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TOWARDS EFFECTIVE IRRIGATION MANAGEMENT FOR COTTON CROP UNDER DIFFERENT CULTIVATION METHODS IN THE NORTH MIDDLE NILE DELTA REGION.

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ABSTRACT

A field investigation was conducted at Sakha Agricultural Research Station (31^0 07¯ N Latitude and 30^0 57¯ E longitude) with an elevation of about 6 metres above mean sea level, Kafr El-Sheikh Governorate during the two successive summer growing seasons 2013 and 2014 to investigate the effect of cultivation methods and irrigation treatments (irrigation scheduling treatments) on seed cotton yield, some yield attributes, seed oil percentage and some water relations in the North Middle Nile Delta region. A split plot design with four replicates was used in this present investigation, where, the main treatments were randomly assigned by cultivation methods (A), where A_1 (cultivation on normal furrows with width, 60 cm., normal cultivation) and A_2 (cultivation on wide furrows with width, 120 cm., and cultivation process performed on two sides (raised-beds), while sub-main treatments were also randomly assigned by irrigation treatments (irrigation scheduling treatments), I_0 (traditional irrigation, like to practise by local farmers in the studied area), I_1 (irrigation with 1.4 Ep), I_2 (irrigation with 1.2 Ep) I_3 (irrigation with 1.0 Ep) and I_4 (irrigation with 0.8 Ep).

❖ **The main results can be summarized as follows:-**

The highest seasonal values for applied water, consumptive use and stored water in the effective root zone were recorded under cultivation method (A_1) in comparison with cultivation method (A_2) and the overall mean values through the two growing seasons are 3847.05 and 3636.48 m^3/ fed. For seasonal applied water, 2629.18 and 2442.74 m^3/ fed. for consumptive use and 2743.93 and 2612.73 m^3/ fed. for stored water in the effective root zone under cultivation methods (A_1) and (A_2), respectively. Regarding, the effect of irrigation treatments (irrigation scheduling treatments), the highest mean values for the abovementioned three studied parameters were recorded under irrigation treatment (I_0) in the two growing seasons comparing with other irrigation treatments I_1, I_2, I_3 and I_4. The highest overall mean values through the two growing seasons are 4309.37 and 4122.46 m^3/ fed. for seasonal applied water, 2917.74 and 2760.81 m^3/ fed. for consumptive use and 3125.44 and 2900.24 m^3/ fed. for stored water in the effective root zone under cultivation method (A_1) and (A_2), respectively. Generally, the overall mean values for the abovementioned three studied parameters can be descended in the order according to the effect of irrigation treatments as follows $I_0 > I_1 > I_2 > I_3 > I_4$.

Concerning the effect of cultivation methods and irrigation treatments on the studied irrigation efficiencies. The highest overall mean values through the two growing seasons were recorded under cultivation method (A_2) comparing with cultivation method (A_1) and the values are 72.10 and 71.43% for water application efficiency, 0.60 and 0.52 kg/ m^3 for water productivity and 0.41 and 0.35 kg/ m^3 for productivity of irrigation water under cultivation method (A_2) and (A_1), respectively. Meanwhile, for consumptive use efficiency, the highest overall mean values were recoded under cultivation method (A_1) in comparison with (A_2) and the values are 68.51 and 67.35% for (A_1) and (A_2), respectively. Regarding, the effect of irrigation treatments under the two cultivation methods on the abovementioned studied efficiencies. The highest mean values for water application efficiency and consumptive use efficiency were recorded under irrigation treatment I_4 and the values are 74.04 and 76.37% for water application efficiency and 71.76 and 70.11% for consumptive use efficiency under (A_1) and (A_2), respectively. On the other hand, the other irrigation efficiencies water productivity (WP) and productivity of irrigation water (PIW), the highest mean values were recorded under irrigation treatment (I_3) and the values are 0.66 and 0.78 kg/ m^3 for (WP) and 0.45 and 0.52 kg/ m^3 for PIW under A_1 and A_2, respectively.

Concerning, the effect of cultivation methods and irrigation treatments on seed cotton yield, some yield attributes such as plant height (cm.), ball weight (g), number of green balls/ plant and cotton seed oil percentage were recorded under cultivation method (A_2) and irrigation treatment (I_3).

Keywords: Cultivation methods – irrigation scheduling – cotton yield.

INTRODUCATION

Cotton is the most important fiber crop used for making textile materials. It can be used in making a wide range of products, from diapers to explosives. It also still ranks as a major source of national income in Egypt. Cotton productivity depends upon a large number of environmental factors such as crop and water management. An amount of irrigation water of cotton is 3400 and 4700 m^3/ fed. which has been recommended by Ministry of Water Resources and Irrigation for lower and upper Egypt, respectively. On the other hand, Ministry of Agriculture and land reclamation in their publications (1961 up till now) devoted farmers to schedule cotton irrigation to be every 15 and 10 days for lower and upper Egypt, respectively. Egyptian cotton also has a good reputation worldwide by its good technological characteristics. So, it considers the first export crop and it plays an important role in increasing our national income because it is a vital source for hard currency. Finally, we should be in a close co-operation with the government to increase production of this crop qualitatively and quantitively but this need to exert more due care for this crop from different aspects, where one of these processes is irrigation which requires a strict control on it to obtain a good yield finally.

The problem of limited water supply is becoming more and more urgent to solve in Egypt due to the following features of water status. Arable land in Egypt is entirely most dependent on artificial irrigation because of the semi-arid climate of Egypt and the main source for fresh water is the Nile River. Its sources are beyond the boundaries of Egypt, which constitute one of the tail end countries of the Nile basin. Egypt is annual share of the Nile water is 55.5 milliard cubic metre. Other water resources such as groundwater, rainfall and reusing of drainage water which are less in magnitude. Irrigation is the main sector in water demand at the national level. Water allocated to irrigation is more than 85% from the total renewable water. So, effective water management at the irrigation sector is the principal way towards rationalization policy for the country. In this aspect, Egypt is in a bad need to make irrigation management on the farm level in order to decrease water losses either by careless irrigation or by decreasing surface irrigation system efficiency which is about 60% or less. To solve the problem of limitation of irrigation water resources a lot of ideas have been raised nowadays some of them were used in this present study such as cultivation on wide furrows (raised-beds technique) instead of cultivation on normal furrows (normal cultivation method) where raised-beds decreasing irrigation inlets, this technique tested on some field and vegetable crops and proved effective in increasing crop and water use efficiency, *Raut et al., (2000) and Anonymous (2006).* The second procedure that be used in this work identification when to irrigate and how much water should be applied (irrigation scheduling).

Irrigation scheduling is the decision of when and how much water to apply to a field. Its purpose is to maximize irrigation efficiencies by applying the exact amount of water needed to replenish the soil moisture to the desired level. It saves water and energy, *Jensen (1980).* It has been described as the primary tool to improve water use efficiency, increase crop yields, increase the availability of water resources and provoke a positive effect on the quality of soil and groundwater, *FAO (1996).* Use the increasing needs of water for the agricultural and non-agricultural activities require that, the available water resources, both surface and groundwater, efficiently and carefully, proper irrigation scheduling makes it possible to use water prudently.

The meteorological based irrigation scheduling approach, such as pan evaporation replenishment, cumulative pan evaporation (CPE) etc., was used by many researchers *(Singh et al; 1997 and Khalil et al; 2006)* have extensively tested the technique of using pan evaporation for irrigation scheduling. It proved to save up to 20% of the applied irrigation water by farmers. Therefore, under Egyptian conditions, extension agricultural is recommended scheduling irrigation using pan evaporation technique to the farmers as a way to conserve irrigation water.

For the abovementioned facts about the urgent rapidly solving for irrigation water problem and the importance of cotton crop. So, the main target for this study was to maximize the value of water unit by using irrigation scheduling technique (class A pan evaporation) under two planting methods normal and wide furrows (raised-beds) on seed cotton yield, some yield attributes seed oil content (%) and some water relations to find out the most suitable planting method and irrigation treatment to maximize irrigation water efficiencies and cotton yield.

MATERIALS AND METHODS

A field investigation was conducted at Sakha Agricultural Research Station, kafr El–Sheikh Governorate during the two successive summer growing season 2013 and 2014 to study the effect of cultivation method and irrigation treatments (irrigation scheduling by using class A pan evaporation) on seed cotton yield, some yield attributes, seed oil percentage (%) and some water relations. The experimental site represents the circumstances and conditions of the North Middle Nile Delta region which allocated at 31^{o}-07' N latitude, 30^{o}-57' E longitude with an elevation of about 6 metres above mean sea level. Soil samples from different depths at the experimental site were collected each (20 cm.) soil depth up to 60 cm. and analyzed for some physical and chemical characteristics. Some physical and chemical characteristics were shown in Tables (1and 2). The soil texture in the experimental field is clay as shown in Table (1). Meteorological data for the two studied growing seasons which obtained from Sakha Meteorological Station was recorded in Table (3). All agricultural practices were performed as recommended for the studied crop and the area except the tested treatments.

Table (1): The mean values for some physical characteristics of the studied experimental site before cultivation in the two growing seasons.

Soil Depth, cm.	Particle Size Distribution			Texture classes	F.C %	P.W.P %	AW %	Bd Mg/m^3
	Clay %	Silt %	Sand%					
0 – 20	57.05	23.45	19.50	Clay	43.00	22.00	21.00	1.14
20 – 40	59.04	22.74	18.22	Clay	40.00	21.00	19.00	1.24
40 – 60	60.32	22.31	17.37	Clay	39.00	21.00	18.00	1.32
Mean	58.80	22.83	18.36	Clay	40.70	21.33	19.33	1.23

Where:-

F.C % = Soil field capacity,
P.W.P % = Permanent wilting point,
AW % = Available water and
Bd, Mg/m^3 = Soil bulk density.

Table (2): The mean values for some chemical characteristics of the studied experimental site before cultivation in the two growing seasons.

Soil Depth,Cm	SAR	EC, ds /m	Soluble ions, meq/l							
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{--}	Cl^{-}	SO_4^{--}
0 – 20	7.12	1.92	4.04	2.22	12.62	0.18	0.00	5.50	8.82	4.74
20 – 40	7.16	1.89	4.08	2.20	12.68	0.18	0.00	5.40	8.88	4.86
40 – 60	7.19	1.93	4.16	2.28	12.90	0.16	0.00	5.50	9.02	4.98
Mean	7.16	1.91	4.09	2.23	12.73	0.17	0.00	5.47	8.91	4.84

Note: SO_4^{--} was calculated by difference between cations and anion.

Physical and chemical characteristics of the studied experimental site:-

Physical characteristics:

1-Field capacity (F.C., %)

Field capacity was determined under field conditions in the experimental site. A uniform 9 m^2 soil area (3m * 3m) was selected, weeds, gravels, stones and pebbles were removed and the area was bound from all sides with a ridge. The area was then filled with sufficient water till complete saturation. The area was covered with a plastic sheet to prevent evaporation from soil surface to determine the soil moisture content. Soil samples were taken daily from about the middle of the surround area for each successive 15 cm soil depth till the effective root zone of 60 cm. The samples were immediately transferred in tightly closed aluminum cans to laboratory where they were weighed and dried at 105 C^0 and moisture content was determined when soil moisture values were nearly the same. Such soil moisture values were then considered as the field capacity which represents as the upper limit of the available water to be used by the growing plants.

2-Permanent wilting point (P.W.P. %):

Permanent wilting point was determined by using pressure membrane apparatus *(*James, 1988*)* and moisture content at a tension of 15 bar which is considered the lower limit of the available water.

3-Available water (AW, %)

Available water was determined according to *(*James, 1988*).*

4-Bulk density (Mg/ m^3):

Bulk density was measured by using the core method (Klute, 1986*)* using a metallic cylinder with a sharp edge obtaining samples of a diameter of 4.5 cm. and a height of 5.8 cm. cylinders were pressed gently into the soil to the desired depth and carefully removed to obtain the undisturbed soil samples. Samples were oven dried at 105 C^0 for 24 h, and dry soil was weighed. Bulk density was then calculated as follows:

$$Bd = W / V$$

Where:

Bd = Soil bulk density (Mg/ m^3),
W = Weight of oven dry soil and
V = Volume of soil container in m^3.

5-The particle size distribution (%)

The particle size distribution was determined according to the international method of *(Klute, 1986),* to obtain the soil texture. The obtained results indicated that the soil is clay in texture and the soil profile is uniform without distinct change in texture.

Chemical characteristics

Chemical characteristics for the studied area such as total soluble salts (soil, EC), both soluble cations and anions were determined according to the methods described by *(Jackson, 1973).* But So_4^{--} calculated by difference. Sodium adsorption ratio (SAR) was calculated according to the following equation:

$$SAR = \frac{Na}{\sqrt{\frac{(Ca^{++} + Mg^{++})}{2}}}$$

Where:-

SAR = Sodium adsorption ratio,
Na^+ = Soluble sodium in meq/ L,
Ca^{++} = Soluble calcium in meq/ L and
Mg^{++} = Soluble magnesium in meq/ L.

Table (3): Some meteorological data for the studied region during the two growing seasons (2013 and 2014).

a- 2013 season.

Month	T (C^0)			RH (%)			W_s	Pan	Rain
	Max	Min	Mean	Max	Min	Mean	m/sec	Evap., mm.	Mm
April	26.04	15.87	20.96	74.20	43.90	59.05	1.11	5.05	20.25
May	31.43	21.81	26.62	75.03	45.78	60.41	1.19	6.13	00.00
June	32.44	23.97	28.21	74.63	51.27	62.95	1.34	6.61	00.00
July	32.32	24.31	28.32	79.57	54.70	67.14	1.28	6.11	00.00
Aug.	33.79	24.76	29.28	83.63	60.52	72.08	1.04	5.13	00.00
Sep.	32.50	22.93	27.72	81.00	56.60	68.80	1.01	3.82	00.00
Oct.	27.79	19.42	23.61	76.23	57.36	66.80	1.26	2.87	00.00

b- 2014 season.

Month	T (C^0)			RH (%)			W	Pan Evap. mm.	Rain Mm
	Max	Min	m/sec	Max	Min	Mean	m/sec		
April	27.50	15.53	21.52	81.80	49.80	65.8	1.07	4.91	20.2
May	30.47	19.57	25.02	77.20	48.60	62.90	1.14	5.87	0.00
June	32.65	20.6	26.63	86.23	52.30	69.27	0.95	6.56	0.00
July	33.15	23.64	28.40	83.19	55.11	69.15	1.13	7.73	0.00
Aug.	34.10	21.80	27.95	92.40	53.50	72.95	1.15	8.14	0.00
Sep.	32.49	20.76	26.63	87.57	52.20	69.89	1.03	6.65	0.00
Oct.	29.75	18.75	24.25	80.92	53.39	67.16	0.95	4.51	0.00

Experimental layout:

Cotton variety Giza 86 as a summer crop was planted on 13rd and 17th April and harvested on 1st October and 8th October in the first and second growing seasons, respectively. All farming practices were performed the same as recommended for the studied crop and area except the studied treatments (cultivation methods) and (irrigation scheduling treatments by pan evaporation). The actual area of the experimental irrigation plot was 60 m^2 (6 m in length * 10 m in width). Meanwhile, the actual area for each cultivation method was 720 m^2 (10 m width * 72 m length). These plots were arranged in a split plot design with three replicates in both growing seasons. The mean plots were randomly assigned by cultivation methods. While, sub-main plots were also randomly assigned by irrigation treatments (irrigation scheduling treatments).

A – Main treatments (cultivation methods, A)

A_1 = Cultivation on normal furrows with width 60 cm. (traditional method), and

A_2 = Cultivation on wide furrows (raised – beds technique) with width (120 cm.) and cultivation process was performed on two sides.

B – Sub-main treatments (irrigation scheduling treatments, I)

I_0=Traditional irrigation like to practise by local farmers in the studied area (control treatment)

I_1 = Irrigation with 1.4 Ep,

I_2 = Irrigation with 1.2 Ep,

I_3 = Irrigation with 1.0 Ep, and

I_4 = Irrigation with 0.8 Ep.

Scheduling of Irrigation:

Irrigation scheduling is the decision of when and how much water to apply to a field. In the present study, the daily class A type, pan evaporation records, by estimating the effective evaporation pan coefficient (Ef) was used *(Jensen and middleton, 1965).* This method is recently widely used to schedule irrigation for field and vegetable crops by many researchers, among of them *Eid et al (1982), Sadik et al (1996), and Rayan et al. (2000) and Ibrahim et al (2003)*. The evaporation pan method is simple, inexpensive, and readily understandable way to estimate irrigated crop water use. The scheduling by this method needs for the determination of the amount of water to be applied at each irrigation and the equivalent amount of evaporation, i.e., usable moisture and usable evaporation, as it will be shown later.

Class A pan evaporation:

Many different types of evaporation pans are being used. The best known pans are the Class A evaporation pan. This kind of pan is very common to determine evaporation rate. It is usually 120.7 cm in diameter and 25 cm deep. It is made of galvanized iron or Monel metal (0.8 mm). The pan is mounted on a wooden open frame platform which is 15 cm above ground level. The soil built up to within 5 cm of the bottom of the pan. The pan must be level. The pan is filled with water to 5 cm below the rim, and the The water level should be not allowed to drop to more than 7.5 cm below the rim. The water should be regularly renewed, at least weekly, to eliminate extreme turbidity. The pan, if galvanized, is painted annually with aluminum paint. Screens over the pan are not a standard requirement and should preferably not be used. Pan should be protected by fences to keep animals from drinking (*Allen et al., 1998*). Pan readings are taken daily in the early morning at the same time that precipitation is measured. Measurements are made in stilling well that is situated in the pan the pan near one edge. The stilling well is a metal cylinder of about 10 cm in diameter and 20 cm deep with a small hole at the bottom.

1- The pan is installed in the field.
2- The pan is filled with a known quantity of water (the surface area of the pan is known and the water depth is measured)
3- The water is allowed to evaporate during a certain period of time (usually 24 hours). For example, each morning at 7 oʾ clock a measurement is taken. The rainfall, if any, is measured simultaneously.
4- After 24 hours, the remaining quantity of water (i.e. water depth) is measured.
5- The amount of evaporation per time unit (the difference between the two measured water depths) is calculated; this is the pan evaporation: E pan (in mm/ 24 hours). The evaporation pan data through the two growing seasons are given in Table (3).
6- The E pan is multiplied by a pan coefficient, K pan, to obtain ET_0.

*** Data collection:-**

Crop – water relation parameters

1-Amount of irrigation applied water (m^3/ fed.)

Amount of irrigation applied water for each irrigation was measured and then seasonal applied water was recorded by using cut throat flume (30 * 90 cm) during the whole growing season and calculated as m^3/ fed. according to (Early, 1975).

2-Water consumptive use (m^3/ fed.):

To compute the actual consumed water of the growing plants, soil moisture percentage was determined (on weight basis) before and after each irrigation as well as at harvesting. Soil samples for moisture determination were taken from successive soil layers each 20 cm. depth for a total depth of 60 cm. form the soil surface by using a regular auger. The soil samples were weighed after sampling immediately and dried in an electric oven to a constant weight at 105 ^oC. Percentage of soil moisture content at the three soil depths (0-20, 20-40, and 40-60 cm.) was calculated on oven dry basis. The amount of water consumed in each irrigation was obtained from the difference between soil moisture content after and before the following irrigation. Water consumptive use by growing plants was calculated based on soil moisture depletion (SMD) according to Hansen *et al.*, (1979).

$$\textbf{Cu = SMD} = \sum_{i=1}^{i=N} \frac{\theta_2 - \theta_1}{100} \ \textbf{* Dbi * Di * 4200}$$

Where:

CU = Water consumptive use in the effective root zone (60 cm),

Θ_2 = Gravimetric soil moisture percentage after irrigation,

Θ_1= Gravimetric soil moisture percentage before irrigation,

Dbi = soil bulk density (Mg/m^3) for depth,

D_i = soil layer depth (20 cm) and

i = number of soil layers (1-3) depth.

3- Stored water in the effective root zone (m^3/ fed.):

Seasonal stored water (SW) in the effective root zone was calculated by using the following equation:-

$$\textbf{SW} = \sum_{i=1}^{i=N} \left\{ \left[(\theta 2 - \theta 1) * Dbi * di * 4200 \right] / 100 \right\}$$

Where:

SW = Seasonal stored water in the effective root zone m^3/ fed.,

Θ_2 = Soil moisture % after irrigation in the i th layer,

Θ_1= Soil moisture % before irrigation in the i th layer, (i.e. directly, before and after the same irrigation.)

Dbi = Soil bulk density (Mg/m^3) for the given depth,

D_i = Soil layer depth (20 cm) and

i = number of soil layers (1-3).

4-Irrigation water efficiencies:

Irrigation application efficiency (Ea %):

Values of irrigation application efficiency (Ea) percent for each treatment were obtained by dividing the total stored water in the effective root zone on the irrigation applied water (Downy, 1970).

Ea = (SW/ Wa) * 100

Where:

Ea = Water application efficiency (%),

SW = Stored water in the effective root zone and

Wa = applied water to the field plot.

Consumptive use efficiency (Ecu):

Values of consumptive use efficiency (Ecu) was calculated according to Bos (1980).

Ecu = (ETc / Wa) *100

Where:

Ecu = Consumptive use efficiency (%),

ETc = Total evapotranspiration ~ consumptive use and

Wa = applied water to the field.

Water productivity (WP, kg/m^3)

Water productivity is generally defined as crop yield per cubic metre of water consumption. Water productivity can be also defined as crop production per unit amount of water used (Molden, 1997). Concept of water productivity in agricultural production systems is focused on producing more food with the same water resources or producing the same amount of food with less water resources. It was calculated according to (Ali *et al.*, 2007).

$$\textbf{WP} = \frac{Y}{ET}$$

Where:

WP = water productivity (kg seed /m^3),

Y = Seed cotton yield (kg/fed) and

ET=Total water consumption, m^3/ fed or consumptive use.

productivity of irrigation water (PIW)

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

PIW = Y/ Wa

Where:

PIW = productivity of irrigation water (kg /m^3),

Y = Seed cotton yield kg/fed and

Wa = Applied water to the field m^3.

Growth parameters

1-Plant height (cm.)

Cotton plant height was measured at the end of growing season. Samples of ten plants were chosen randomly from each treatment and were measured by a tape from the coty ledonary nodes to the top of the plant.

*** Yield and yield components:**

Seed cotton yield obtained from each plot (area of 6 * 10 m2 or 1/70 fed.) was weighed. Seed cotton yield was calculated in kentar/ fed. (one kentar = 157.5 kg.)

$$\textbf{Yield (kentar/ fed.)} = \frac{\textbf{yield per plot in kg}}{\textbf{157.5}} \ \textbf{* 70}$$

The following variables contributing cotton yield were studied

1-Boll weight (g):

It was determined by recording the mean boll weight in grams.

2-Number of green bolls/ plant:

It was determined by recording the total number of green bolls/ plant.

3-Seed oil percentage:

Hexan extraction was used for extracting oil from cotton seeds by using soxholet apparatus according to the method of *A.O.A.C. (1965).*

Statistical analysis:

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) as published by *Gomez and Gomez (1984).* Means of the treatment were compared by the least significant difference (LSD) at 5 % level of significance which developed by *Waller and Duncan (1969).*

RESULTS AND DISCUSSION

Effect of cultivation methods and irrigation treatments on

1-Amount of seasonal applied water (m^3/ fed.)

Cotton is a summer crop, which grows in Egypt under artificial watering because there is no rainfall during summer months in Egypt. Amounts of irrigation applied water throughout the growing season for different treatments were presented in Table (4), data in this Table clearly illustrated that the amount of seasonal applied water was affected by both cultivation methods and irrigation treatments (irrigation scheduling treatments) by using class A pan evaporation. Concerning, the effect of cultivation methods on seasonal amount of applied water. The highest seasonal values were recorded under normal furrows (60 cm.) a part comparing with wide furrows (120 cm., raised bed) in the two growing seasons. The overall mean values are 3847.05 and 3636.48 m^3/ fed. under normal and wide furrows, respectively. This means that the amount of water saving between the two cultivation methods is 210.57 m^3/ fed. Generally, under all treatments of irrigation scheduling by using class A pan evaporation the values of applied water were higher under normal furrows in comparison with wide furrows (raised bed cultivation). Increasing amount of seasonal applied water under normal furrows might be attributed to two reasons, the first one is increasing number of irrigation inlets and the second one is increasing irrigated area because of increasing number of water ways per faddan and hence, increasing time of watering. Therefore, increasing amount of applied water under normal cultivation method in comparison with wide furrows which considers more practical and appropriate mean for on farm effective water management because it has both irrigation inlets, water ways and little irrigated area. These results are in a great harmony with those obtained by *(Raut et al., 2000), Kassab, M. M. (2003), Meleha, (2000), Anonymous, (2006) and Mona. S. M. Eid (2012).* They showed that wide furrows (raised-bed planting) irrigation is technique that can be easily implemented by the farmers. It can lead to saving applied water as compared with farmers' practices (normal cultivation).

Table (4): Effect of cultivation methods and irrigation treatments on amount of seasonal applied water (m^3/ fed.) of cotton crop in heavy clay soils in the two growing seasons.

Cultivation methods (A) / Irrigation treatments (I)	1st growing season		2nd growing season		The mean values through the two growing seasons	
	Cultivation methods		Cultivation methods			
	Normal furrows (60 cm) A_1	Wide furrows (120 cm) raised – beds A_2	Normal furrows (60 cm) A_1	Wide furrows (120 cm) raised – beds A_2	Normal furrows (60 cm) A_1	Wide furrows (120 cm) raised – beds A_2
I_0	4325.81	4189.25	4292.92	4055.67	4309.37	4122.46
I_1	4215.17	3989.15	4117.12	3870.16	4166.15	3929.66
I_2	3864.15	3732.59	3902.95	3689.32	3883.55	3710.96
I_3	3653.08	3482.91	3533.74	3237.63	3593.41	3360.27
I_4	3307.50	3011.97	3258.08	3106.11	3282.79	3059.04
Overall mean	3873.14	3681.17	3820.96	3591.78	3847.05	3636.48

Regarding, the effect of irrigation treatments (irrigation scheduling treatments), data in the same Table clearly showed that irrigation scheduling treatments have a great effect on amount of seasonal mean values of applied water in the two growing seasons. The highest overall mean values during the two growing seasons were recorded under irrigation treatment (I_0) and the mean values are 4309.37 and 4122.46 m^3/ fed. On the other hand, the lowest mean values were recorded under irrigation treatment (I_4) and the mean values are 3847.05 and 3636.48 m^3/ fed. under normal and raised-bed cultivation method, respectively. Generally, the amount of seasonal mean values of applied water can be descended in order $I_0 > I_1 > I_2 > I_3 > I_4$. Increasing the seasonal mean values of applied water under I_0 in comparison with other irrigation treatments I_1, I_2, I_3 and I_4. This may be due to decreasing irrigation interval and so increasing number of watering. Consequently, increasing amount of applied water under the conditions of this treatment. These findings are in agreement with those obtained by *Mannini, P. (1988), Darwesh. R. Kh. A. (2006), Eid et al., (2010), Fuad Hessein et al., (2011), and Mona. S. M. Eid (2012).* Who reported that, the highest amount of applied water was recorded under irrigation treatment I_0 (traditional irrigation) in comparison with other irrigation treatments.

2-Consumptive use (Cu, m^3/ fed.) and amount of stored water (Sw, m^3/ fed.) in the effective root zone.

Presented data in Tables(5 and 6) clearly showed that the mean values of consumptive use and stored water in the effective root zone for cotton crop were affected by both cultivation method and irrigation treatments (irrigation scheduling treatments according to class A pan evaporation). Concerning with, the effect of cultivation methods, the highest overall mean values for the abovementioned two studied parameters were recorded under cultivation on normal furrows (A_1) in comparison with cultivation on wide furrows or which so-called raised-beds (A_2) and the values are 2629.18 and 2743.93 m^3/ fed. On the contrary, the lowest overall mean values were recorded under cultivation method (A_2) and the values are 2442.74 and 2612.73 m^3/ fed for consumptive use and stored water in effective root zone, respectively. Generally, as shown in the same Tables, the overall mean values for stored water were higher than those for consumptive use. Also, the overall mean values for consumptive use and stored water in the effective root zone were higher under cultivation method (A_1) in comparison with cultivation method

(A_2). Increasing the overall mean values for the abovementioned two studied parameters under cultivation method (A_1) comparing with (A_2) may be attributed to increasing amount of applied water due to increasing number of irrigation inlets, waterways, time of irrigation and irrigated area. These findings are in a great harmony with those obtained by *Meleha M.I.(2000), Raut et al. (2000), Kassab, M. M. (2003) and Mona. S. M. Eid (2012).*

Regarding, the effect of irrigation treatments (irrigation scheduling treatments) on both the mean values of consumptive use and stored water in the effective root zone. The highest mean values for the abovementioned two studied parameters were recorded under irrigation treatment I_0 (traditional irrigation) and the mean values are 2917.74 m^3/ fed, 2760.81m^3/ fed for consumptive use and 3125.44 and 2900.24 m^3/ fed. for stored water in the effective root zone. On the other hand, the lowest mean values for the abovementioned two studied parameters were recorded under irrigation treatment I_4 (irrigation with 0.8 Ep) and the values are 2355.45, 2142.75 m^3/ fed for consumptive use and 2430.37 and 2335.48 m^3/ fed under cultivation methods, normal furrows and wide ones (A_1 and A_2), respectively. Generally, under the two cultivation methods, the mean values for consumptive use and stored water in the effective root zone can be descended in order $I_0 > I_1 > I_2 > I_3 > I_4$ in the two growing seasons. Increasing the mean values of consumptive use and stored water in the effective root zone under irrigation treatment (I_0) in comparison with other irrigation treatments I_1, I_2, I_3 and I_4 may be due to decreasing irrigation intervals. Consequently, increasing amount of applied water under the conditions of this treatment where the irrigation intervals can be descended in order $I_4 > I_3 > I_2 > I_1 > I_0$ in the two growing seasons. These results are in a great agreement with those obtained by *Darwesh, R. Kh. A. (2006), Eid et al. (2010) Fuad Hessein et al., (2011) and Mona. S.M. Eid (2012).*

Table (5): Effect of cultivation methods and irrigation treatments on the seasonal mean values of consumptive use (m^3/ fed.) of cotton crop in heavy clay soils in the two growing seasons.

Cultivation methods (A) / Irrigation treatments (I)	1st growing season Cultivation methods		2nd growing season Cultivation methods		The mean values through the two growing seasons	
	Normal furrows (60 cm) A_1	Wide furrows (120 cm) (raised-beds) A_2	Normal furrows (60 cm) A_1	Wide furrows (120 cm) (raised-beds) A_2	Normal furrows (60 cm) A_1	Wide furrows (120 cm) (raised-beds) A_2
I_0	2901.31	2731.17	2934.17	2790.44	2917.74	2760.81
I_1	2743.45	2595.12	2817.12	2610.18	2780.29	2602.65
I_2	2588.77	2418.22	2648.43	2490.70	2618.60	2454.46
I_3	2429.43	2218.88	2518.17	2290.17	2473.80	2254.53
I_4	2362.47	2114.70	2348.42	2170.80	2355.45	2142.75
Overall mean	2605.09	2415.02	2653.26	2470.46	2629.18	2442.74

Table (6): Effect of cultivation methods and irrigation treatments on the amount of stored water (m^3/ fed.) in the effective root zone of cotton crop in heavy clay soils in the two growing seasons.

Cultivation methods (A) / Irrigation treatments (I)	1st growing season Cultivation methods		2nd growing season Cultivation methods		The mean values through the two growing seasons	
	Normal furrows (60 cm) A_1	Wide furrows (120 cm) (raised-beds) A_2	Normal furrows (60 cm) A_1	Wide furrows (120 cm) (raised-beds) A_2	Normal furrows (60 cm) A_1	Wide furrows (120 cm) (raised-beds) A_2
I_0	3110.18	2870.14	3140.70	2930.34	3125.44	2900.24
I_1	2870.18	2730.17	2910.15	2820.20	2890.17	2775.19
I_2	2618.37	2550.34	2770.38	2680.34	2694.38	2615.34
I_3	2544.47	2464.31	2614.14	2410.48	2579.31	2437.40
I_4	2430.39	2340.47	2430.35	2330.48	2430.37	2335.48
Overall mean	2714.72	2591.09	2773.14	2634.37	2743.93	2612.73

3-Water application efficiency (%):

Tabulated data in Table (7) clearly illustrated that, the overall mean values for water application efficiency were affected by cultivation methods and irrigation treatments (irrigation scheduling treatments) in the two growing seasons. Concerning, the effect of cultivation methods the highest overall mean value was recorded under wide furrows cultivation method (A_2) and the value is 72.10%. On the other hand, the lowest overall mean value was recorded under normal cultivation method (A_1) and the value is 71.43%. Increasing the overall mean values for water application efficiency under wide furrows cultivation method (A_2) comparing with normal cultivation one (A_1) because of, decreasing amount of applied water under the conditions of this cultivation method (A_2) as previously mentioned through discussion of applied water. Consequently, increasing the mean values of water application efficiency. These results are in a great harmony with those obtained by Fahong wang *et al.* (2011) and Swelem and Atta (2012).

Table (7): Effect of cultivation methods and irrigation treatments on water application efficiency (%) of cotton crop in heavy clay soils in the two growing seasons.

Irrigation treatments (I) \ Cultivation methods (A)	1st growing season Cultivation methods		2nd growing season Cultivation methods		The mean values through the two growing seasons	
	Normal furrows (60 cm) A_1	Wide furrows (120 cm) (raised-beds) A_2	Normal furrows (60 cm) A_1	Wide furrows (120 cm) (raised-beds) A_2	Normal furrows (60 cm) A_1	Wide furrows (120 cm) (raised-beds) A_2
I_0	71.90	68.51	73.16	72.25	72.53	70.38
I_1	68.09	68.44	70.68	72.87	69.39	70.66
I_2	67.76	68.33	70.98	72.65	69.37	70.49
I_3	69.65	70.75	73.98	74.45	71.82	72.60
I_4	73.48	77.71	74.59	75.03	74.04	76.37
Overall mean	70.18	70.75	72.68	73.45	71.43	72.10

Regarding, the effect of irrigation treatments (irrigation scheduling treatments) on water application efficiency, the mean values were for water application efficiency were clearly affected by irrigation scheduling treatments. As shown in Table (7), the highest mean value was recorded under irrigation treatment I_4 (irrigation with 0.8 Ep) where, elongation of irrigation interval under the conditions of this treatment. Therefore, decreasing amount of applied water because of decreasing number of waterings. So, increasing the mean values of water application efficiency and the overall mean values during the two growing seasons are 74.04 and 76.37 (%) under irrigation treatment I_4 and cultivation methods (A_1 and A_2), respectively. These results are in a great agreement with those reported by Darwesh, R. Kh. A. (2006) and Mona. S. M. Eid (2012).

4-Consumptive use efficiency (ECu, %):

Consumptive use efficiency is a parameter which indicates the capability of plants to utilize the soil moisture stored in the effective root zone. Presented data in Table (8) clearly illustrated that, the overall mean values through the two growing seasons for consumptive use efficiency were affected by both cultivation methods and irrigation treatments. Concerning, the effect of cultivation methods, the highest mean values were recorded under normal furrows (traditional method) comparing with using wide furrows cultivation method (raised-beds technique) and the mean values through the two growing seasons are 68.51 and 67.35% for normal and wide furrows cultivation methods, respectively. Increasing the mean values of consumptive use efficiency under normal furrows comparing with cultivation on wide ones, may be attributed to increasing both seasonal water applied and water consumptive use under the conditions of normal furrows cultivation method. These results are in a great harmony with those obtained by *Mona. S. M. Eid (2012*).

Regarding, the effect of irrigation treatments, the highest mean values were recorded under irrigation treatment I_4 (which exposed to water stress conditions) and the mean values through the two growing seasons are 71.76 and 70.11% under normal and wide furrows cultivation methods, respectively. Increasing the mean values of consumptive use efficiency under the conditions of irrigation treatment I_4 comparing with other irrigation treatments I_0, I_1, I_2 and I_3. Therefore, by decreasing the seasonal water applied higher amount of irrigation water could be beneficially used by the growing plants which resulting in decreasing water losses. These results are in a great agreement with those obtained by Ibrahim and Emara (2009), Ibrahim and Emara (2010), Eid *et al.* (2010), Kassab M.M. (2012) and Mona. S. M. Eid (2012).

Table (8): Effect of cultivation methods and irrigation treatments on consumptive use efficiency (%) of cotton crop in heavy clay soils in the two growing seasons.

Irrigation treatments (I) \ Cultivation methods (A)	1st growing season Cultivation methods		2nd growing season Cultivation methods		The mean values through the two growing seasons	
	Normal furrows (60 cm) A_1	Wide furrows (120 cm) (raised-beds) A_2	Normal furrows (60 cm) A_1	Wide furrows (120 cm) (raised-beds) A_2	Normal furrows (60 cm) A_1	Wide furrows (120 cm) (raised-beds) A_2
I_0	67.07	65.19	68.35	68.80	67.71	67.00
I_1	65.09	65.05	68.42	67.44	66.76	66.25
I_2	66.99	64.79	67.86	67.51	67.43	66.15
I_3	66.50	63.71	71.26	70.74	68.88	67.23
I_4	71.43	70.21	72.08	70.00	71.76	70.11
Overall mean	67.42	65.79	69.59	68.90	68.51	67.35

5-Water productivity (WP) and productivity of irrigation water (PIW, kg/ m^3):

Presented data in Table (9a & 9b) clearly showed that, the overall mean values for the abovementioned two studied parameters (WP) and (PIW) were affected by both cultivation methods and irrigation scheduling treatments (irrigation treatments). Concerning, the effect of cultivation methods on (WP) and (PIW) data in the same Table illustrated that, the highest overall mean values for (WP) and (PIW) were recorded under wide furrows cultivation method (A_2) and the values are 0.60 and 0.41 (kg/ m^3) for (WP and PIW) in comparison with the values under normal furrows cultivation method (A_1) and the values are 0.52 and 0.35 kg/ m^3 for WP and PIW, respectively. Increasing, the overall mean values for WP and PIW under wide furrows cultivation method (A_2) comparing with normal furrows (A_1) may be due to decreasing amount of applied water and consumptive use under the conditions of this cultivation method comparing with normal one which received a large amount of applied water. Consequently, increasing consumptive use and hence decreasing the overall mean values for WP and PIW. These results are in the same line with those reported by *Kassab, M. M. (2003), Fahong wang, et al. (2011), Swelam and Atta (2012) and Mona S. M. Eid (2012).*

Regarding, the effect of irrigation scheduling treatments on the values of WP and PIW. The lowest mean values were recorded under traditional irrigation treatment (I_0) under the same cultivation methods where the mean values are 0.44, 0.49 for WP and 0.29 and 0.33 kg/m^3 for PIW under A_1 and A_2, respectively. As clearly shown in Tables (9a &9b), the stress conditions (elongation of irrigation interval) increased both WP and PIW, because of decreasing amount of applied water and consumptive use under the conditions of this treatment. The highest mean values for WP and PIW were recorded under irrigation treatment I_3 (irrigation with 1.0 Ep) and the values are 0.66 and 0.78 for WP and 0.45 and 0.52 kg/ m^3 under A_1 and A_2, respectively. Generally, the mean values for WP and PIW can be decreased in order $I_3 > I_2 > I_1 > I_4 > I_0$ for the two studied efficiencies, form this data, the irrigation scheduling treatments led to increasing WP and PIW efficiencies comparing with traditional irrigation which practice by local farmers in the studied area. These findings are in a great harmony with those obtained by *Eid et al (2010), Swelam and Atta (2012) and Mona. S. M. Eid (2012).*

Table (9a): Effect of cultivation methods and irrigation treatments on water productivity (WP, kg/ m^3) and productivity of irrigation water (PIW, kg/ m^3) in heavy clay soils in the two growing seasons.

Cultivation Methods (A) / Irrigation treatments(I)	1st growing season				2nd growing season			
	Normal furrows (60 cm.)A_1		Wide furrows (120 cm.) (raised-beds)A_2		Normal furrows (60 cm.)A_1		Wide furrows (120 cm.) (raised-beds)A_2	
	WP (kg/ m^3)	PIW (kg/ m^3)	WP (kg/ m^3)	PIW (kg/ m^3)	WP (kg/ m^3)	PIW (kg/ m^3)	WP (kg/ m^3)	PIW (kg/ m^3)
I_0	0.43	0.28	0.47	0.31	0.45	0.30	0.50	0.35
I_1	0.49	0.32	0.54	0.35	0.50	0.34	0.56	0.38
I_2	0.55	0.36	0.61	0.40	0.55	0.37	0.63	0.43
I_3	0.66	0.44	0.78	0.49	0.65	0.46	0.77	0.54
I_4	0.44	0.31	0.53	0.38	0.47	0.33	0.57	0.40
Overall mean	0.51	0.34	0.59	0.39	0.52	0.36	0.61	0.42

Table (9b): Effect of cultivation methods and irrigation treatments on the mean values of water productivity (WP, kg/ m^3) and productivity of irrigation water (PIW, kg/ m^3) in heavy clay soils in the two growing seasons.

Cultivation Methods (A) / Irrigation Treatments (I)	Normal furrows cultivation method (60 cm.) A_1		Wide furrows cultivation method (120 cm.) (raised-beds) A_2	
	Water productivity (WP, kg/ m^3)	Productivity of irrigation water (PIW, kg/ m^3)	Water productivity (WP, kg/ m^3)	Productivity of irrigation water (PIW, kg/ m^3)
I_0	0.44	0.29	0.49	0.33
I_1	0.50	0.33	0.55	0.37
I_2	0.55	0.37	0.62	0.42
I_3	0.66	0.45	0.78	0.52
I_4	0.46	0.32	0.55	0.39
Overall mean	0.52	0.35	0.60	0.41

Effect of cultivation methods and irrigation treatments on:

1-Seed cotton yield.

Presented data in Table (10) illustrated that, the overall mean values for seed cotton yield were clearly affected by both cultivation methods and irrigation scheduling treatments (irrigation treatments). Regarding, the effect of cultivation methods on seed cotton yield, the highest overall mean values were recorded under wide furrows cultivation method (A_2) and the values are 8.86 kentar/ fad. (1405.97 kg/ fed.) and 9.43 kentar/ fed. (1484.71 kg/ fed.) in the first and second growing seasons, respectively. While, under normal furrows cultivation method (A_1) the values are 8.37 kentar/ fed (1318.82 kg/ fed) and 8.75 kentar/ fed (1378.70 kg/fed.) in the first and second growing seasons, respectively. Decreasing the overall mean values for seed cotton yield under normal furrows cultivation method (A_1) in comparison with wide furrows cultivation method (A_2) may be attributed to increasing amount of applied water under (A_1). Therefore, increasing leaching process for soil nutrients and hence, decreasing uptake rate of these nutrients. So, forming weak plants which it is easy for pests to attack these plants and affect the final yield by decreasing. Another reason for decreasing seed cotton yield under normal cultivation method (A_1) due to increasing plant populations. So, increasing rate of competition among plants to take their nutritional and light requirements. Consequently, the plants will be weak and finally give low yield. These results are in a great harmony with those obtained by *Fahong Wang et al. (2011), Mona. S. M. Eid (2012) and Swelam and Atta (2012).*

Concerning, irrigation scheduling treatments (irrigation traetments) showed highly significant effect on seed cotton yield. The highest mean values were recorded under irrigation treatment (I_3) in the two growing seasons in comparison with other irrigation treatments I_0, I_1, I_2 and I_4. The highest mean values 10.13 kentar/ fed. (1627.53 kg/fed.) and 11.13 kentar/ fed. (1753.53 kg/fed.) under cultivation methods A_1 and A_2 in the first and second growing seasons, respectively. On the other hand, the lowest mean values for seed cotton yield were recorded under irrigation treatment I_4 which exposed to strict water stress by elongation irrigation interval in comparison with other irrigation treatments. Generally, the mean values of seed cotton yield in the two growing seasons can be decreased in order $I_3 > I_2 > I_1 > I_0 > I_4$. Increasing the mean values of seed cotton yield under irrigation treatment I_3 (irrigation with 1.0 Ep) in the two growing seasons may be due to irrigation under the conditions of this treatment considers the suitable irrigation treatment for cotton crop where no excess or stress on plants. So, plants take their nutritional needs without any effort, finally, forming strong plants with a high yield, where the excess in water application gives the same effect in case of water stress. Therefore, the lowest mean values in the two growing seasons were recorded under I_4 (irrigation with 0.8 Ep) and I_0 (traditional irrigation) under the two cultivation methods. Concerning, the interaction between irrigation treatments and cultivation methods, showed no significant effect on seed cotton yield in the two growing seasons. These findings are in a great hormony with those obtained by *Howell, T. A. et al. (2002) and Mona. S. M. Eid (2012).*

Table (10): Effect of cultivation methods and irrigation treatments on seed cotton yield in heavy clay soils in the two growing seasons.

Cultivation methods (A) / Irrigation treatments (I)	1st growing season				2nd growing season				The mean values through the two growing seasons			
	Cultivation method				Cultivation method				Cultivation method			
	A_1		A_2		A_1		A_2		A_1		A_2	
	Kentar/ fed.	Kg/ fed.	Kentar/ fed.	Kg/ fed.	Kentar/ fed.	Kg/fed.	Kentar/ fed.	Kg/ fed.	Kentar/ fed.	Kg/ fed.	Kentar/ fed.	Kg/ fed.
I_0	7.87	1239.03	8.23	1296.77	8.30	1307.27	8.93	1406.93	8.09	1273.15	8.58	1351.85
I_1	8.47	1333.53	8.90	1401.77	8.93	1407.03	9.30	1464.77	8.70	1370.28	9.10	1433.27
I_2	8.97	1412.27	9.40	1480.50	9.20	1449.03	9.97	1569.77	9.09	1430.65	9.69	1525.14
I_3	10.13	1596.00	10.93	1722.03	10.33	1627.53	11.13	1753.53	10.23	1611.77	11.03	1737.78
I_4	6.43	1013.27	6.83	1128.77	7.00	1102.53	7.80	1228.53	6.72	1057.90	7.32	1178.65
Overall mean	8.37	1318.82	8.86	1405.97	8.75	1378.70	9.43	1484.71	8.56	1348.76	9.15	1445.34

In a column, means followed by a common letter are not significantly different at the 5 level by DMRT.

1st growing season

- **Kentar/ fed.**

Comparison	S.E.D	LSD (5)	LSD (1)
2-I means at each (A)	0.19	0.39	0.54
2-I means	0.13	0.28	0.38
I*A		ns	

Kg/ fed.

Comparison	S.E.D	LSD (5)	LSD (1)
2-I means at each (A)	22.71	48.14	66.32
2-I means	16.06	34.04	46.90
I*A		ns	

2nd growing season

- **Kentar/ fed.**

Comparison	S.E.D	LSD (5)	LSD (1)
2-I means at each (A)	0.12	0.25	0.34
2-I means	0.08	0.18	0.24
I*A		ns	

Kg/ fed.

Comparison	S.E.D	LSD (5)	LSD (1)
2-I means at each (A)	18.47	39.16	53.95
2-I means	13.06	27.69	38.15
*I*A		ns	

2-Some yield attributes and cotton seed oil percentage.

Tabulated data in Tables (11 and12) showed that the mean values of, plant height (cm.), boll weight (g), number of green bolls/ plant and cotton seed oil percentage were clearly affected by both cultivation methods and irrigation scheduling treatments (irrigation treatments). Concerning, the effect of cultivation methods, the highest mean values for the abovementioned studied parameters were recorded under wide furrows cultivation method (A_2) in comparison with normal furrows cultivation method (A_1) in the two growing seasons. These results are in a great harmony with those obtained by *Howell, T. A. et al . (2002), Kassab, M. M. (2003) and Mona. S. M. Eid (2012).*

Regarding, the irrigation treatments, showed highly significant effect on the abovementioned studied parameters. Where, the highest mean values were recorded under irrigation treatment (I_3) in comparison with other irrigation treatments I_1, I_2, I_0 and I_4 in the two growing seasons. Generally, the mean values of the abovementioned studied parameters can be descended in order $I_3 > I_2 > I_1 > I_0 > I_4$ in the two growing seasons. These findings are in the same line with those reported by *Doorenbos. J. (1979)* who stated that the little supply of irrigation water raises the oil percentage but severe water deficit substantially reduce the oil percentage in the cotton yield. Also, these results are in a great harmony with those obtained by *Meleha M.I. (1996), Fahong Wang et al. (2011) and Swelem and Atta (2012).* Under all studied parameters which abovementioned, the interaction between irrigation treatments and cultivation methods showed no significant effect.

Table (11): Effect of cultivation methods and irrigation treatments on cotton plant height and boll weight in heavy clay soils in the two growing seasons.

Cultivation methods (A) / Irrigation treatments (I)	1st growing season				2nd growing season			
	Cultivation method (A)				Cultivation method (A)			
	Plant height (cm.)		Boll weight (g)		Plant height (cm.)		Boll weight (g)	
	A_1	A_2	A_1	A_2	A_1	A_2	A_1	A_2
I_0	148.20	152.37	2.80	3.00	149.00	150.03	2.93	3.17
I_1	156.17	157.53	3.20	3.47	156.53	159.03	3.33	3.60
I_2	162.23	166.50	3.53	3.80	162.63	166.07	3.70	3.90
I_3	166.40	168.33	3.87	4.17	166.83	169.17	3.93	4.30
I_4	141.33	143.47	2.57	2.80	143.73	145.77	2.67	2.90
Overall mean	154.87	157.64	3.19	3.45	155.75	158.01	3.31	3.57

Plant height (cm.)

1st growing season

Comparison	S.E.D	LSD (5)	LSD (1)
2-I means at each (A)	0.77	1.63	2.25
I*A		ns	

2nd growing season

Comparison	S.E.D	LSD (5)	LSD (1)
2-I means at each (A)	1.43	3.02	4.16
2-I means	1.01	2.14	2.94
I*A		ns	

Boll weight (g)

1st growing season

Comparison	S.E.D	LSD (5)	LSD (1)
2-I means at each (A)	0.09	0.19	0.26
2-I means	0.06	0.14	0.19
I*A		ns	

2nd growing season

Comparison	S.E.D	LSD (5)	LSD (1)
2-I means at each (A)	0.07	0.16	0.22
2-I means	0.05	0.11	0.19
I*A		ns	

Table (12): Effect of cultivation methods and irrigation treatments on cotton number of green bolls/ plant and cotton seed oil percentage in heavy clay soils in the two growing seasons.

Cultivation methods (A) / Irrigation treatments (I)	1st growing season				2nd growing season			
	Cultivation method (A)				Cultivation method (A)			
	Number of green bolls/ plant		Seed oil (%)		Number of green bolls/ plant		Seed oil (%)	
	A_1	A_2	A_1	A_2	A_1	A_2	A_1	A_2
I_0	34.0	38.3	20.23	20.80	35.3	40.0	20.70	20.97
I_1	38.7	40.7	20.40	20.97	40.3	41.7	20.80	21.40
I_2	42.7	43.3	20.90	21.20	43.3	44.3	21.00	21.80
I_3	45.0	46.7	21.37	21.50	45.3	47.7	21.37	21.93
I_4	30.0	35.3	19.97	20.30	30.3	36.3	20.00	20.87
Overall mean	38.1	40.9	20.57	20.95	38.9	42.0	20.77	21.39

Number of green bolls/ plant
1st growing season

Comparison	S.E.D	LSD (5)	LSD (1)
2-I means at each (A)	0.4	0.9	1.2

2nd growing season

Comparison	S.E.D	LSD (5)	LSD (1)
2-I means at each (A)	0.5	1.0	1.4

Cotton seed oil percentage
1st growing season

Comparison	S.E.D	LSD (5)	LSD (1)
2-I means at each (A)	0.13	0.27	0.37
2-I means	0.09	0.19	026

2nd growing season

Comparison	S.E.D	LSD (5)	LSD (1)
2-I means at each (A)	0.07	0.15	0.21

CONCLUSION AND RECOMMENDATION

This present study recommends that cotton crop variety Giza 86 in the North Middle Nile Delta region should be cultivated on wide furrows cultivation method (A_2, with width 120 cm and cultivation on two sides) instead of using normal furrows cultivation method (A_1, with width 60 cm and cultivation on one side, normal cultivation method) and irrigation with 1.0 Ep (pan evaporation readings) irrigation treatment (I_3).

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نحو ادارة مائية فعالة لمحصول القطن تحت طرق زراعة مختلفة فى منطقة شمال وسط دلتا النيل .

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***معهد بحوث الاراضى والمياه والبيئة...... مركز البحوث الزراعية – الجيزة – مصر**

معهد بحوث القطن – مركز البحوث الزراعية – مصر

تجربة حقلية نفذت فى المزرعة البحثيه بمحطة البحوث الزراعية بسخا خلال موسمى النموالصيفى 2013و 2014 بهدف دراسة تأثيرطريقه الزراعة ومعاملات الرى (جدولة الرى حسب قراءات وعاء البخر) على محصول القطن ومكوناته ، النسبة المئوية للزيت فى البذور و كذلك بعض العلاقات المائيه - التصميم الاحصائى المستخدم فى الدراسة هو القطع المنشقه مره واحدة، حيث المعاملات الرئيسيه هى طريقة الزراعة (A) حيث A_1 (الزراعة على خطوط بعرض 60 سم)، A_2 (الزراعة على مصاطب بعرض 120 سم و الزراعة على ريشتين) و المعاملات تحت الرئيسية هى معاملات الرى والتى كانت عبارة عن معاملات الجدولة حسب قراءات وعاء البخر وهى I_0 (رى عادى) ، I_1 (رى ب 1.4 من قراءات الوعاء) ، I_2 (رى ب 1.2 من قراءات الوعاء) ، I_3 (رى ب 1.0 من قراءات الوعاء) ، I_4 (رى ب 0.8 من قراءات الوعاء).

اهم النتائج يمكن تلخيصها فيما يلى:

- أعلى القيم بالنسبه للماء الموسمى المضاف ، الاستهلاك المائى وكذلك الماء المخزن فى منطقة الجذور الفعالة سجلت تحت طريقة الزراعة (A_1) مقارنة (A_2) والقيم 3847.05 , 3636.48 م^3/ فدان للماء الموسمى المضاف ، 2629.18 ، 2442.74 م^3/ فدان للاستهلاك المائى ، 2743.93 ، 2612.73 م^3/ فدان للماء المخزن فى منطقة الجذور الفعالة تحت طريقتى الزراعة A_1 ، A_2 على الترتيب.
- بالنسبة لتأثير معاملات الرى ، أعلى القيم بالنسبة للماء الموسمى المضاف ، الاستهلاك المائى و كذلك الماء المخزن فى منطقة الجذور الفعالة سجلت تحت معاملة الرى I_0 مقارنة I_1 ، I_2 ، I_3 و I_4 و كانت القيم 4309.37 و 4122.46 م^3/ فدلن للماء الموسمى المضاف ، 2917.74 ، 2760.81 م^3/ فدان للاستهلاك المائى ، 3125.44 ، 2900.24 م^3/ فدان للماء المخزن بمنطقة لبجذور الفعالة تحت طريقتى الزراعة A_1 ، A_2 على الترتيب بصفة عامة قيم القياس سالفة الذكر يمكن ترتيبها تنازليا كما يلى $I_0 > I_1 > I_2 > I_3 > I_4$ فى كلا موسمى الدراسة.
- بالنسبة لكفاءة الرى التطبيقية ، انتاجية وحدة المياة المستهلكة (WP) و كذلك انتاجية وحدة المياة المضافة (PIW) سجلت أعلى القيم تحت طريقة الزراعة A_1 والقيم 72.10 ، 71.43 لكفاءة الرى التطبيقية ، 0.60 ، 0.52 كجم/ م^3 ل (WP) ، 0.41 ، 0.35 كجم/ م^3 ل (PIW) تحت طريقتى الزراعة A_2 ، A_1 على الترتيب. بينما كفاءة الاستهلاك المائى سجلت أعلى القيم تحت طريقة الزراعة A_1 مقارنة A_2 والقيم 68.51 ، 67.35 % تحت A_1 ، A_2 على الترتيب. بالنسبة لتأثير معاملات الرى سجلت أعلى القيم بالنسبة لكفاءة الرى التطبيقية و كفاءة الاستهلاك المائى تحت معاملة الرى I_4 و القيم 74.04 و 76.37 % لكفاءة الرى التطبيقية ، 71.76 و 70.11 % لكفاءة الاستهلاك المائى تحت A_1 ، A_2 على الترتيب. و على العكس من ذلك فان WP ، PIW أعلى القيم سجلت تحت معاملة الرى I_3 و القيم 0.66 ، 0.78 كجم/ م^3 للWP ، 0.45 ، 0.52 م^3/ فدان لل PIW تحت A_1 ، A_2 على الترتيب.
- بالنسبة لمحصول البذور و مكوناته و كذلك النسبة المئوية للزيت بالبذور سجلت أعلى القيم تحت طريقة الزراعة A_2 مقارنة A_1 و تحت معاملة الرى I_3 مقارنة I_0 ، I_1 ، I_2 و I_4.
- توصى الدراسة بزراعة القطن صنف جيزة 86 فى منطقة شمال الدلتا على مصاطب بعرض 120 سم و الزراعة على ريشتين بدلا من الزراعة على خطوط بعرض 60 سم والزراعة على ريشة واحدة (الطريقة العادية) و الرى باستعمال 1.0 من قراءات وعاء البخر.

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