Cotton Production as Affected by Irrigation Intervals, Nitrogen and Potassium Fertilization in the Newly Reclaimed Soil of West Nubaria Region

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ABSTRACT

Two field experiments were conducted at the Research Farm of Nubaria Agric. Res. Stn. during 1998 and 1999 summer seasons to study the effect of two irrigation intervals (I_1 = 14 days and I_2 = 14-28 days), three nitrogen (N_1 = 50, N_2 = 75 and N_3 = 100kg N/fed) and three potassium (K_1 = 24, K_2 = 48 and K_3 = 72kg K_2O/fed) fertilization levels on seed cotton yield, yield components, fiber quality, water consumptive use (WCU) and water use efficiency (WUE) and to develop crop-coefficient curve (K_C) for extra-long staple cotton cultivar Giza 70 grown under calcareous soils conditions at west Nubaria region. A split split-plot design with three replicates was used. Results indicated that plots irrigated every 14-28 days (I_2 irrigation interval) recorded higher boll weights (2.44, 2.08g), seed cotton yield/plant (28.92, 25.75g), seed cotton yield/fed (7.31, 5.51 kentar), lower number of damaged bolls/plant (4.51, 6.64) and earlier maturity of cotton plants (earliness indices of 74.92, 65.46%) as compared to the 14d (I_1) treatment for the 1998 and 1999 seasons, respectively. Irrigating every 14-day resulted in higher lint percentage (39.43, 40.33%) and finer fibers (micronaire readings of 3.25 and 3.51) as compared to I_2 treatment for the same two seasons, respectively. Water use efficiency values increased with alternating irrigation (I_2 treatment). . Average WUE values for I_1 and I_2 irrigation treatments were 0.34 and 0.42 kg seed cotton yield/m^3 consumed water, respectively. Average water consumptive use values were 64.8 and 61.2cm for I_1 treatment and were 59.6 and 56.3cm for I_2 treatment for the two respective seasons First- and second-order interactions were evaluated. The I X N interaction was significant for seed cotton yield/fed and the N X K interaction was significant for No. of damaged bolls/plant and seed cotton yield/plant in the two seasons. The two-season average values of applied irrigation water were 76cm (3197m^3/fed) and 63cm (2646m^3/fed) for I_1 (14d) and I_2 (14-28d) treatments, respectively. The obtained results indicated that using the I_2 irrigation interval increased seed cotton yield and saved about 17.23% (551m^3/fed) of irrigation water. From the obtained results it could be concluded that using I_2 (14-28d) irrigation interval, N_2 (75kg N/fed) and K_3 (72kg K_2O/fed) treatment is the best practice for cotton production at west Nubaria region since it produced the highest seed cotton yield/fed of 8.43, 7.91 kentar in the 1998 and 1999 seasons, respectively.

INTRODUCTION

Historically, cotton is one of the most important field crops in Egypt. It is yearly cultivated in about one million feddans. Recently, there is a vast increase in areas devoted to cotton cultivation in the newly reclaimed calcareous soils at west Nubaria region. According to MALR (2001), cotton area increased from 55 (1975) to 6240 feddans (2001)at west Nubaria region. To obtain optimum cotton yield under the newly reclaimed soil conditions, it is essential to provide the farmers of these regions with the proper production package of cotton especially suitable cultivar, irrigation scheduling and fertilizer doses.

Water is a vital and scarce commodity. In Egypt, agricultural sector consumes about 85% of total water resources (Abu Zeid, 1999). Thus, water conservation in irrigation is critical to face the competing demands from other users. One management technology that help the optimization of on-farm irrigation water for optimum cotton production is the use of proper irrigation scheduling techniques. Gomma *et al.* (1981) studied the effect of irrigation intervals (14, 21 and 28days) and nitrogen levels on cotton yield and its components. Their results showed significant increase in seed cotton yield/fed, number of open bolls/plant, boll weight and seed index by decreasing irrigation intervals. Maximum seed cotton yield/fed was obtained from the combination effect of 60kg N/fed and 21days irrigation interval treatment. Gendy *et al.* (1990) reported that increasing number of irrigation to 7 compared to 3 or 5, significantly increased number of open bolls/plant, seed cotton yield/fed and lint percentage. Abd El-Dayem (1994) indicated that seed cotton yield decrease with increasing irrigation intervals from 10 to 26 days. Eid and Hosny (1995) indicated that optimum water requirements for cotton production in Egypt ranges between 94.5cm and 115.5cm, depending on regional climate. Darwish and Hegab (2000) studied the effect of irrigation intervals (2, 3 and 4 weeks) and soil conditioners on water use efficiency (WUE), growth, yield and fiber quality of cotton in the clay soils of Nile Delta. Their results indicated that water consumptive use (WCU) values increased with more frequent irrigation. Highest values of WUE were obtained from the interaction between three weeks irrigation interval and chicken manure soil conditioner treatment. Awad *et al.* (2001) mentioned that actual evapotranspiration values of Giza 85 cotton cultivar grown at El-Serw area (North Delta) were 58.9cm and 60.2cm for 1999 and 2000 growing seasons, respectively. Results showed also that WUE values were 0.41 kg and 0.43 kg seed cotton yield/m^3 of water consumed for the same seasons, respectively. Abou Zaid and Mohamed (2001) indicated that average WCU values for cotton grown in the calcareous soil under furrow irrigation system was 59.08cm/season. They also showed that average seasonal crop coefficient (K_C) value for cotton was 0.83.

Soil fertility is very poor in the newly reclaimed calcareous soils. Therefore, use of fertilizers plays a major role in increasing cotton productivity. Results by Darwish *et al.* (1995) showed that highest seed cotton yield was obtained from the combined effect of 40kg N and 24kg K_2O/fed. Abou Zaid and El-Tabbakh (1996) indicated that the application of 70kg N/fed resulted in a significant increase in seed cotton yield, number of open bolls/plant, boll weight and plant height as compared to the application of 50kg N/fed. Results reported by Abou Zaid and El-Haddad (1997) revealed that both N and K fertilizers are important factors in increasing seed cotton yield in the calcareous soils. They indicated that the addition of 75kg N and 48kg K_2O/fed resulted in the highest seed cotton yield of 9.09 and 12.98 kentar/fed for the 1995 and 1996 growing seasons, respectively.

The objective of this study was to test the effect of irrigation interval, nitrogen, potassium fertilization levels and their interactions on seed cotton yield, yield components, fiber quality, water consumptive use and water use efficiency and to develop crop-coefficient curve for cotton crop grown under the newly reclaimed soil conditions of west Nubaria region.

MATERIALS AND METHOD

Two field trials were carried out during the summer seasons of 1998 and 1999 at the experimental farm of Nubaria Agricultural Research Station, Agricultural Research Center. The aim of this study was to test the effect of irrigation interval, nitrogen and potassium fertilization levels on seed cotton yield, yield components, fiber quality, WCU and WUE and to develop K_C for cotton crop in calcareous soils.

Soil samples from the experimental site were collected before sowing to determine main soil physical and chemical characters (Page *et al.*, 1982) and some soil hydro-physical parameters. Results of the analysis are presented in Tables 1 and 2.

Table 1. Some physical and chemical characteristics of the experimental site soil.

Soil depth (cm)	Particle size analysis					$CaCO_3$ (%)	O.M. (%)	PH	EC (dS/m)
	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Soil texture class				
0 – 30	11.4	35.7	26.4	26.5	Sandy clay loam	29.8	0.38	8.5	1.05
30 - 60	8.0	36.9	27.3	27.8	Sandy clay loam	30.1	0.45	8.3	0.90

Table 2. Soil water characteristics of the experimental site soil.

Soil depth (cm)	Field capacity (%)	Wilting point (%)	Available water (%)	Bulk density (g/cm^3)
0 – 15	29.82	16.21	13.61	1.18
15 - 30	28.50	15.94	12.56	1.46
30 - 45	27.73	15.07	12.66	1.43
45 – 60	27.40	14.89	12.51	1.42

A split split-plot experimental design with three replicates was used. Two different irrigation intervals represented the main plots (I_1: irrigation every 14 days and I_2: alternating irrigation every 14-28 days), three levels of nitrogen fertilizer (N_1: 50, N_2: 75 and N_3: 100 kg N/feddan) represented the sub-plots and three potassium fertilizer levels (K_1: 24, K_2: 48 and K_3: 72kg K_2O/feddan) represented the sub sub-plots. The area of the sub sub-plot was 19.5m^2, consisted of six ridges 0.65m apart and 5m long.

In 1998, cotton (*Gossypium barbadense* L., var. Giza 70, extra-long staple) was sown on April 1st and picking started on September 15th and ended on October 5th. In 1999, the same cultivar was sown on April 10th and picking started on September 28th and ended on October 14th. Cotton seeds were sown in hills spaced 0.20m apart. Hills were thinned before the 1st irrigation to two plants/hill. During land preparation, 30kg P_2O_5/fed in the form of calcium super-phosphate (15.5% P_2O_5) was incorporated with the soil. Nitrogen fertilizer levels (ammonium sulfate, 20.5% N) were applied in two equal doses before the 1st and 2nd irrigations. Potassium fertilizer levels (potassium sulfate, 48% K_2O) were applied in one dose before the 2nd irrigation. All standard practices for cotton production at west Nubaria region were followed. At harvest time, ten guarded plants from each sub sub-plot were randomly taken to determine the following growth, yield, yield components and fiber quality parameters: Plant height (cm), No. of open bolls/plant, boll weight (g), No. of damaged bolls/plant, seed cotton yield/plant (g), earliness index (%); determined as the ratio of seed cotton yield from 1st picking to total yield, lint percentage, fiber length (mm); determined at 2.5% span length, fiber strength (g/tex.), and fiber fineness; determined using the micronaire reading.

Data of seed cotton yield/plot were recorded on the middle four ridges and then adjusted to kentar/fed (one kentar = 157.5kg). Number of plants/fed was also determined at harvest time.

Applied irrigation water was measured using a water meter connected to an irrigation pump placed very close to the experimental plots to ensure high water application efficiency. Irrigation treatments started after the application of fertilizer doses, i.e., after the 2nd irrigation.

Crop water-use parameters:

1- Actual water consumptive use (WCU):

Actual water consumptive use (WCU) or actual evapotranspiration (ET_a) values for cotton crop were determined. Gravimetric soil samples, from soil

$$WCU = \sum_{i=1}^{i=4} \frac{(\theta_2 - \theta_1)}{100} \times \rho_b \times D \qquad \text{(Israelsen and Hansen, 1962)}$$

surface down to 60cm depth, were collected after sowing, before and after each irrigation, and at harvest time to determine water consumptive use values. Seasonal WCU values were calculated as follows:

Where WCU = seasonal water consumptive use (cm),

Θ_2 = soil moisture content after irrigation (on mass basis, %),

Θ_1 = soil moisture content before irrigation (on mass basis, %),

ρ_b = soil bulk density (g/cm^3),

D = depth of soil layer (15cm each), and

i = number of soil layer.

2- Water use efficiency (WUE):

Water use efficiency (WUE) values for the examined treatments were calculated according to the relation given by Jensen (1983) as:

$$WUE = \frac{\textbf{Total seed cotton yield (kg)}}{\textbf{Total water consumed (cubic meter)}}$$

3- Potential evapotranspiration (ET_o):

Penman-Monteith method used in CROPWAT model (Smith, 1991) and described by Allen *et al.* (1998) was used to calculate potential evapotranspiration values. The equation is given as:

$$ET_o = \frac{0.408\,\Delta\,(Rn + G) + \gamma\,[900/(T + 273)]\,U_2\,(es - ea)}{\Delta + \gamma\,(1 + 0.34\,U_2)}$$

where:

ET_o = reference evapotranspiration, mm/day
Rn = net radiation ($MJm^{-2}d^{-1}$)
G = soil heat flux ($MJm^{-2}d^{-1}$)
Δ = slope vapor pressure and temperature curve (kPa $°C^{-1}$)
γ = psychrometric constant (kPa $°C^{-1}$).
U_2 = wind speed at 2 m height (ms^{-1}).
e_s-e_a = vapor pressure deficit (kPa).
T = mean daily air temperature at 2 m height (°C).

The input parameters needed to calculate ETo using the CROPWAT model are air temperature, relative humidity, sunshine hours and wind speed. The agro-meteorological data needed to calculate potential evapotranspiration (ET_o) values using Penman-Monteith equation for the two growing seasons are presented in Table 3.

Table 3. Monthly average meteorological data for the 1998 and 1999 growing seasons.

	1998				1999			
Month	T_{ave} (°C)	RH (%)	Wind (m/s)	Sunshine (hr)	T_{ave} (°C)	RH (%)	Wind (m/s)	Sunshine (hr)
Jan.	11.27	67.27	1.86	5.28	13.27	61.87	1.75	6.15
Feb.	11.82	65.92	1.82	5.58	12.70	61.90	1.64	5.65
Mar.	13.55	64.90	1.82	5.97	16.83	58.90	1.67	7.97
Apr.	23.42	58.47	1.52	8.52	20.60	59.80	1.62	7.68
May	24.75	58.27	1.62	8.23	24.08	58.07	1.57	10.10
Jun.	27.28	59.87	1.39	9.93	25.07	58.80	1.48	11.01
Jul.	28.07	61.38	1.42	10.78	26.93	60.67	1.38	11.03
Aug.	28.50	62.62	1.51	10.29	26.47	61.12	1.44	10.73
Sep.	26.97	61.20	1.51	9.53	26.20	58.40	1.45	10.60
Oct.	25.48	59.67	1.82	8.67	24.68	60.20	1.90	8.20
Nov.	20.43	61.47	1.91	6.30	21.23	59.15	1.71	7.38
Dec.	12.97	65.00	2.43	4.05	17.90	60.65	1.66	6.23

Where: T_{ave} = average maximum and minimum air temperature (°C), RH = relative humidity (%), Wind = wind speed at 2m height (m/sec), and daily sunshine period (hours). [Data were obtained from the agro-meteorological station at El-Bangar area, west Nubaria region].

4- Cotton crop coefficient (Kc):

Cotton crop coefficient (K_C) values for west Nubaria region are calculated using the following relation:

$$Kc = \frac{ET_a}{ET_o}$$

where:

ET_a: actual evapotranspiration or water consumptive use (WCU), and

ET_o: potential evapotranspiration.

Statistical analysis:

The collected data for the two seasons were statistically analyzed at 0.05 probability level for the split-plot statistical design according to SAS-GLM statistical package (SAS, 1988).

RESULTS AND DISCUSSION

The results are presented and discussed in the following sequence:

1. Main effect:

1.1. Irrigation interval effect:

The results in Tables 4 and 5 showed significant differences between the two irrigation intervals in all studied characters, except for number of open bolls/plant, number of plants/fed, plant height, fiber length and strength for the two seasons. Alternating irrigation every 14-28d (i.e., I_2) resulted in higher boll weight (2.44, 2.08g), seed cotton yield/plant (28.92, 25.75g), lower number of damaged bolls/plant (4.51, 6.64) and earlier maturity of cotton plants (earliness indices of 74.92, 65.46%),consequently higher seed cotton yield/fed (7.31, 5.51 kentar) as compared to the regular irrigation interval (I_1: 14d) in the 1998 and 1999 growing seasons, respectively. On the contrary, the irrigation every 14d resulted in higher lint percentages (39.43, 40.33%) and finer fibers (micronaire readings of 3.25 and 3.51) as compared to I_2 treatment for the same respective seasons. The obtained results were in agreement with those reported by Mohamed *et al.* (1984) and Abd El-Dayem (1994).

1.2. Nitrogen fertilizer effect:

The results in Tables 4 and 5 showed that the high two levels of N fertilizer (75 and 100kg N/fed) gave significantly the highest seed cotton yield, its components, earliness index and fiber finesses as compared to the lowest N level (50kg N/fed) in the two seasons. No significant differences were observed between No. of open bolls/plant, boll weight, seed cotton yield/plant, seed cotton yield/fed and plant height at the two nitrogen levels of 75 and 100kg N/fed in the two growing seasons. Also increasing N-level had a significant effect on increasing No. of damaged bolls/plant. This result was due to increasing vegetative growth and delaying maturity, which allowed the attack of cotton plants by bollworms. On the other hand, decreasing N-levels had a significant effect on enhancing earliness index. Similar results were obtained by Mohamed *et al.* (1984) and Abou-Zaid and El-Haddad (1997).

1.3. Potassium fertilizer effect:

The data in Tables 4 and 5 indicated that increasing potassium fertilization levels from 24 to 72kg K_2O/fed significantly increased seed cotton yield, its components, earliness index and micronaire reading in 1998 and 1999 seasons. While, it significantly decreased number of damaged bolls/plant in 1998 season. The obtained results were in agreement with those reported by Abd El-Hadi *et al.* (1994) and Abou-Zaid and El-Haddad (1997).

2. Interaction effect:

The two general concepts considered while discussing the interaction effects are the facts that higher order interactions excise the less order interactions and the longer period interaction, i.e. two seasons, excise the shorter period interaction, i.e. one season.

The results in Table 4 showed that the first-order interaction, I X K, and the higher-order interaction, I X N X K, were not significant for both 1998 and 1999 seasons, except for seed cotton yield/plant which was significant in the 1998 season only. The interaction between irrigation interval (I) and nitrogen level (N) was significant on boll weight and seed cotton yield/plant for 1999 season and on seed cotton yield/fed for both growing seasons. Results in Table 6 indicate that the response of seed cotton yield/fed to N-fertilization levels was different at each irrigation interval treatment. At I_1 (14d) irrigation treatment the highest seed cotton yield/fed (7.25, 5.66 kentar) was obtained from N_3 level (100kg N/fed). While, the highest seed cotton yield/fed (8.10 and 6.47 kentar) was obtained from N_2 level (75kg N/fed) at I_2 (14-28d) irrigation treatment for both 1998 and 1999 seasons, respectively. The obtained results were in line with those reported by Mohamed *et al.* (1984).

As for the interaction between nitrogen (N) and potassium (K) levels, the results in Table 4 revealed significant differences for boll weight and seed cotton yield/fed only during 1999 season. While, significant differences were observed for seed cotton yield/plant and number of damaged bolls/plant during the 1998 and 1999 seasons. The data in Table 6 showed also that, seed cotton yield/plant responded differently to increasing N fertilization levels at each level of K fertilizer. Highest yields of seed cotton/plant (35.34, 33.90g) were obtained at N_2 (75kg N/fed) and K_3 (72kg K_2O/fed) fertilization levels in 1998 and 1999 seasons, respectively.

Table 4. Means of seed cotton yield and yield components as affected by the tested variables during 1998 and 1999 seasons.

Factor	Level	No. of open bolls/plant		Boll weight (g)		Seed cotton yield/plant (g)		No. of damaged bolls/plant		No. of plants/fed		Seed cotton yield/fed (kentar)	
		1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Irrigation (I)	I_1	11.17	11.97	2.21	1.91	24.55	23.11	6.47	8.29	64548	63528	6.66	4.84
	I_2	11.87	12.24	2.44	2.08	28.92	25.75	4.51	6.64	64252	64021	7.31	5.51
LSD (0.05)		NS	NS	0.06	0.07	1.78	1.17	0.19	0.18	NS	NS	0.17	0.12
Nitrogen	50	10.47	10.68	2.04	1.84	21.43	18.56	4.43	6.58	64411	63422	5.84	3.75
(kg N/fed)	75	12.24	12.90	2.46	2.05	29.87	26.71	5.49	7.43	64424	63987	7.51	5.87
	100	11.84	12.73	2.47	2.10	28.92	26.73	6.54	8.40	64367	64213	7.59	5.89
LSD (0.05)		1.19	0.39	0.29	0.05	1.79	0.56	0.30	0.43	NS	NS	0.11	0.13
Potassium	24	10.86	10.60	2.18	1.84	23.58	19.72	5.64	7.48	64481	63257	6.64	4.53
(kg K_2O/fed)	48	11.44	12.07	2.38	1.99	26.88	24.07	5.46	7.55	64323	64620	6.93	5.34
	72	12.27	13.64	2.43	2.16	29.76	29.49	5.37	7.38	64395	63448	7.37	5.66
LSD (0.05)		1.15	0.43	0.15	0.09	1.46	1.62	0.21	NS	NS	NS	0.16	0.16
Overall mean		11.52	12.11	2.32	2.00	26.74	24.43	5.49	7.47	64400	63774	6.98	5.17
I X N		NS	NS	NS	*	NS	**	NS	NS	NS	NS	***	***
I X K		NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS
N X K		NS	NS	NS	*	**	*	***	***	NS	NS	NS	***
I X N X K		NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS

Table 5. Means of plant height, earliness index, lint percentage and fiber properties as affected by the tested variables during 1998 and 1999 seasons.

Factor	Level	Plant height (cm)		Earliness index (%)		Lint percentage (%)		Fiber length (mm) at 2.5% span length		Fiber strength (g/tex.)		Fiber fineness (M. R.)	
		98	99	98	99	98	99	98	99	98	99	98	99
Irrigation.	I_1	165.93	178.44	65.94	56.49	39.43	40.33	33.96	35.25	34.70	34.43	3.28	3.51
(I)	I_2	155.59	165.78	74.92	65.46	36.91	37.74	33.84	35.11	34.13	34.12	3.52	3.82
LSD (0.05)		NS	NS	2.08	2.33	0.80	0.53	NS	NS	NS	NS	0.12	0.15
Nitrogen	50	147.17	157.89	72.06	62.43	37.52	38.56	33.58	35.06	34.37	34.12	3.42	3.71
(kg N/fed)	75	162.83	172.89	72.47	63.06	38.12	39.02	33.92	35.17	34.43	34.33	3.45	3.73
	100	172.28	182.56	66.76	57.41	38.87	39.53	34.18	35.32	34.44	34.39	3.29	3.55
LSD (0.05)		18.74	18.72	1.85	1.70	NS	NS	NS	NS	NS	NS	0.11	0.13
Potassium	24	164.06	164.28	68.14	58.89	37.88	38.86	33.74	35.06	34.22	34.07	3.23	3.51
(kg K_2O/fed)	48	161.44	171.67	70.19	60.49	38.17	39.09	33.82	35.21	34.43	34.28	3.38	3.66
	72	166.78	177.39	72.96	63.55	38.45	39.16	34.13	35.29	34.59	34.48	3.57	3.83
LSD (0.05)		NS	NS	0.88	1.04	NS	NS	NS	NS	NS	NS	0.18	0.15
Overall mean		160.76	171.11	70.43	60.96	38.17	39.04	33.90	35.19	34.42	34.28	3.39	3.66

All the first- and second-order interactions were not significant.

Irrigation interval, nitrogen and potassium fertilization levels and their interactions did not exhibit any significant effect on number of plants/fed at harvest in the two seasons (Table 4). This result was expected since the same planting method and management practices were followed for all I, N and K treatments.

Table 6. Means of seed cotton yield/fed and its components as affected by the first-order interactions, I X N and N X K, during 1998 and 1999 seasons.

				N-levels (kg N/fed)			
Character	Factor	Season	Level	50	75	100	LSD (0.05)
Seed cotton yield/fed (kentar)	Irrigation	1998	I_1	5.77	6.92	7.25	0.15
			I_2	5.88	8.10	7.91	
		1999	I_1	3.59	5.29	6.66	0.19
			I_2	3.91	6.47	6.12	
No. of damaged bolls/plant	K_2O (kg/fed)	1998	24	3.85	5.63	7.43	
			48	4.47	5.45	6.47	0.36
			72	4.99	5.40	5.72	
		1999	24	6.12	7.42	8.32	
			48	6.55	7.54	8.57	0.40
			72	7.02	7.35	7.72	
Seed cotton yield/plant (g)	K_2O (kg/fed)	1998	24	18.83	25.20	26.71	
			48	22.15	29.08	29.42	2.53
			72	23.35	35.34	30.62	
		1999	24	15.12	20.33	23.72	
			48	19.49	25.91	26.82	2.80
			72	24.93	33.90	29.66	

Cotton-water relations:

1- Actual water consumptive use (WCU):

Water consumptive use values as affected by irrigation interval, nitrogen and potassium fertilization levels for the two growing seasons are presented in Table 7. The results showed that average WCU value for I_1 treatment (14d) was 9.5% higher than the average value for I_2 treatment (14-28d). Average values for I_1 were 64.8 and 62.1cm and for I_2 were 59.6 and 56.3cm for the 1998 and 1999 growing seasons, respectively. The results revealed also that, the I_2 (14-28d) irrigation interval resulted in reducing WCU values and increasing seed cotton yield (Table 4). Yield increase may be due to the fact that imposing water deficit during flowering, high enough to restrict vegetative growth, will lead to good boll-set and higher yields (Grimes and El-Zik, 1990).Also, WCU values increased with increasing fertilization rates. The increase in water consumptive use values due to increasing nitrogen levels was higher than that for increasing potassium fertilization levels. The higher WCU values for higher N-fertilizer levels is due to its role in increasing growth rates of leaves and stem (i.e. vegetative growth), while potassium fertilizer has direct role in flowering and fruiting.

The two-season average values of applied irrigation water were 76cm (3197m^3/fed) and 63cm (2646m^3/fed) for I_1 (14d) and I_2 (14-28d) treatments, respectively. The obtained results indicated that using the I_2 irrigation interval increased seed cotton yield and saved about 17.23% (551m^3/fed) of irrigation water.

Water consumptive use values of this study were in close agreement with those reported by Doorenbos and Pruitt (1977), Darwish and Hegab (2000), Abou-Zaid and Mohamed (2001)and Awad *et al.* (2001).

Table 7. Water consumptive use values (cm) as affected by the three studied variables during 1998 and 1999 growing seasons.

Irrigation		1998				1999			
		N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	K1	58.2	64.7	66.9	63.3	58.9	61.3	63.4	61.2
(14d)	K2	62.0	65.7	67.8	65.1	59.3	61.7	64.5	61.8
	K3	62.1	66.7	69.1	66.0	59.5	62.2	68.1	63.3
	Mean	60.8	65.7	67.9	64.8	59.2	61.7	65.3	62.1
I_2	K1	56.0	58.7	59.6	58.1	53.2	56.8	57.8	55.9
(14-28d)	K2	56.3	59.2	63.7	59.8	53.5	56.8	58.3	56.2
	K3	58.0	59.5	65.5	61.0	54.5	57.0	58.8	56.8
	Mean	56.8	59.2	62.9	59.6	53.7	56.9	58.3	56.3

2- Water use efficiency (WUE):

Seed cotton yield/fed and the calculated water use efficiency values (kg seed cotton yield/m^3 consumed water) as affected by irrigation intervals, nitrogen and potassium fertilization levels for the 1998 and 1999 growing seasons are presented in Table 8. Results showed that average WUE values for I_1 (14d) treatment were 0.38 and 0.29 kg seed cotton yield/m^3 consumed water and for I_2 (14-28d) treatment the average values were 0.46 and 0.37 kg seed cotton yield/m^3 consumed water for 1998 and 1999 growing seasons, respectively. Results indicated that, alternating irrigation during mid- and late-growth stages would result in high yield as well as maximizing the use of irrigation water. The obtained results were in close agreement with those of Darwish and Hegab (2000) and Awad *et al.* (2001). Results in Table 8 revealed also that maximum WUE values were obtained from the combined effect of N_2 (75kg N/fed) and K_3 (72kg K_2O/fed) treatment for both seasons. From the obtained results it could be concluded that using I_2 (14-28d) irrigation interval, N_2 (75kg N/fed) and K_3 (72kg K_2O/fed) treatment is the best practice for cotton production at west Nubaria region since it produced the highest seed cotton yield/fed of 8.43 and 7.91kentar in 1998 and 1999 seasons, respectively (Table 8).

Table 8. Seed cotton yield/fed (kentar) and water use efficiency values (kg seed cotton yield/m^3 consumed water) as affected by the three studied variables during 1998 and 1999 growing seasons.

Irrigation		1998 N_1	1998 N_2	1998 N_3	1998 Mean	1999 N_1	1999 N_2	1999 N_3	1999 Mean
		Seed cotton yield/fed (kentar)							
I_1	K1	5.35	6.73	6.68	6.25	3.35	4.65	4.89	4.30
(14d)	K2	5.61	6.90	7.31	6.61	3.69	5.91	5.30	4.97
	K3	6.38	7.21	7.77	7.09	3.73	6.25	5.81	5.26
I_2	K1	5.56	7.91	7.61	7.03	3.58	5.40	5.29	4.76
(14-28d)	K2	5.94	7.96	7.85	7.25	4.05	7.14	5.91	5.70
	K3	6.21	8.43	8.29	7.64	4.09	7.91	6.17	6.06
		WUE							
I_1	K1	0.35	0.39	0.37	0.37	0.21	0.28	0.29	0.26
(14d)	K2	0.34	0.39	0.40	0.38	0.23	0.36	0.31	0.30
	K3	0.39	0.40	0.42	0.40	0.24	0.38	0.32	0.31
	Mean	0.36	0.39	0.40	0.38	0.23	0.34	0.31	0.29
I_2	K1	0.37	0.50	0.48	0.45	0.25	0.36	0.34	0.32
(14-28d)	K2	0.40	0.50	0.46	0.45	0.28	0.47	0.38	0.38
	K3	0.40	0.53	0.48	0.47	0.28	0.52	0.39	0.40
	Mean	0.39	0.51	0.47	0.46	0.27	0.45	0.37	0.37

3- Potential evapotranspiration (ET_O):

Potential evapotranspiration values (mm/d) calculated using Penman-Monteith method for 1998 and 1999 are presented in Table 9. The calculated values indicate that peak climatic evaporative demand for cotton grown at west Nubaria region is during June, July and August. Total ET_O values for cotton growing seasons were 871 and 881.8 mm/season for the 1998 and 1999 growing seasons, respectively.

Table 9. Potential evapotranspiration values (mm/d) for 1998 and 1999.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1998	1.7	2.0	2.6	4.5	4.9	5.6	5.8	5.5	4.7	3.9	2.6	1.9
1999	1.9	2.2	3.3	4.1	5.2	5.6	5.7	5.3	4.8	3.8	2.7	2.1

4- Cotton crop-coefficient (K_C):

Crop coefficient values for cotton crop grown at west Nubaria region are illustrated in Figure 1. Average actual and potential evapotranspiration values for the two growing seasons were used to develop the K_C curve. The results indicated that a period of rapid canopy development is observed during July ($K_C > 0.90$). While, lower K_C value of 0.52 was observed by the end of the growing season reflecting plant aging and less atmospheric evaporative demand. Maximum K_C value (0.97) for cotton grown at west Nubaria region was observed to be slightly lower than maximum K_C values (1.05 – 1.25) suggested by Doorenbos and Pruitt (1977). The difference can be due to the specific site conditions. Results indicated also that, seasonal average crop coefficient value for cotton crop at west Nubaria region is 0.73. The obtained results were in close agreement with those reported by Abou Zaid and Mohamed (2001).

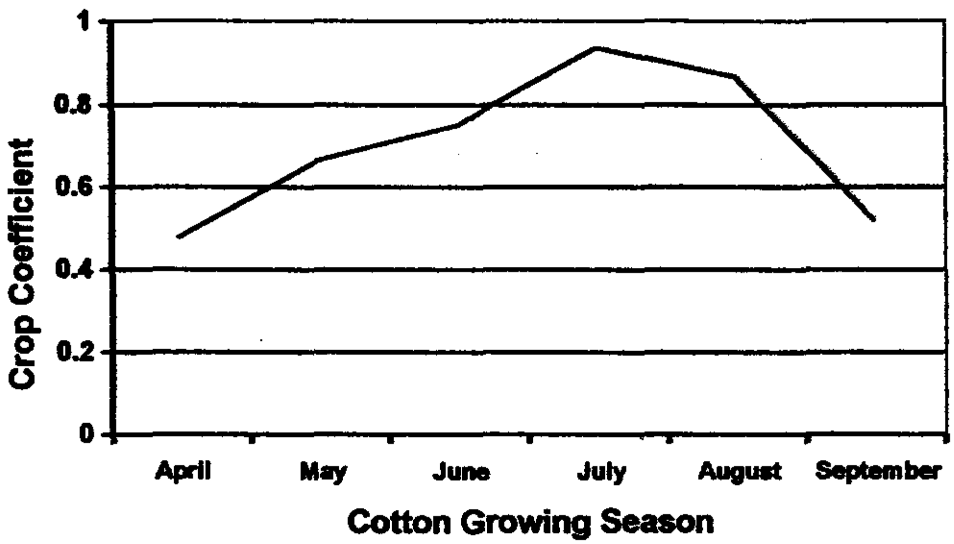

Figure 1: Crop coefficient curve for cotton at west Nubaria region.

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الملخص العربي

تأثر إنتاجية القطن بفترات الري والتسميد الآزوتي والبوتاسي في الأراضي المستصلحة حديثا بمنطقة غرب النوبارية

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أجريت تجربتان حقليتان بالمزرعة البحثية لمحطة البحوث الزراعية بالنوبارية خلال الموسم الصيفي لعامي ١٩٩٨ و ١٩٩٩ بهدف دراسة تأثير فترتين للرى (أ١: رى كل ١٤ يوم ، أ٢: رى كل ١٤-٢٨ يوم بالتبادل) وثلاثة مستويات من السماد الآزوتي (ن١: ٥٠ ، ن٢: ٧٥ ، ن٣: ١٠٠كجم آزوت/فدان) و ثلاثة مستويات من التسميد البوتاسي (بو١: ٢٤ ، بو٢: ٤٨ ، بو٣: ٧٢كجم بو٢أ/فدان) والتفاعل بينهم على إنتاجية القطن ، مكونات المحصول ، خواص التيلة ، الاستهلاك المائي ، كفاءة استخدام وحدة المياه وإيجاد معامل المحصول للقطن فائق طول التيلة –صنف جيزة ٧٠– والمنزرع بالأراضي الجيرية حديثة الإستصلاح بمنطقة غرب النوبارية. وكان التصميم الإحصائي المستخدم هو القطع المنشقة مرتين في ثلاثة مكررات. أوضحت النتائج أن معاملة الرى كل ١٤-٢٨ يوما بالتبادل أعطت أثقل اللوزات (٢,٤٤ ، ٢,٠٨جم) وأعلى إنتاجية للقطن/نبات (٢٨,٩٢ ، ٢٥,٧٥جم) ، عدد أقل من اللوز المصاب/نبات (٤,٥١ ، ٦,٦٤) ، نضج مبكر لنبات القطن (نسبة تبكير ٧٤,٩٢ ، ٦٥,٤٦%) وبالتالي أعطت أعلى إنتاجية قطن زهر/فدان (٧,٣١ ، ٥,٥١ قنطار) وذلك بالمقارنة بمعاملة الرى التقليدى (أ١: رى كل ١٤ يوم) وذلك لموسمى الزراعة ١٩٩٨ و ١٩٩٩ على الترتيب. أما معاملة الرى أ٢ فقد تفوقت فى تصافى الحليج (٣٩,٤٣ ، ٤٠,٣٣%) ونعومة التيلة (قراءة ميكرونير بلغت ٣,٢٥ ، ٣,٥١) وذلك لنفس موسمى الدراسة على الترتيب. تم تقييم التفاعلات من الدرجة الأولى والثانية للعوامل الثلاثة تحت الدراسة وكان التفاعل ما بين فترات الرى والآزوت معنويا لصفة محصول القطن الزهر/فدان بينما كان التفاعل ما بين الآزوت والبوتاسيوم معنويا لصفتى عدد اللوز التالف/نبات ومحصول القطن الزهر/نبات فى كلا الموسمين. متوسط قيم الاستهلاك المائى كانت ٦٤,٨سم ، ٦١,٢سم للمعاملة أ١ وكانت ٥٩,٦سم ، ٥٦,٣سم للمعاملة أ٢ لموسمى الزراعة على الترتيب. متوسط كفاءة استخدام وحدة المياه للمعاملتين أ١ ، أ٢ كانت ٠,٣٤ ، ٠,٤٢كجم قطن زهر/م٣ من الماء المستهلك على الترتيب. متوسط كميات مياه الرى المضافة فى الموسمين كان ٧٦سم (٣١٩٧م٣/فدان) و ٦٣سم (٢٤٤٦م٣/فدان) لمعاملتي الري أ١ (١٤يوم) و أ٢ (١٤-٢٨يوم بالتبادل) على الترتيب. أوضحت النتائج أن الرى التبادلى كل ١٤-٢٨يوم أدى إلى زيادة معنوية فى محصول القطن الزهر/فدان بالإضافة إلى توفير حوالى ١٧,٢٣% (٥٥١م٣/فدان) من مياه الرى طوال الموسم. من النتائج السابقة يمكن التوصية باستخدام فترة الرى التبادلى(١٤-٢٨يوم) تحت مستويات التسميد الآزوتي (٧٥كجم آزوت/فدان) والبوتاسي (٧٢كجم بو٢أ/فدان) باعتبارها أحسن معاملة لإنتاج القطن بالأراضي الجيرية حديثة الإستصلاح بمنطقة غرب النوبارية حيث أعطت أعلى محصول من القطن الزهر للفدان (٨,٤٣ ، ٧,٩١ قنطار) خلال موسمي الزراعة ١٩٩٨ و ١٩٩٩ على الترتيب.