasons of 2013and 2014 to study the three irrigation interval 50, 65 and 80 % from accumulation pan evaporation and two intercropping systems 1: 1 and 1: 2) rows of sunflower *cv*. Sakha 53 and cowpea *cv*. Balady were used along with sole planting of each crop. Sunflower and cowpea seeds were obtained from Agric. Res. Center (ARC.),Giza ,Egypt. The site located at Kafr EL Sheikh Governorate, which located at (31¯ 07° N Latitude, 30¯ 57° longitude) with an elevation of about 6 meters above sea level

Data presented in Table 1 which showed some meteorological parameters during the studied period, recorded from Sakha Agro-meteorological Station. The meteorological parameters, include; air temperature (T., °C), relative humidity (RH, %), wind speed (U_2, Km / day at 2 m height) and evaporation pan (Ep, mm).

Table1. Some agro-meteorological parameters in the first and second seasons.

Months*	T (°c)			RH (%)			U_2 m Sec^{-1}	Pan Evap. (mmday^{-1})
	Max.	Min.	Mean	Max.	Min.	Mean		
2013 Season								
June	32.44	23.97	28.21	74.63	51.27	62.95	1.34	6.61
July	32.32	24.31	28.32	79.57	54.70	67.14	1.28	6.11
Aug.	33.79	24.72	29.29	83.63	60.52	72.08	1.04	5.13
Sep.	32.50	22.93	27.72	81.00	56.6	68.80	1.01	3.82
2014 Season								
June	32.65	20.60	26.63	86.23	52.30	69.27	0.95	6.56
July	33.15	23.64	28.40	83.19	55.11	69.15	1.13	7.73
Aug.	34.10	21.80	27.95	92.40	53.50	72.95	1.15	8.14
Sep.	32.49	20.76	26.63	87.57	52.20	69.89	1.03	6.65

*** Source: Agro-meteorological station at Sakha 31^0-07' N Latitude, 30^0-57'E Longitude, N. elevation 6 m.**

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.

All recommended agriculture were performed according to the crop and the studied site except the studied treatments.

Sunflower (*Helianthus annuus,* L.) and cowpea(*vigna unguiculata*, L.) a summer crops were planted on june,12,2013 for two crops and harvested september,12,2013 for sunflower and september,25,2013 for cowpea in first, and in second season planted on june,12,2014 for two crops and harvested september,9,2014 for sunflower and september,23,2014 for cowpea, respectively. The sunflower variety *cv*. Sakha 53 and forage cowpea *cv*. balady.

The amounts of fertilizers were applied for each crop according to recommendations of Field Crops Research Institute, Agricultural Research Center (ARC). Nitrogen fertilizer as 30 nitrogen unit fed^{-1} for sunflower and 15 nitrogen unit fed^{-1} for cowpea. For nitrogen was splitted into two doses was applied with the first irrigation and the second dose was applied with the second irrigation. The phosphates fertilizer was applied during tillage preparation as the recommended dose of 150 kg single superphosphate (15.5 P_2O_5/ fed.).

Table 2. Particle size distribution, bulk density, some both soil-water characters and chemical soil properties of the experimental site (mean of 2013 and 2014 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)
0-15	9.80	28.60	61.60	Clay	1.19	46.55	24.20	22.35
15-30	11.50	28.75	59.75	Clay	1.22	44.90	23.30	21.60
30-45	13.50	29.10	57.40	Clay	1.23	42.56	23.00	19.56
45-60	16.30	30.60	53.1	Clay	1.26	41.30	21.35	19.95
Mean	12.78	29.26	57.96	Clay	1.23	43.83	22.96	20.87

Chemical Soil characteristics

	pH	EC dSm^{-1}	Soluble cations, $meqL^{-1}$				Soluble anions, $meqL^{-1}$			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
0-15	8.38	2.35	4.65	5.11	13.14	0.60	-	8.35	4.20	10.95
15-30	8.27	2.58	3.85	3.68	17.82	0.45	-	9.15	5.13	11.52
30-45	8.19	3.02	4.58	4.32	20.92	0.38	-	11.50	6.25	12.45
45-60	8.11	3.25	5.23	5.12	21.79	0.36	-	10.60	6.95	14.95
Mean	8.24	2.80	4.57	4.55	18.41	0.45	-	9.90	5.63	12.47

FC* = Field capacity, PWP = Permanent wilting point and AW*** = Available soil water**

Experimental layout:-

Agricultural practices for two crops were performed according to the technical recommendations of A.R.C.

The treatments under study

I- The main plot was allocated to irrigation scheduling:-

I_1- Irrigation at 50% of accumulation pan evaporation (APE),

I_2- Irrigation at 65% of accumulation pan evaporation (APE), and

I_3- Irrigation at 80% of accumulation pan evaporation (APE).

The available water in the effective root zone (122 mm) was used to calculate the allowable depletion. Therefore, irrigation water was applied when 61 mm (50% x 122 mm) of available water had evaporated from the pan in the treatment 50% pan evaporation, 79.3 mm (65 % x 122) in the treatment 65% pan evaporation and 97.6 mm (80 % x 122) in the treatment 65% pan evaporation. Taking in consideration, pan coefficient and irrigation efficiency.

P- The sub-plot were occupied at random with four growing systems as follow:-

p_1 -Planting (1 : 1) ridges of cowpea (2 plants/ hill) and sunflower respectively as in pure stand, This provides 200% total population i.e. 100% component population of cowpea plus 100% component population of sunflower., and

p_2- Planting (1 : 2) ridges of cowpea (2 plants/ hill) and sunflower respectively as in pure stand, This provides 200% total population i.e. 133.4% component population of cowpea plus 66.6% component population of sunflower.

p_3- Planting pure stand of sunflower was planted in ridges 60 cm width, spaced 30 cm between hills to give 23333 plants/fad.,

p_4- Planting pure stand of cowpea was planted in ridges 60 cm width, spaced 10 cm between hills (one plant in hill) on both sides of ridges to give 140000 plants/fad.,

Irrigation practices:

1- Irrigation water (I.W):

Irrigation water was measured and controlled by rectangular weir. Irrigation water discharge was determined 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:

Percentage of soil moisture was determined (on weight basis) just before and 48 hrs after 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 layer (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:

$$\text{Ecu} = \frac{\text{ETc}}{\text{Wa}} \times 100$$

Where:

Ecu = Consumptive use efficiency%

ETc =Total evapotranspiration ≃ consumptive use ($m^3 fed^{-1}$).

Wa=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).

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

Where

PIW = productivity of irrigation water (Kg m^{-3}),

Y = yield kg fed^{-1}, and

I = irrigation water applied (m^3 fed^{-1}).

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

Water productivity is generally defined as crop yield per cubic meter 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 of the growing season m^3 fed^{-1}.

- Studied plant parameters:

1-Sunflower:

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

1-Plant height (cm). 2-. Stem diameter, (cm)
3-Head diameter (cm). 4-Weight of seeds/plant (g).
5-100-seed weight (g). 6- Seed yield fed^{-1}
7- oil %

The plants in two ridges of each experimental unit were harvested, collected together, labeled, thrashed and the seeds were separated. The seed yield was recorded in kg/square meter for separately, then it converted to record seed yield in kg fad^{-1}, and then calculated the following character:

8-Seed yield (kg fed^{-1}).

2-cowpea:

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

1- Plant height (cm). 2- Stem diameter (cm)
3- Number of leaves/plant.
4- Green fodder yield (ton fed^{-1}).
5- Dry matter yield (ton fed^{-1}). 6- Dry matter %
7- Crude protein % 8- Crude fiber %

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

9-Seed yield (kg fad^{-1}).

3-Competitive relationships and yield advantages:

-Land equivalent ratio (LER):

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

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

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 sunflower and (L.E.)/ton of forage cowpea seeds in both seasons as follows:-

Kg of sunflower = 2.5L.E. and kg of cowpea seeds = 14L.E. for first season, and

Kg of sunflower = 3.0 L.E. and ton of cowpea seeds = 14 L.E. for second season.

Price of sunflower and cowpea seeds 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. Irrigation water applied and water productivities.

Irrigation water applied

The highest irrigation water applied obtained for sole cowpea for the other irrigation treatments in the two growing seasons (Table 3). The amounts of irrigation applied under 1:2 sunflower/cowpea intercropping pattern were slightly higher than the applied amounts to either sole sunflower or 1:1 sunflower/cowpea under another irrigation treatments in the two growing seasons. However, these amounts water for different intercropping patterns resulted in producing yield from two crops (sunflower and cowpea), which is more useful. For irrigation treatments, irrigation at 50% of accumulation pan evaporation I_1 (57.9 and 59.1 cm in the first and second seasons, respectively) showed slightly higher than the applied amounts I_2 (55.2 and 58.4 cm) and these two irrigation scheduling were higher than I_3 (50.1 and 52.2 cm).

In general, increasing the seasonal values of applied water for irrigation treatments I1 and I2 as compare with irrigation treatment I3 might be assign to increasing one irrigation and hence high the amount of applied water. These results are in an agreement with those reported by Ouda *et al* (2007) and Ahmed and Ali (2015)

Table3. Seasonal water applied ($m^3 fed.^{-1}$), Consumptive use (cm), consumptive use efficiency (Ecu) in the two growing seasons.

Irrigation scheduling	Planting patterns	Water applied, m^3 fed.$^{-1}$ 1st Season	Water applied, m^3 fed.$^{-1}$ 2nd Season	Water applied, season cm 1st Season	Water applied, season cm 2nd Season	CU, cm 1st Season	CU, cm 2nd Season	Ecu, % 1st Season	Ecu, % 2nd Season
I_1	P_1	2418.0	2465.0	57.6	58.7	49.70	49.03	86.28	83.53
	P_2	2438.0	2485.0	58.1	59.2	48.95	50.60	84.25	85.65
	P_3	2256.5	2301.5	53.7	54.8	44.74	46.22	83.31	84.35
	P_4	2614.5	2667.0	62.3	63.5	52.15	55.14	83.70	86.83
Mean I_1		2431.7	2479.6	57.9	59.1	48.89	50.25	84.39	85.09
I_2	P_1	2282.0	2413.0	54.3	57.4	46.76	48.85	86.11	84.95
	P_2	2337.5	2472.0	55.7	58.8	49.97	51.20	89.71	86.92
	P_3	2142.5	2271.5	51.0	54.1	43.05	46.55	84.41	86.04
	P_4	2503.5	2653.5	59.6	63.5	52.46	54.50	88.05	85.83
Mean I_2		2316.5	2452.5	55.2	58.4	48.06	50.28	87.07	85.93
I_3	P_1	1953.0	2060.0	46.5	49.1	40.32	42.30	86.70	86.32
	P_2	2107.0	2191.0	50.2	52.2	42.15	44.30	83.96	84.86
	P_3	1881.0	1931.0	44.8	46.0	39.00	40.25	87.05	87.50
	P_4	2478.0	2581.0	59.0	61.5	47.50	52.20	80.50	84.87
Mean I_3		2105.0	2191.0	50.1	52.2	42.24	44.78	84.55	85.89
Mean I		2284.3	2374.5	54.4	56.6	46.39	48.44	85.34	85.63

I_1: Irrigation at 50% of APE, I_2: Irrigation at 65% of APE. and I_3: Irrigation at 80% of APE.
P_1: 1:1 sunflower / cowpea planting pattern, P_2: 1:2 sunflower / cowpea planting pattern and P_4: sole cowpea

Water consumptive use (cm)

Presented data in Table (3) showed that the mean values of seasonal water consumptive use in the two growing seasons were affected by irrigation scheduling and planting patterns under study where the differences under irrigation treatments among I_1 and I_2 studied were slight or so-called the mean values were rather similar, but the two treatments higher than I_3. The mean values are 48.89, 48.06 and 42.24 for I_1, I_2 and I_3 in the first season respectively. The corresponding values are 50.25, 50.28 and 44.78 for the same treatments in the second season. These results were harmony with those obtained by El-Shamy *et al.* (2015).

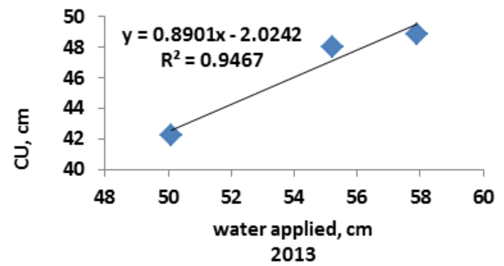
For planting patterns, data showed also that the highest values of CU were recorded under sole cowpea (C_4). Decreasing the values of water consumptive use under planting pattern treatments C_1, C_2 and C_3 in comparison with C_4 attributable to increasing the water applied under the status of this treatment. so, increasing the open area to sunlight, then, increasing transpiration from plant surfaces in addition to evaporation.

Consumptive use efficiency (Ecu), %

Consumptive use efficiency as affected by the adopted irrigation scheduling and planting patterns is presented in Table 3. Data revealed that the highest Ecu value was noticed under irrigation at 65% of accumulation pan evaporation (I_2) with values 87.07 and 85.93% in the first and second seasons respectively. These results are in a great agreement with those obtained by El-Shamy *et al.* (2015)

Data in the same Table indicated that planting patterns had slight effect on all treatments in consumptive use efficiency.

The linear regression equations between irrigation water applied, cm over all planting pattern on consumptive use, cm are shown in Fig. (1), these equations show that, the relationship between applied irrigation water and plants water consumed, cm is more reliable in the two seasons.



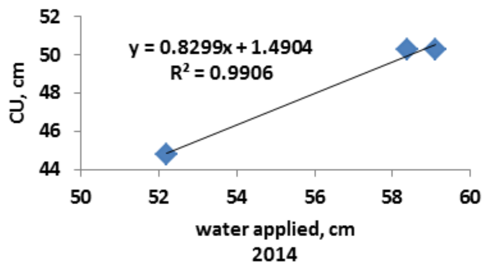


Fig. 1 Correlation between irrigation water applied, cm and water consumed, cm overall planting pattern in the two growing seasons.

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

Productivity of irrigation water was computed to evaluate the treatments for maximum yield per unit of water applied in the field. In this case, the greatest PIW for sunflower was observed in I_3 (0.363 and 0.359 kg m^{-3}), then I_2 (0.357 and 0.335kg m^{-3}), and I_1 (0.294 and 0.285 kg m^{-3}) in the first and second seasons respectively. On the other hand for cowpea the corresponding values were I_3 (0.789 and 0.708 kg m^{-3}), followed by I_2 (0.740 and 0.666kg m^{-3}), and I_1 (0.661 and 0.606 kg m^{-3}) in the first and second seasons, respectively. The slight increase in PIW in I_3 than in I_2 was connected with increase in seed yield than the corresponding minimum amount of irrigation water.

For planting pattern in 1:1 and 1:2 sunflower/cowpea systems, PIW were with sunflower plus cowpea that were use the same unit of applied water, Hence, cubic meter of irrigation water under I_3 (irrigation at 80% of accumulation pan evaporation) produced 0.355 and 0.334 kg of sunflower plus 0.771 and 0.725 kg of cowpea under 1:1 sunflower/cowpea intercropping pattern in 2013 and 2014 growing seasons, respectively. Likewise, 1:2 sunflower/cowpea intercropping pattern the values were0.368 and 0.352 kg of sunflower plus 0.746 and 0.714 kg of cowpea, and the same trend in I_1 and I_2 irrigation scheduling. Similar results were reported by Ouda et al (2007).

Water productivity WP, kg m^{-3}.

Data showed in Table (4) demonstrate that, WP was affected by irrigation water scheduling; the values were increased under increasing water stress conditions in the two growing seasons. Under sunflower and cowpea crops, the highest and lowest values of WP were recorded under I_3 and I_1 treatment, respectively, in two seasons. The slight increase in WP in I_3 than in I_2 was correlating with a minimum amount of irrigation water and could be due to a major loss of water by evapotranspiration than the corresponding increase in seed yield. These results are harmony with Ahmed and Ali (2015)

For planting pattern in 1:1 and 1:2 sunflower/cowpea systems WP, were recorded with sunflower plus cowpea that were use the same unit of water consumed, Hence, cubic meter of irrigation water under I_3 (irrigation at 80% of APE) produced 0.409 and 0.387 kg of sunflower plus 0.889 and 0.841 kg of cowpea under 1:1 sunflower/cowpea intercropping pattern in 2013 and 2014 growing seasons, respectively. Likewise, 1:2 sunflower/cowpea intercropping pattern the values were0.417 and 0.415 kg of sunflower plus 0.884 and 0.841 kg of cowpea, and the same trend in I_1 and I_2 irrigation scheduling. These findings are in good agreement with those obtained by Ouda et al (2007) and Ahmed and Ali (2015).

Table4. Seasonal productivity of irrigation water (kgm^{-3}) and water productivity (WP, kg m^{-3}) for sunflower and cowpea crops in the two growing seasons.

Irrigation scheduling	Planting patterns	Sunflower crop				Cowpea 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	0.281	0.272	0.326	0.326	0.613	0.598	0.711	0.715
	P_2	0.293	0.285	0.347	0.334	0.642	0.626	0.761	0.732
	P_3	0.307	0.298	0.367	0.354	--	--	--	--
	P_4	--	--	--	--	0.728	0.594	0.610	0.684
Mean I_1		0.294	0.285	0.347	0.338	0.661	0.606	0.694	0.710
I_2	P_1	0.320	0.301	0.372	0.354	0.693	0.652	0.806	0.766
	P_2	0.360	0.338	0.401	0.389	0.731	0.688	0.814	0.791
	P_3	0.391	0.367	0.463	0.426	--	--	--	--
	P_4	--	--	--	--	0.796	0.658	0.701	0.762
Mean I_2		0.357	0.335	0.412	0.390	0.740	0.666	0.774	0.773
I_3	P_1	0.355	0.334	0.409	0.387	0.771	0.725	0.889	0.841
	P_2	0.368	0.352	0.417	0.415	0.746	0.714	0.844	0.841
	P_3	0.367	0.358	0.421	0.408	--	--	--	--
	P_4	--	--	--	--	0.800	0.613	0.644	0.722
Mean I_3		0.363	0.359	0.437	0.416	0.789	0.708	0.837	0.828
Mean I		0.346	0.326	0.399	0.381	0.730	0.660	0.768	0.770

I_1: Irrigation at 50% of APE, I_2: Irrigation at 65% of APE. and I_3: Irrigation at 80% of APE.
P_1: 1:1 sunflower / cowpea planting pattern, P_2: 1:2 sunflower / cowpea planting pattern and P_4: sole cowpea

2.Sunflower crop

Sunflower growth

plant height, cm

Plant height is a substantial yield component, the results of sunflower plant height are shown in Table 5. It recorded a significant effect of irrigation scheduling and planting pattern on the plant longest. The higher plant height (123.9 and 123.7 cm) were found when sunflower irrigation with I_2. But in case of I_1 and I_3 plant height slightly lower from compared to I_2. The results were similar to those of Abd El-Hafez et al. (2002) indicated that reduced irrigation intervals lead to decrease plant height.

The data in Table 5 shows the effect of intercropping and interaction of planting pattern and irrigation on plant height was significant. The highest plant height was measured in case of sole sunflower and lower height was obtained in case 1:1 intercropping of sunflower with cowpea.

Stem diameter, cm

Steam diameter was significantly higher means values under irrigated scheduling. In addition, the highest stem diameter were obtained under irrigation at 65 % of accumulation pan evaporation (I_2) with values 1.62 and 1.54 cm in the first and second seasons, respectively, while the lowest values for steam diameter were obtained under irrigation at 50 % of accumulation pan evaporation (I_1) with values 1.39 and 1.34 cm in the first and second seasons, respectively.

Concerning, the impact of intercropping treatments in all irrigation scheduling, the highest mean values were listed for intercropping treatment 1:2 intercropping of sunflower with cowpea.

Table5. Effect of irrigation scheduling and planting patterns on plant height, cm, stem diameter, cm and head diameter, cm of sunflower in the two growing seasons.

Irrigation scheduling	Planting patterns	Plant height, cm		Stem diameter, cm		Head diameter, cm	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
	P_1	116.4	115.9	1.32	1.26	14.85	14.73
I_1	P_2	121.7	120.9	1.53	1.47	15.44	15.40
	P_3	124.9	124.5	1.33	1.29	15.33	15.25
Mean I_1		121.0	120.1	1.39	1.34	15.21	15.12
	P_1	119.5	119.3	1.46	1.31	15.27	15.23
I_2	P_2	124.6	124.5	1.78	1.73	16.45	16.39
	P_3	127.5	127.3	1.63	1.59	15.51	15.42
Mean I_2		123.9	123.7	1.62	1.54	15.74	15.68
	P_1	113.1	112.9	1.35	1.31	14.07	14.00
I_3	P_2	123.1	122.9	1.52	1.49	14.80	14.74
	P_3	124.7	124.5	1.43	1.40	14.17	14.11
Mean I_3		120.3	120.1	1.43	1.40	14.35	14.28
Mean I		121.73	121.3	1.48	1.43	15.10	15.03
$LSD_{0.05}$		1.493	1.489	0.694	0.109	0.355	0.311
	I	***	**	**	*	*	*
F test	P	***	***	***	***	***	***
	I*P	**	**	***	**	*	*

I_1: Irrigation at 50% of APE, I_2: Irrigation at 65% of APE. and I_3: Irrigation at 80% of APE.
P_1: 1:1 sunflower / cowpea planting pattern, P_2: 1:2 sunflower / cowpea planting pattern and P_4: sole cowpea
***, **, *** and NS: significant at $p \leq 0.05$, 0.01, 0.001or not significant, respectively. Means separated at $P \leq 0.05$, LSD test.**

Head diameter, cm

Head diameter is one of the most important yield components in sunflower plant. The head diameter measured in the study were not significantly influenced (Table 5). The effect of the irrigation scheduling was significant, as irrigation regime increased from I_1 to I_2, the head diameter of sunflower plants increased, but the decrease with more water applied in I_3. Indeed, this effect was expected because of positive contribution of water on plant growth. The consistently better performance values of head diameter was 15.74 and 15.68 cm for the I_2 in the first and second seasons, respectively, while it was 18.48 cm for the check treatment. For intercropping, also significantly affect the head diameter as shown in (Table 5), since the highest values were found in 1:1 sunflower/cowpea intercropping pattern in overall irrigation scheduling.

Sunflower yield and yield components

Seed yield, kg

The seed yield of sunflower was presented in Table 6. As seen in Table, there were significant differences between the growing seasons. Similarly, maximum seed yield was observed for irrigation at 65 % of accumulation pan evaporation (I_2) with values 803.26 and 789.13 kg fed.$^{-1}$, in the first and second seasons, respectively, as a percentage, the sunflower seed yield reduced with the irrigation period (I_1) with mean values about 13.0% and reduced with the irrigation period (I_3) with mean values about 9.5%. In this context, Mahendar *et al*., (2000) reported that seed yield was consolidated with increase in irrigations number.

Concerning planting pattern, seed yield increased were the highest values in 1:2 sunflower/cowpea intercropping pattern in overall irrigation scheduling, the sunflower seed yield reduced from 1:2 to 1:1 sunflower/cowpea intercropping pattern with mean values about 5.0% and 13.0% and 10.0% in I_1, I_2 and I_3 respectively, the reduction of seed yield from 1:2 sunflower/cowpea intercropping pattern to sole sunflower with mean values about 3.5% and 0.5% and 10.5% in I_1, I_2 and I_3 respectively.

100 seed weight, g. and Seed weight, g flower disk^{-1}

Among the various yield contributing factors 100 seed weight and seed weight flower disk $^{-1}$ was two of the noticeable factors that play a serious role in the final yield of a crop. The data of sunflower 100 seed weight and seed weight flower disk -1 in Table 6. It shows significant effect of irrigation scheduling and planting patterns on seed weight plant-1. The maximum seed weight and seed weight flower disk^{-1} were measured when sunflower was sown under irrigation at depletion 65% of available water with accumulation pan evaporation I_2 in the first and second seasons respectively. On the other hand planting pattern showed that the highest values were recorded in 1:2 sunflower/cowpea for the all irrigation treatments overall the two seasons.

Table 6. Effect of irrigation scheduling and planting patterns in seed yield, kg., 100 seed weight, g., seed weight g., flower disk^{-1} and oil % of sunflower in the two growing seasons.

Irrigation treatments	Planting patterns	Seed yield, kg		100 Seed weight, g.		Seed weight, g flower disk^{-1}		Oil %	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
	P_1	679.60	670.5	5.23	5.17	35.20	35.13	36.75	36.43
I_1	P_2	714.20	709.2	5.74	5.68	37.57	38.87	38.20	38.14
	P_3	689.64	686.9	5.54	5.45	38.95	37.53	37.23	37.14
Mean I_1		694.48	688.86	5.50	5.43	37.24	37.18	37.39	37.24
	P_1	730.64	725.3	6.40	6.33	38.47	41.33	38.01	37.90
I_2	P_2	840.93	835.9	7.18	7.09	46.34	46.11	39.70	39.60
	P_3	838.22	833.2	7.10	7.02	41.48	46.25	39.11	39.05
Mean I_2		803.26	789.13	6.89	6.81	42.07	44.57	38.94	38.85
	P_1	692.80	687.2	5.82	5.73	38.40	38.29	36.96	36.71
I_3	P_2	775.45	771.8	6.20	6.14	43.58	43.12	38.24	38.15
	P_3	689.68	691.3	6.35	6.27	41.66	41.59	37.93	37.81
Mean I_3		719.31	716.76	6.12	6.05	41.21	41.00	37.71	37.56
Mean I		739.02	731.58	6.15	6.10	40.17	40.92	38.01	37.88
$LSD_{0.05}$		17.745	15.354	0.420	0.408	1.223	1.423	0.278	0.246
	I	*	**	**	***	***	***	***	***
F test	P	***	***	**	**	***	**	***	***
	I*P	***	***	NS	NS	NS	NS	*	*

I_1: Irrigation at 50% of APE, I_2: Irrigation at 65% of APE. and I_3: Irrigation at 80% of APE.
P_1: 1:1 sunflower / cowpea planting pattern, P_2: 1:2 sunflower / cowpea planting pattern and P_4: sole cowpea
***, **, *** 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.**

Oil %

Our results showed also oil content was significantly affected by irrigation scheduling, planting pattern and interaction between irrigation scheduling x planting patterns (Table 6). Data showed that maximum oil content was produced within 2013 compared with 2014. For scheduling irrigation, maximum oil content was recorded under irrigated at 65 % of accumulation pan evaporation (I_2) with values 38.94 and 38.85 %, in the first and second seasons, respectively. Planting pattern revealed maximum oil content under 1:2 sunflower/cowpea intercropping pattern in the two growing seasons under overall irrigation scheduling. These results do not harmony with those announced by Santonoceto et al., (2003) who noticed that an increase in oil content due to increase in irrigation applied.

The interaction between deficit irrigation scheduling and intercropping system significantly affected seed yield, kg and oil % and show no significant in 100 seed weight, g and seed weight, g flower disk^{-1}.

3.Cowpea forage crop

Cowpea growth

Data illustrated in Table 7 show irrigation and intercropping systems had a significant effect on all studied characters in both seasons. While plant height, Stem diameter, number of leaves, Fiber recorded the highest values under irrigation at 65 % of accumulation pan evaporation (I_2) and when grown cowpea plants as sole in both seasons. This result mainly attributed to increase the amount of water consumed in the sole system for intercropping systems due to lack of competition on the water and thus an increase in these attributes, in addition to light use efficiency of solar radiation utilized by cowpea plants, which resulted in minimizing competition between cowpea plants as well as between cowpea and sunflower plants for light, which in turn enhances the conversion of light energy to chemical energy and consequently encourages the dry matter accumulation, followed by 1:2 system then 1:1 system which came in the last rank, this may be due to the differences of distribution for both crops per unit area under intercropping systems, which resulted in maximizing the effect of intra and inter specific competition among cowpea plants, also between cowpea and sunflower plants, which lead to low water use and light solar radiation use efficiency utilized by cowpea, which in turn low in the conversion of light energy to chemical energy and consequently low the dry matter accumulation. Similar results were reported by Sawan *et al.* (2001), Nawar and Al- Kafoury (2002) and Nofal and Attalla (2006).

The interaction between deficit irrigation scheduling and intercropping system significantly affected plant height, cm and number of leaves and show no significant in steam diameter, cm and fiber%.

Table 7. Effect of irrigation scheduling and planting patterns in plant height, cm and steam diameter, cm number of leaves and fiber of cowpea frorage in the two growing seasons.

Irrigation treatments	Planting patterns	Plant height, cm		Stem diameter, cm		No of leaves / plant		Fiber %	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
	P_1	130.96	130.89	1.26	1.16	41.33	41.01	30.22	30.13
I_1	P_2	145.54	145.49	1.36	1.26	54.99	54.91	31.66	31.54
	P_4	150.29	150.20	1.49	1.37	57.45	57.37	32.86	32.27
Mean I_1		142.26	142.19	1.37	1.26	51.26	51.10	31.31	31.31
	P_1	137.19	137.12	1.55	1.47	49.50	49.40	31.80	31.70
I_2	P_2	152.76	152.68	1.67	1.58	61.17	61.10	32.86	32.75
	P_4	163.57	163.49	1.80	1.72	61.70	61.63	33.20	33.09
Mean I_2		151.17	151.10	1.67	1.59	57.46	57.38	32.62	32.51
	P_1	134.04	133.93	1.32	1.23	44.41	44.33	30.40	30.29
I_3	P_2	148.61	148.51	1.39	1.27	56.37	56.27	31.89	31.82
	P_4	153.71	153.59	1.52	1.44	58.70	58.59	32.67	32.61
Mean I_3		145.45	145.38	1.41	1.31	53.16	53.06	31.65	31.57
Mean I		146.29	146.22	1.48	1.39	53.96	53.85	31.86	31.80
LSD $_{0.05}$		1.368	1.363	0.044	0.082	1.194	1.283	0.534	0.530
	I	***	***	***	***	**	**	**	***
F test	P	***	***	***	***	***	***	***	***
	I*P	*	*	NS	NS	**	**	NS	NS

I_1: Irrigation at 50% of APE, I_2: Irrigation at 65% of APE. and I_3: Irrigation at 80% of APE.
P_1: 1:1 sunflower / cowpea planting pattern, P_2: 1:2 sunflower / cowpea planting pattern and P_4: sole cowpea
***, **, *** 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.**

Cowpea forage yield and its components.

Irrigation scheduling and intercropping systems had a significant effect on all yield components of cowpea forage in both seasons. While Grain yield fed^{-1}, Protein %, Dry matter, kg and Dry matter % recorded the highest values when grown sole cowpea in both seasons. This result mainly attributed to more increase in the amount of water applied and consumed in the sole system than the other intercropping systems due to lack of competition on the water and thus an increase in these attributes but for scheduling, irrigated at 65 % of accumulation pan evaporation (I_2) give the highest yield and its components. These results are in agreement with Amer et al (2002) and Buan (2002) they concluded that dry seed yield significantly increased with increasing the amount of applied irrigation water, in addition to light use efficiency of solar radiation utilized by cowpea plants , which resulted in minimizing competition between cowpea plants as well as between cowpea and sunflower plants for light, which in turn enhances the conversion of light energy to chemical energy and consequently encourages the dry matter accumulation, followed by 1:2 sunflower/ cowpea planting pattern then 1 : 1 sunflower/ cowpea planting pattern which came in the last rank, this may be due to the differences of distribution for both crops per unit area under intercropping systems, which resulted in maximizing the effect of intra and inter specific competition among cowpea plants, also between cowpea and sunflower plants, which lead to low light use efficiency of solar radiation utilized by cowpea, which in turn low in the conversion of light energy to chemical energy and consequently low the dry matter accumulation. Similar results were reported by Nawar and Al- Kafoury (2002) and Nofal and Attalla (2006).

Land equivalent ratio (LER) and gross return (L.E., fed^{-1}):

This is a method used to calculate the effectiveness of intercropping systems. It is the most widely used index for measuring 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 Table (9) recorded that, the land equivalent ratio values were affected by irrigation scheduling and intercropping pattern in the two growing seasons. with regard to the effect of irrigation scheduling on land equivalent ratio, the highest values in the two growing seasons were showed under irrigation treatment I3. meanwhile, the lowest values were recorded under irrigation treatment I2. These results are in harmony with those obtained by Aou Khadra et al. (2013) they concolded that LER values were high at any intercropping systems.

Table 8. Effect of irrigation scheduling and planting patterns in dry seed yield kg , protein %, dry matter, kg and dry mater % of cowpea forage in the two growing seasons.

Irrigation treatments	Planting patterns	Dry seed yield, kg 1st Season	Dry seed yield, kg 2nd Season	Protein % 1st Season	Protein % 2nd Season	Dry matter, kg 1st Season	Dry matter, kg 2nd Season	Dry matter, % 1st Season	Dry matter, % 2nd Season
	P_1	1484	1473	11.89	11.82	1.93	1.85	15.64	15.55
I_1	P_2	1564	1555	12.67	12.53	2.86	2.41	16.27	16.18
	P_4	1594	1583	12.83	12.75	3.07	3.00	16.90	16.79
Mean I_1		15.47	1537	12.46	12.3	2.62	2.42	16.27	16.17
	P_1	1582	1571	13.17	13.09	2.48	2.39	16.36	16.27
I_2	P_2	1709	1701	14.83	14.73	3.38	3.29	17.41	17.32
	P_4	1754	1745	15.52	15.41	3.52	3.41	17.75	17.40
Mean I_2		1682	1672	14.51	14.41	3.13	3.03	17.17	17.00
	P_1	1505	1495	11.65	11.55	2.06	1.96	15.81	15.70
I_3	P_2	1571	1564	12.79	12.70	2.93	2.83	16.82	16.70
	P_4	1596	1583	12.90	12.79	3.16	3.07	16.95	16.84
Mean I_3		1557	1547	12.45	12.35	2.72	2.62	16.53	16.41
Mean I		1595	1585	13.14	13.02	2.82	2.69	16.66	16.53
$LSD_{0.05}$		46.501	49.502	0.393	0.399	0.177	0.364	0.368	0.425
	I	**	**	**	**	**	**	***	***
F test	P	***	***	***	***	***	***	***	***
	I*P	NS	NS	**	**	NS	NS	NS	NS

I_1: Irrigation at 50% of APE, I_2: Irrigation at 65% of APE. and I_3: Irrigation at 80% of APE.
P_1: 1:1 sunflower / cowpea planting pattern, P_2: 1:2 sunflower / cowpea planting pattern and P_4: sole cowpea
***, **, *** and NS: significant at p ≤ 0.05, 0.01, 0.001or not significant, respectively. Means separated at P≤ 0.05, LSD test.**

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

Irrigation treatments	Planting patterns	Land equivalent ratio 1st Season	Land equivalent ratio 2nd Season	Gross return (L.E. fed^{-1}) 1st Season	Gross return (L.E. fed^{-1}) 2nd Season
I_1	P_1	1.92	1.90	22475	22633
	P_2	2.02	2.01	23681	24023
Mean I_1		1.97	1.95	23078	23328
I_2	P_1	1.77	1.77	23973	24337
	P_2	1.97	1.95	26028	25645
Mean I_2		1.87	1.86	25000	24990
I_3	P_1	1.94	1.92	22802	22992
	P_2	2.11	2.10	23932	24208
Mean I_3		2.02	2.01	23367	23600

Water scheduling and planting pattern had effect on gross return, for irrigation scheduling the highest values were recorded under irrigation treatment I_2 and the values are 25000.0 and 24991.0 (L.E. fed^{-1}.,) at the same time , the lowest values were showed under irrigation treatment I1 and the values are 23078.00 and 23328.00 in the first and second growing seasons, respectively. On the other hand, planting pattern showed effect on gross return under overall irrigation scheduling in the two growing seasons. These results were in line with were reported by El-Shamy *et al.* (2015).

CONCLUSION

Our results showed that moderate water scheduling (irrigation at 65% of `APE) in sole crop and intercropping pattern not only does not reduce sunflower and forage cowpea yield, but led to increase yield component. Hence 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. Therefore, under limited water sources in summer season it could be recommended that using intercropping system with moderate water scheduling. It is still need to have more studies for deepen understanding of intercropping systems interacted with irrigation scheduling.

REFERENCES

Abd El-Hafez S.A.A., A.A. El-Sabbagh, A.Z. El-Bably, A. Abou Ahmed (2002). Evaluation of sprinkler irrigated sunflower in North Delta, Egypt. Alexandria J. Agric. Res. 47: 147-152.

Abou Khadra, S.H., A.E.B. Shaimaa, E.A.T. Salah and E.E.E. Dina (2013). Effect of intercropping wheat with sugar beet on their productivity and land use. J.Agric. R.es. Kafr El-Sheikh Univ., 39:37-53.

Abou-Kheira, A.A. (2009). Micromanagement of deficit – irrigated peanut with sprinkler irrigation. Agric. Water Manage, 9 (2009)1409 – 1420.

Ahmed M.A.El-Sherif1 and M. M. Ali (2015) Effect of deficit irrigation and soybean/maize intercropping on yield and water use efficiency. *Int.J.Curr.Microbiol.App.Sci* 4(12): 777-794.

Ali, M.H.; M.R. Hoque; A.A. Hassan and A. khair (2007). Effects of deficit irrigation on yield, water productivity and economic returns of wheat. Agricultural water management, 92 (3): 151-161.

Amer, A.H; O.M. Sawan, and S.R. Salman (2002).Water requirements of snap bean (*phaseolus vulgaris*, L.) as affected by sowing date under newly reclaimed soil at Shark El-Owinat region . J .Agric .Sic. Mansoura Uinv., 27:6097-6107.

Beyazgul M., Y. Kayam and F. Engelsman (2000). Estimation methods for crop water requirements in the Gediz Basin of western Turkey. Journal of Hydrology. 229: 19-26.

Buan , U.A. E. (2002). Studies on water requirements of some fabaceae crops. M. Sc. Thesis, Fac. Agric., Ain Shams Univ. Egypt.

Demir A.O., A.T. Goksoy, H. Buyukcangaz, Z.M. Turan and E.S. Koksal (2006). Deficit irrigation of sunflower (*Helianthus annuus* L.) in a sub-humid climate. Irrigation Science. 24: 279-289.

Doornbos, J. and Pruit W.O. (1975). Crop water requirements. Irrigation and Drainage Paper, No. 24, FAO Rome.

El-Shamy M.A., E.A. Moursi, and M. A.M.EL-Mansoury (2015). Maximizing water productivity by intercropping onion on sugar beet in the North Middle Delta Region. J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol.8

Goksoy, A.T., A.O. Demir, Z.M. Turan and N. Dagusta, (2004). Responses of sunflower (Helianthus annuus L.) to full and limited irrigation at different growth stages. Field Crops Res., 87: 167-178.

Gomez, K.A. and A. Gomez (1984). Statistical procedures for agricultural research. 1st ed. John Willey & Sons, New York.

Hansen, V.W., Israelsen and Stringharm Q.E. (1979). Irrigation principles and practices, 4th ed., John Willey and Sons, New York.

Jackson, M.L. (1973). Soil chemical analysis. Prentice Hall of India, Private Ltd. New Delhi.

James, L.G. (1988). Principles of farm irrigation system design. John Willey and Sons Inc., New York, 543.

Klute, A. (1986). Water retention: laboratory methods: In: A. Koute (ed). Methods of soil analysis, Part 1, 2nd ed. Agron. Monogr. 9, ASA, Madison, W1, USA, pp. 635-660.

Mahender, S.H., T. Singh, R.K. Jhorar, B.P. Singh, M. Singh, H. Singh and T. Singh. (2000). Seed yield water use and water-use efficiency of sunflower (*Helianthus annuus* L.) genotypes under irrigation and nitrogen variables. *Ind. J. Agron*., 45: 188-192.

Michael, A. M. (1978). Irrigation – Theory and practices. Vikas Publishing House, New Delhi.

Nawar, F. R. R. and A. A. Al-Kafoury (2002) Effect of tillage system and some intercropping pattern on yield of Maize and soybean in reclaimed land. J .Agric .Sic. Mansoura Uin., 27(2):725-732.

Nofal, F. A. E. and R. A. Attalla (2006) Intercropping efficiency of some Maize hybrids on peanut in sandy soils. J .Agric .Sci. Mansoura Uinv., 31(1):1-16.

Olowe, V.I.O., J.A. Ajayi, and A.S. Ogunbayo (2006). Potential of intercropping soybeans (*Glycine max* (L.) Merrill and cowpea (*Vigna unguiculata* L. Walp) with sunflower (*Helianthus annuus* L.) in the transition zone of south west Nigeria. *Tropical Agricultural Research and Extension*, 9, 91–96.

Ouda , S. A., T. El Mesiry, E. F. Abdallah and M. S. Gaballah (2007). Effect of water stress on the yield of soybean and Maize grown under different intercropping patterns. Australian Journal of Basic and Applied Sciences, 1(4):578-585.

Santonoceto, C., U. Anastasi, E. Riggi and V. Abbate. (2003). Accumulation dynamics of dry matter, oil and major fatty acids in sunflower seeds in relation to genotype and water regime. *Italian J. Agron*., 7: 3-14.

Sawan, O. M.; Amer, A. H. and El-Desuki, M. (2001). Effect of irrigation and organic fertilizer on sugar pea (Pisum sativum, L.) under Shark El-Owinat condition.Ann. Agric. Sci. Moshtohor, 39(2): 1251-1264.

Sudo, A., J.G.M. Guerra, D.L. Almeida, and R.L.D. Ribeiro (1998).Cultivo consorciado de cenoura e alface sob manejo organic. CNPAB, Seropedica.

Tsubo, M., E. Mukhala, H. O. Ogindo and S. Walker (2003). Productivity of maize-bean intercropping in a semi-arid region of South Africa. Water South Africa. 29:381-388.

Waller, R.A. and D.B. Duncan(1969). Symmetric multiple comparison problem. Amer. Stat. Assoc. December, 1485-1503.

Willey, R.W. (1979). Intercropping: Its importance and research needs. Part1. Competition and yield advantages. Field Crop Abstr., 32:1-10.

Yildirim, E. and I. Guvenc (2005). Intercropping Based on Cauliflower: More Productive, Profitable and Highly Sustainable". European Journal of Agronomy, 22, 11-1.8.

Zegada-Lizarazu, W., Y. Izumi, and M. Iijima (2006). Water competition of intercropped pearl millet with cowpea under drought and soil compaction stresses. Plant Prod. Sci. 9, 123–132.

تاثير جدولة الري لتكثيف عباد الشمس مع لوبيا العلف علي النمو والمحصول ومكوناته.

رضا خالد درويش[1]، منى عبدالحليم المنصورى[1] و مشيرة أحمد ابراهيم الشامى[2]
1- معهد بحوث الأراضى والمياة والبيئة - مركز البحوث الزراعية - الجيزة- مصر.
2- قسم بحوث التكثيف المحصولى- معهد بحوث المحاصيل الحقلية- مركز البحوث الزراعية-الجيزة- مصر.

اقيمت تجربتان حقليتان بمحطة البحوث الزراعية بسخا - كفر الشيخ لمنطقة شمال الدلتا خلال موسمى 2013 ، 2014م لمعرفة تأثير جدولة الرى وتحميل لوبيا العلف علي عباد الشمس وأثر ذلك علي العائد المحصولي من وحدة الماء المضاف والعلاقات المائية لمحصولي عباد الشمس ولوبيا العلف وكان التصميم الاحصائى المستخدم هو القطع المنشقة مرة واحدة فى 3 مكررات.
وكانت المعاملات:-

1- القطع الرئيسية (جدولة الري):-

- الري عند فقد 50% من الماء الميسر باستخدام البخر تجميعي من وعاء البخر(I_1).
- الري عند فقد 65% من الماء الميسر باستخدام البخر تجميعي من وعاء البخر(I_2).
- الري عند فقد 80% من الماء الميسر باستخدام البخر تجميعي من وعاء البخر(I_3).

2- القطع التحت رئيسية (نظم التحميل):-

- زراعة عباد الشمس واللوبيا بمعدل 1:1 مع الحفاظ علي الكثافة النباتية للمحصولين 100% عباد الشمس و100% لوبيا علف.(P_1)
- زراعة عباد الشمس واللوبيا بمعدل 2:1 مع الحفاظ علي أن تكون الكثافة النباتية 66.6 % عباد الشمس و133.3 % لوبيا علف (P_2)
- زراعة 100% عباد شمس فقط (P_3)
- زراعة 100% لوبيا علف فقط (P_4)

وكانت اهم النتائج المتحصل عليها:-

سجلت المعاملة I_1 اعلي القيم للماء المضاف وكذلك المستهلك في الموسمين وكانت القيم 57.9 و 59.1 سم للماء المضاف 48.9 و 50.3 سم للماء المستهلك في الموسم الاول والثاني علي التوالي. العائد المحصولى من وحدة المياه المضافةPIW والمستهلكهWP سجلت تحت المعاملة I_3 (اقل المعاملات للماء المضاف والمستهلك) لمحصولي عباد الشمس واللوبيا في الموسمين ثم تتناقص القيم تدريجيا مع ويادة الماء المضاف. أما بالنسبة لتاثير نظام التحميل فأن التحميل 2:1 عباد شمس/ لوبيا علف أعلي القيم وكانت النتائج بالنسبة للـ PIW 0.368 و 0.352 كجم م-3 + 0.746 و 0.714 كجم/ م-3 للوبيا العلف للموسمين على الترتيب وأخذت WP نفس الاتجاه في الموسمين.

هناك اختلافات معنوية بين المعاملات المدروسة لكل من المحصول ومكوناته لمحصول عباد الشمس متأثرة بجدولة الري وكذلك نظم التحميل في الموسمين فقد وجد أن كل من طول النبات ، قطر الساق ، قطر القرص ، وزن الحبوب في القرص ، وزن 100 حبة ، محصول الحبوب الكلي و النسبة المئوية للزيت أعطت اعلي القيم تحت معاملة الري I_2 ونظام التحميل 2:1 عباد شمس / لوبيا علف. أوضحت النتائج ايضا أن كل صفات نمو لوبيا العلف وكذلك المحصول ومكوناته من طول نبات ، وقطر ساق ، وعدد الاوراق في النبات ، وزن الحبوب الجافة للفدان ، وزن الماده الجافة وكل من النسبة المئوية للبروتين والماده الجافة والالياف كلها سجلت أعلي القيم تحت معاملة الري I_2 ونظام التحميل 2:1 عباد شمس / لوبيا علف أيضا. بالنسبة لقيم المكافئ الأرضى (LER) فأن المعامله I_3 سجلت أعلي القيم بينما I_2 سجلت أعلي القيم لاجمالى الدخل. بالنسبة لتأثير معاملات التحميل علي المكافئ الأرضى واجمالى الدخل فإن نظام التحميل 2:1 عباد شمس / لوبيا علف P_2 سجل أعلي القيم.

وعليـــة فتوصي الدراسة بتحميل محصول عباد الشمس مع لوبيا العلف بنظام 2:1 عباد شمس / لوبيا علف وريهم كل حوالي من 10-12 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.