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SOME FACTORS AFFECTING LINSEED (*Linum usitatissimum* L.) YIELD , QUALITY AND WATER USE EFFICIENCY

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ABSTRACT: For maximizing the productivity , quality and water use efficiency of linseed crop in a clay soil, two field experiments were conducted at Zankalon, Water Requirement Research Station, El-Sharkia Governorate during the two growing seasons of 2004/2005 and 2005/2006 to study the response of two , flax cultivars to different irrigations levels and nitrogen fertilizer rates. The most important results as average of the two growing seasons could be summarized as follows:

Treatment of 100% of F.C. (1_1) recorded the highest values of straw and seed yields / fed and all of their related characters, followed by 80% of F.C. (I_2), while 60% of F.C. (I_2) recorded the lowest ones. $Sakha_1$ cultivar ranked first and outyielded $Sakha_2$ cultivar in straw yield / fed and its related characters, meanwhile, $Sakha_2$ cultivar surpassed significantly $Sakha_1$ cultivar in seed yield/fed and its related characters. Applying 45 kgN/ fed recorded the highest values of straw and seed yields/ fed as well as their related characters. I_1 treatment recorded the highest values of water consumptive use, followed by I_2 treatment. Moreover I_3 treatment recorded the lowest ones. In this respect, $Sakha_1$ cultivar had the highest values for this trait comparing with $Sakha_2$ cultivar. I_3 treatment had the highest values for crop and water use efficiencies for seed yield , however, I_2 treatment recorded the highest values for fiber yield for the same trait respectively. $Sakha_1$ cultivar had the highest values for crop field water use efficiencies for fiber yield , while, $Shaka_2$ cultivar had the highest values for seed yield for the same traits respectively. Adding 45 kg N/ fed produced the highest values for crop water use efficiency for seed and fiber yields. Applying treatment I_3 gave the highest value of water application

efficiency. Sakha$_2$ cultivar had the highest values of water use efficiency. Treatment I$_1$ recorded the highest values for percolation losses and the lowest ones was recorded for treatment I$_3$. Sakha$_1$ cultivar had the higher values for percolation losses than Sakha$_2$ cultivar . Increasing nitrogen levels up to 60 kg N/ fed decreased percolation losses.

Key words: Flax cultivars , irrigation, nitrogen fertilizer

INTRODUCTION

In Egypt, flax (*Linum usitatissimum* L.) is considered the main fiber crop after cotton. It grown during winter season as a dual purpose crop for fiber from the stems and oil extracted from the seeds. It plays an important role in the Egyptian national income. Therefore, these effects are focused on increasing productivity of this crop by growing high yielding cultivars and by application of improved agronomic practices. Irrigation is one of the most important factors contributing to increase flax production.

In general, scheduling of flax irrigation through its growing season by using the optimum irrigation levels is a very important process. Moursi and El-Hariri (1977) found that plant height, number of capsules/plant were increased with increasing nitrogen application and number of irrigation and they added that there were significant interactions between irrigation and nitrogen fertilization. Doorenbos and pruitt (1977) reported that seasonal evapotranspiration for small grain crops ranged from 300-450 mm, and was affected by crop characteristics, climatic, length of growing seasons, time of planting, soil water levels and agricultural practices. Yusuf *et al* (1978) concluded that the water consumptive use of oil seed flax increased with the increase of irrigation frequency and added that water use efficiency was the highest with one irrigation and decreased by increasing irrigation frequency. Bauder and Ennen (1981) found that seasonal water use of oil seed flax was 13.7 inches (34.25 cm.). El-Kady (1985) mentioned that increasing available soil moisture in root zone increased length of top capsule zone, fiber length and fiber strength as well as oil percentage. He added that water consumptive use values increased as available soil moisture content increased and the seasonal water consumptive use for high production for both seeds and fiber found to be 42.86 cm with 60kg N/fed. Abd-Allah (1990) indicated that flax seed and straw yield/fed, significantly increased by 35.5 and 21.8%, respectively, with irrigation at 80% of field capacity as compared with watering at 50% of field capacity. The mean values of water consumptive use were 44.05, 40.05, 37.90 and 32.85 cm, recorded from irrigated at 80, 70, 60 and 50% of field capacity. Albinet (1992) found that oil seed and fiber flax consumed a total of 4182 and 6638 m^3. water/ha under irrigation and 3449 and 4669 m^3. water without irrigation. Avergae seed yield was 50% higher than without irrigation. Shams El-Din *et al* (1996) found that the irrigation treatment received five irrigations increased flax seed and straw yields and recorded the highest amount of water applied and consumed more water as compared with holding one irrigation at seed filling stage. El-Kady *et al* (1995) reported that amount of water applied increased with decreasing the last irrigation intervals. The 6 weeks treatment (I_3) saved about 30% of applied water (4 irrigations) 1895 m^3/fed than 2 week treatment (I_1) (6 irrigations) 2823 m^3/fed. while, the 4 weeks interval (I_2) (5 irrigations) 2250 m^3/fed. saved about 20% compared with 2 week treatment. Water consumptive use were 41.50, 32.23 and 28.60 cm for treatments I_1, I_2 and I_3 respectively. Also, they added that treatment I_3 and application of 60 kg N/fed. is the best treatment to produce the maximum flax yield. El-Sabbagh *et al* (1998) studied the response of two flax cultivars to water stress by watering at 50,70 and 90% of soil moisture depletion at Sakha (North Delta). They found that the highest amount of irrigation water applied was 56.90 cm (2390m^3/fed) resulted from irrigated at 50% soil moisture depletion which produced higher yield and water consumptive use for the same treatment was 37.89 cm. They added that treatment irrigated at 90% soil moisture depletion had the highest value of water use efficiency (0.32 kg/m^3.) and flax plants extracted about 74 and 26% of its water needs from the upper and second foot, respectively, when plants were irrigated at 50% soil moisture depletion. Mladenova (1998) indicated that average seed yield of flax "c.v. Viking" was 265 kg/ha without irrigation and 491 kg. with the optimum irrigation to maintain soil moisture above 80% of field capacity. Reducing irrigation rates to 75 and 50% of the optimum reduced yields to 448 and 385 kg/ha. respectively, and omitting irrigation at the green-ripe stage reduced it to 372 kg/ha. Singh et al (2000) found that seed yield increased with increasing irrigation (694, 765 and 904 kg/ha. with irrigation at 0.4, 0.6 and 0.8 irrigation water (IW), Cumulative pan evaporation (CPE) respectively. Also added that total water use and water use efficiency increased with increasing nitrogen fertilizer rates.

The yield of various cultivars were studied by many investigators and they noticed that flax cultivars differed significantly from each other. Among them El-Kady (1985) Momtaz *et al* (1989), El-Shimy *et al* (1997), Mostafa *et al* (1998), El-Sabbagh *et al* (1998), Moawed and Abd El-Hamid (1999), El-Shimy and Moawed (2000), Al-Thabet (2003), Mostafa (2003) and Zedan (2004) who reported that $Sakha_1$ cultivar produced the highest values of straw yield per plant and straw and biological yields/fed while, $Sakha_2$ cultivar produced the highest values of the length of fruiting zone, number of capsules/plant, seed index, seed yield/plant as well as seed yield/fed, oil percentage and oil yield/fed.

Nitrogen is the nutrient element frequently deficient in Egyptian soils. Therefore, adequate supply of nitrogen is essential for optimum yield and quality of flax. Many investigators, indicated that increasing nitrogen fertilizer levels from 30, 45 and 60 kg N/fed caused an increment in straw, seed and oil yields/fed. Among them El-Kady *et al* (1995), El-Sweify *et al* (1997), Mostafa *et al* (1998), Bader *et al* (1998), Moawed and Abd-El-Hamid (1999) and Nassar and El-Taweel (2001).

The main objective of this study was to determine the most suitable irrigation requirements for some flax cultivars under different levels of nitrogen fertilizer and, to study their effects on yield, some yield attributes as well as some their water relations.

MATERIALS AND METHODS

Two field experiments were conducted during two successive seasons of 2004/2005 and 2005/2006 at Zankalon, Water Requirements Research Station, El-Sharkia Governorate, Water Management and Irrigation Systems Research Institute, National Water Research Center (N W R C). This site is located at 30°-35 N latitude and 30°-57 E longitude with an elevation of about 7 meters above mean sea level. The location represents the conditions and circumstances of East Nile Delta region. Soil of experimental site was clay in textures. Soil samples were collected to determine some soil physical and chemical properties of the experimental site. The average values of these measurements at different soil depths down to 60 cm. are presented in Table 1. Meteorological data of Zanklon Water Requirements Research Station, during the growing seasons are presented in The experiments were performed to study the effect of different levels of the water applied with rates of nitrogen fertilizer to determine the optimum water requirements and to study their effects on the straw, seed yields, and some yield attributes of two flax cultivars as well as some water relations. Flax cultivars $Sakha_1$ and $Sakha_2$ were selected from cross between Bombay X 1.1485, and cross between Hira X 1.2348 respectively. Seeds of the two flax cultivars were hand drilled in rows, 15 cm. apart, at sowing rate of 70 kg. seeds/fed. Sowing dates were 18^{th} and 20^{th} November in the first and second seasons respectively. Seeds were obtained from Fiber Crops Research Section, Field Crops Research Institute, Agricultural Research Center Giza Egypt. Sowing irrigation was applied in the next day after sowing as recommended. Harvesting took place at 1^{st} and 3^{th} May for the two growing seasons respectively. The preceding crop was Maize in the two seasons. A split-split plot design with for replication was used, where the three irrigation levels allocated in main plots, two flax cultivars occupied the sub plots. The three rates of nitrogen fertilizer were allocated to the sub-sub plots. However the treatments were as follows:

Irrigation levels (I)

Irrigation water was applied to refill the soil profile (60 cm. depth) to the following levels:

I_1:100% of field capacity (F.C.).

I_2 : 80% F.C.

I_3 : 60% F.C.

Flax plants were given five irrigations including sowing irrigation and irrigation treatments started after first irrigation.

Flax cultivars (C)

C_1 : $Sakha_1$

C_2: $Sakha_2$

Nitrogen fertilizer rates (N)

N_1 : 30 kg N/fed.

N_2 : 45 kg N/fed.

N_3 : 60 kg N/fed.

The sub-sub plot area was 150 m^2 (12×12.5 m.) consisted of 80 row of 12.5m. length and spaced 15 cm. apart with a border of 1.5m. between plots. Nitrogen was applied as (ammonium nitrate 33.5% N) in the two equal doses, the first dose was added before the first irrigation, while the remainder was added before the second irrigation. Calcium superphosphate (15.5% P_2O_5) at a rate of 100 kg/fed and potassium in the form of potassium sulphate (48% K_2O) at a rate of 50 kg/fed were applied as one dose at field preparation. Agricultural practices were applied as recommend for the region.

Recorded Data

At maturity, ten guarded plants were taken randomly from each sub-sub plot to determine the yield components of flax. However yields of straw, fiber and seed per fed were calculated from a central area of $25m^2$. which estimated in kg/m^2. and, therefore, it was converted to (kg/fed), fiber yield (kg/fed) and straw yield (ton/fed). Seed oil percentage was determined by using Soxhelt apparatus and using pure petroleum ether as a solvent according to A. O. A. C. (1975), oil yield (kg/fed) was calculated by multiplying seed oil percentage x seed yield/ fed.

Data Collected Included

Yield and yield components

Straw yield and its related characters

1-Total plant height (cm.): was measured from soil surface to the highest point of plant.
2-Technical length / plant (cm.): was determined from soil surface to the first branch.
3-Straw yield/plant (g.): average yield of ten plants.
4- Straw yield/fed (ton/fed.).
5- Fiber yield (kg/fed.).
6- Fiber length (cm.).
7-Fiber percentage % = fiberyield /fed straw yield/fed. X100.

Seed yield and its related characters:

1-Number of fruiting branches / plant.
2- Number of capsules/plant.
3- 1000 seed weight (g).
4- Seed yield/plant (g).
5- Seed yield (kg/fed).
6- Oil yield (kg/fed).
7- Seed oil %.

Soil Water Relations

Irrigation water applied (IWA)

The amounts of water applied at each irrigation was determined on the basis of raising the soil moisture content (60 cm. depth) to 100, 80 and 60% of field capacity (F.C.). A water pump provided with a calibrated water meter (in m^3.) was used for water measurements. Irrigation water was transmited through polyethylene pipes of 6 inches in diameter to each plot in front of each plot there was a valve. So that the amount of water delivered to plots exactly was controlled.

Water consumptive use (cu) or actual evapotranspiration (Eta)

Gravimetric soil samples on 15 cm. intervals down to 60 cm, were taken at sowing before and two day after every irrigation as well as, at harvest time to determine (Eta) of flax crop. Water depth of irrigation and water consumptive use were calculated according to the equations (1)and (2)given by Israelsen and Hansen (1962) as follows:

$$Diwa = DX\,Bd \times (F.C - Q_1) / 100 \quad (1)$$

$$Eta = DX\,Bd \times (Q_2 - Q_1) / 100 \quad (2)$$

Where: Diwa: Depth of irrigation water applied (cm.).

Eta : Water consumptive use (evapotranspiration) /cm.

D : Soil depth (cm.).

F.C.: Soil moisture content at field capacity by weight (%).

Q_1 : Soil moisture % before next irrigation.

Q_2 : Soil moisture % 48 hours after irrigation.

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

Depth (cm)	Sand %	Silt %	Clay %	texture	Bulk density (g/cm^3)	Field capacity (%)	Wilting point (%)	Available water (%)	E.C dsm^{-1}	pH
0-15	25.80	28.90	43.51	clay	1.25	43.51	23.55	19.96	1.40	8.10
15-30	25.12	30.10	42.50		1.27	40.50	21.06	19.44	1.22	8.00
30-45	26.90	31.50	40.50		1.35	37.12	17.59	19.53	1.25	8.01
45-60	29.78	31.50	37.12		1.40	36.25	16.62	19.63	1.05	8.02
Average	26.90	30.50	40.91		1.32	39.34	11.65	19.64	1.23	8.03

Table 2. Metrological data for Zankalon Water Requirements Research Station in 2004/2005 and 2005/2006 seasons

seasons	2004/2005					2005/2006				
Month	Temp. C°		Relative humidity %	Pan evaporation mm/day	Rainfall (mm)	Temp. C°		Relative humidity %	Pan evaporation mm/day	Rainfall (mm)
	Max	Min				Max	Min			
Nov.	16.2	13.5	68.3	2.86	0.8	23.7	10.5	69.90	3.32	-
Dec.	20.6	7.6	71.5	2.32	2.4	20.4	8.4	77.90	2.20	-
Jan.	19.9	6.6	71.9	2.43	17.8	19.6	6.1	67.77	2.43	3.8
Fed.	19.7	5.4	69.8	3.28	3.8	20.1	6.2	67.40	2.66	9.4
March	22.8	7.8	73.3	4.23	10.6	24.3	9.4	63.90	3.82	-
April	27.3	10.5	71.2	5.02	-	27.5	11.9	67.90	5.47	10.6
May	32.6	13.5	64.7	8.20	-	30.5	14.3	71.20	8.87	-

Crop water use efficiency (CWUE)

It was calculated for both seed and fiber yields/fed. according the following equations (Micheal, 1978).

$$CWUE\ crop = Y / Eta$$

Y: Seed yield (kg/fed) or fiber yield (kg/fed.).

Et.a: Actual evapotranspiration (m^3 /fed.).

Field water use efficiency (FWUE)

It was calculated for both seed and fiber yields / fed according the following equation (Michael, 1978).

$$FWUE = \frac{Y}{I\ WA}$$

Where

Y : Seed yield (kg/fed.) or fiber yield (kg/fed).

I.W.A: Irrigation water applied (m^3/fed).

Percolation losses/cm (PL)

It was calculated according the following equation (*El-Refaie and Khater, 1996*).

$$PL = IWA - Eta.\ (cm).$$

Water application efficiency (WAE)

It was calculated using the following equation (Downey, 1971).

$$WAE = \frac{Eta}{IWA} \times 100$$

Regression and correlation coefficients

Values of regression and correlation coefficients between irrigation water applied /cm (IWA), seed yield/ kg /fed (SY) fiber yield /kg/fed(FY), percolation losses/ cm.(PL), water application efficiency % (WAE), field water use efficiency per kg/cm. of irrigation water applied for seed ($FWUE_s$) and for fiber ($FWUE_f$) yields were calculated for two flax cultivars under irrigation levels (Snedecor and Cochran 1980).

Statistical analysis:

Analysis of variance was conducted for each experiment (Snedecor and Cochran., 1980). The combined analysis of the two seasons was performed (Le Clerg *et al.* 1966). The differences between the mean values were compared by using the least significant different (L.S.D) method.

RESULTS AND DISCUSSION

Yield and Yield Components

Straw yield and its related characters

Mean values of straw yield and its related characters of two flax cultivars as affected by irrigation levels and nitrogen fertilizer rates for both growing seasons and combined are presented in Tables 3 and 4.

Table 3. Total plant height, technical length/plant, straw yield/plant, straw yield/fed as affected by irrigation levels and nitrogen fertilizer rates for two flax cultivars in the two seasons and combined

Characters	Total plant height (cm).			Technical length plant (cm).			Straw yield/plant (g).			Straw yield (ton/fed).		
Seasons / Treatment	2004/ 2005	2005/2 006	comb.	2004/ 2005	2005/ 2006	comb.	2004/ 2005	2005/2 006	comb.	2004/ 2005	2005/ 2006	comb.
Irrigation levels (I):												
I_1: 100% of F.C.	108.16	100.64	104.40	98.33	90.55	94.44	2.116	2.031	2.075	4.476	3.979	4.227
I_2: 80% of F.C.	106.04	100.07	103.06	94.92	89.78	92.35	2.112	2.009	2.061	4.411	3.965	4.188
I_3: 60% of F.C.	101.66	94.10	97.88	89.55	84.13	86.84	1.837	1.746	1.792	3.754	3.134	3.444
L.S.D. at 5%	4.05	3.84	1.63	1.00	3.23	1.42	0.125	0.102	0.058	0.409	0.373	0.199
Cultivars (C):												
C_1 : $Sakha_1$	107.45	100.69	104.07	96.13	90.08	93.11	2.213	2.128	2.171	4.413	3.961	4.187
C_2 : $Sakha_2$	103.13	95.85	99.49	92.39	86.23	89.31	1.831	1.728	1.780	4.013	3.424	3.719
L.S.D. at 5%	2.10	1.31	1.42	2.48	1.21	1.63	0.144	0.152	0.129	0.142	0.213	1.460
Nitrogen rates (N):												
N_1 : 30kgN/fed	100.24	90.66	95.45	87.81	78.75	83.28	1.407	1.334	1.371	3.513	2.875	3,194
N_2 : 45kgN/fed	106.77	101.38	104.07	95.60	91.71	93.66	2.316	2.216	2.266	4.524	4.074	4.299
N_3 : 60kgN/fed	108.86	102.77	105.82	99.37	94.01	96.69	2.342	2.234	2.289	4.603	4.125	4.366
L.S.D. at 5%	2.83	2.03	2.38	4.30	2.35	3.33	0.097	0.115	0.066	0.186	0.174	0.111
Interactions:												
I × C	N.S	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
I × N	N.S	N.S	N.S	N.S	N.S	N.S	*	N.S	N.S	N.S	N.S	N.S
C × N	N.S	N.S	N.S	N.S	N.S	N.S	*	*	*	N.S	N.S	N.S
I × C × N	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table 4. Fiber yield/fed, fiber length and fiber percentage as affected by irrigation levels and nitrogen fertilizer rates for two flax cultivars in the two seasons and combined

Characters	Fiber yield (kg/fed).			Fiber length (cm).			Fiber %.		
Seasons / TreatmentS	2004/ 2005	2005/ 2006	Comb.	2004/ 2005	2005/ 2006	comb.	2004/ 2005	2005/ 2006	comb.
Irrigation levels (I):									
I_1: 100% of F.C.	850.34	700.72	775.53	103.17	95.72	99.45	18.85	17.89	18.37
I_2: 80% of F.C.	845.83	692.81	769.32	100.33	95.06	97.70	18.81	17.87	18.34
I_3 : 60% of F.C.	678.50	534.28	606.39	95.69	89.25	92.47	18.14	16.93	17.53
L.S.D. at 5%	55.43	50.70	26.96	1.96	3.48	1.43	N. S	N.S	N. S
Cultivars (C):									
C_1: Sakha$_1$	864.42	725.00	794.71	102.08	96.01	99.05	19.66	18.48	19.07
C_2: Sakha$_2$	718.70	560.20	639.45	97.39	90.67	94.03	17.55	16.64	17.10
L.S.D. at 5%	41.70	28.99	84.77	2.23	1.72	1.70	0.67	1.03	0.74
Nitrogen rates (N):									
N_1 : 30 kg N/fed	688.73	539.99	614.36	91.65	82.32	86.99	18.13	16.73	17.43
N_2 : 45 kg N/fed	842.67	685.89	764.28	102.57	97.93	100.25	18.54	17.75	18.15
N_3 : 60kg N/fed	843.28	701.92	772.60	104.98	99.77	102.38	19.13	18.20	18.66
L. S. D. at 5%	64.56	30.14	30.99	2.83	2.02	2.18	N. S	0.93	1.06
Interactions:									
I × C	N.S	N.S	N.S	N.S	*	N.S	N.S	N.S	N.S
I × N	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
C × N	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
I × C × N	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Statistical analysis showed significant differences between each of the two flax cultivars, irrigation levels and nitrogen rates in all the seven traits studied.

Effect of irrigation levels

Data in Tables 3 and 4 show in both seasons and combined that irrigation levels affected significantly all characters under study.

Applying treatment I_3 (60% F.C.) caused a significant decrease in characters i.e. total plant height (cm), technical length/plant (cm), straw yield / plant (g),straw yield / fed (ton), fiber yield/fed (Kg), fiber length (cm) and fiber percentage by 6.25, 8.06, 13.40, 18.55, 21.78, 7.02 and 2.50% as compared with treatment I_1(100% F.C.) as average for both seasons.

In this respect, no significant differences were detected in the same characters between treatments I_1 and I_2 in both seasons and combined, respectively. The reduction in straw yield per ton/fed in treatment I_3 may be attributed to the decrease in total plant height. Similar results were obtained by Abd-Allah (1990), Albinet (1992), Shams El-Din *et al* (1996), El-Sabbagh *et al* (1998), Mladenova (1998), Singh *et al* (2000).

Effect of cultivars

The differences among cultivars in all seven straw characters studied reached the significant level Tables 3 and 4. Sakha$_1$ cultivars had the highest plant height (cm), technical length/plant (cm), straw yield/plant (g), straw yield per ton/fed, fiber yield/fed., fiber length and fiber percentage and outyielded Sakha$_2$ cultivar by 4.60, 4.25, 21.97, 12.58, 24.29, 5.34, and 9.47% respectively as average for both seasons. These results may be due to the cultivars gentenical make-up. These results are in harmony with those obtained by El-Kady (1985), Momtaz et al. (1989), El-Shimy *et al* (1997), Mostafa *et al* (1998), El-Sabbagh *et al.,* (1998), Moawed and Abd El-Hamid (1999), El-Shimy and Moawed (2000),Al-Thabet (2003), Mostafa (2003) and Zedan (2004).

Effect of nitrogen fertilizer rates

Regarding to nitrogen fertilizer, data in Tables 3 and 4 revealed that there was a significant increase in all straw yield per fed and its related characters studied i.e. total plant height (cm), technical length/plant (cm), straw yield/plant (g), straw yield/fed (ton), fiber yield/fed (kg), fiber length (cm) and fiber percentage with adding nitrogen at the rate of 60kg N/fed. The increment was 10.86, 16.10, 67.00, 36.63, 25.90, 17.69 and 7.00% over the treatment received 30 kg N/fed for the previous traits, respectively, as an average for both seasons Tables 3 and 4. On the other hand, no significant difference in mean yield of straw and its related characters occurred between 45 and 60 kg N/fed. This result may be explained on the basis that nitrogen had effect in metabolism processes i.e. enhanced cell division building new merstimic cells, cell elongation, increasing photosynthesis activity which, in turn, resulted in an increase in the number and the length of the internodes which gave a remarkable increase in flax plant. These results agree with those reported by Moursi and El-Hariri (1977), El-Sweify *et al* (1997), El-Kady *et al* (1995), Mostafa *et al* (1998), Bader *et al* (1998), Moawed and Abdel-Hamid (1999) and Nassar and El-Taweel (2001).

Seed yield and its related characters

Mean values of seed yield and its related characters for two flax cultivars as effected by irrigation levels and nitrogen fertilizer rates for both growing seasons and combined are presented in Tables (5 and 6).

Effect of irrigation levels

Data in Tables 5 and 6 show in both seasons and combined that irrigation levels affected significantly all characters in this study. Applying treatment I_3 (60% F.C.) caused a significant decrease in number of fruiting branches/plant, number of capsules/plant, 1000 seed weight, seed yield/plant, seed yield/fed, oil yield/fed. and seed oil percentage by 15.19, 19.44, 5.89, 11.35, 18.03, 4.57 and 14.96% as compared with treatment I_1 (100% F.C.) as average for both seasons. In this respect, no significant differences were detected in the same characters between the treatments I_1 (100% of F.C.) and I_2 (80%, F.C.) respectively in both seasons and combined.

Exposing flax plants to water stress by irrigation at 60% of F.C. (treatment I_3) _was associated with a great reduction in all estimated characters as compared with irrigation at 100% F.C. (treatment I_1). This is to be expected since water plays an important role in plants and moisture deficits can have a deleterious effect on most biological processes. The reduction in seed yield under treatment I_3 (60% of F.C.) may be attributed to the decrease in number of capsules/plant and 1000-seed weight. These results are in agreement with those obtained by Yusuf *et al* (1978), Bauder and Ennen (1981), El-Kady (1985), Abd-Allah (1990), Albinet (1992), El-Sabbagh *et al* (1998), Mladenova (1998), and Al-Thabet (2003).

Table 5. Number of fruiting branches/plant, number of capsules/plant, 1000-seed weight and seed yield/plant as affected by irrigation levels and nitrogen fertilizer rates for two flax cultivars in the two seasons and combined

Characters	Number of fruiting brunches/plant			Number of capsules/plant			1000-seed weight (g).			Seed yield/plant (g).		
Seasons / Treatments	2004/2005	2005/2006	Comb.	2004/2005	2005/2006	Comb.	2004/2005	2005/2006	Comb.	2004/2005	2005/2006	Comb.
Irrigation levels (I):												
I_1: 100% of F.C.	9.52	8.52	9.02	8.19	7.55	7.87	8.62	8.35	8.49	0.557	0.541	0.549
I_2: 80% of F.C.	9.29	8.48	8.89	8.06	7.42	7.74	8.60	8.34	8.47	0.545	0.502	0.524
I_3: 60% of F.C.	8.05	7.24	7.65	6.79	6.09	6.44	8.23	7.75	7.99	0.473	0.427	0.450
L.S.D. at 5%	0.43	0.51	0.24	0.52	0.56	0.28	0.23	0.40	0.17	0.046	0.048	0.024
Cultivars (C):												
C_1 : $Sakha_1$	7.53	7.13	7.33	6.20	5.96	6.08	7.83	7.47	7.65	0.461	0.436	0.449
C_2 : $Sakha_2$	10.38	9.04	9.71	9.16	8.08	8.62	9.14	8.83	8.99	0.589	0.544	0.567
L.S.D. at 5%	0.31	0.18	0.27	0.27	0.26	0.23	0.20	0.35	0.25	0.041	0.037	0.003
Nitrogen rates (N):												
N_1 : 30kgN/fed	7.33	7.11	7.22	6.04	6.16	6.10	8.15	6.73	7.44	0.350	0.330	0.340
N_2 : 45kgN/fed	9.73	8.50	9.12	8.42	7.41	7.92	8.61	8.29	8.45	0.602	0.556	0.579
N_3 : 60kgN/fed	9.80	8.64	9.22	8.58	7.48	8.03	9.69	9.42	9.06	0.623	0.583	0.603
L.S.D. at 5%	0.42	0.28	0.22	0.36	0.28	0.20	0.20	0.17	0.11	0.031	0.034	0.020
Interactions:												
I × C	N. S	N. S	N. S	*	*	*	N. S	N. S	N. S	N. S	N. S	N. S
I × N	N. S	N. S	N. S	N. S	N. S	N. S	N. S	N. S	N. S	**	*	*
C × N	*	N. S	*	N. S	*	N. S	N. S	N. S	N. S	N. S	N. S	N. S
I × C × N	N. S	N. S	N. S	N. S	N. S	N. S	N. S	N. S	N. S	N. S	N. S	N. S

Table 6. Seed yield/fed, seed oil percentage and oil yield/fed.as affected by irrigation levels and nitrogen fertilizer rates for two flax cultivars in the two seasons and combined

Characters / Seasons / Treatments	Seed yield/fed. (kg)			Seed oil %			Oil yield/fed. (kg).		
	2004/ 2005	2005/ 2006	Comb.	2004/ 2005	2005/ 2006	Comb.	2004/ 2005	2005/ 2006	Comb.
Irrigation levels (I)									
I_1: 100% of F.C.	801.88	709.62	755.75	39.16	38.35	38.76	315.51	274.51	295.01
I_2: 80% of F.C.	778.76	705.74	742.25	38.99	38.23	38.61	305.34	272.94	289.14
I_3: 60% of F.C.	714.25	625.77	670.01	37.14	36.84	36.99	267.58	234.15	250.86
L.S.D. at 5%	21.45	46.90	24.54	0.45	0.22	0.60	5.85	23.25	17.14
Cultivars (C):									
C_1 : $Sakha_1$	707.45	591.65	649.55	36.79	36.15	36.47	261.05	214.52	237.79
C_2 : $Sakha_2$	822.60	769.10	795.85	40.08	39.46	39.77	331.23	306.51	318.87
L.S.D. at 5%	20.11	14.88	29.28	0.40	0.39	1.29	9.41	17.99	13.39
Nitrogen rates (N):									
N_1 : 30 kg N/fed	657.80	582.08	619.94	37.20	36.37	36.79	245.58	212.80	229.19
N_2 : 45 kg N/fed	808.12	727.11	767.62	39.07	38.50	38.79	317.31	282.16	299.74
N_3 : 60kg N/fed	829.15	731.93	780.53	39.04	38.55	38.79	325.53	286.58	306.06
L. S. D. at 5%	39.16	31.25	21.80	0.37	0.32	0.95	15.42	12.60	14.21
Interactions:									
I × C	N. S	N.S	N. S	N.S	N.S	N.S	N.S	N.S	N.S
I × N	N. S	*	N. S	N.S	*	N.S	*	**	**
C × N	N. S	N. S	N. S	N.S	N.S	N.S	N.S	N.S	N.S
I × C × N	N. S	N. S	N. S	N.S	N.S	N.S	N.S	N.S	N.S

Effect of cultivars

The differences among cultivars in all seed yield characters studied reached the significant level Tables 5 and 6.Sakha$_2$ cultivars surpassed significantly Sakha$_1$ cultivars in most characters, i.e. number of fruiting branches/plant, number of capsules/plant, 1000 seed weight, seed yield/plant, seed yield/fed., oil yield/fed and seed oil percentage by 32.47, 41.78, 17.52, 26.28, 22.52, 9.13 and 34.10% as average for both seasons. The superiority of Sakha$_2$ cultivar in seed yield per fed may be attributed to the increase in number of fruiting branches plant, number of capsules/plant, 1000 seed weight and seed yield/plant. Similar results were found by Momtaz *et al* (1989), El-Shimy *et al* (1997), Mostafa *et al* (1998), El-Sabbagh *et al* (1998), Moawed and Abd El-Hamid (1999), El-Shimy and Moawed (2000), Al-Thabet (2003). Mostafa (2003) and Zedan (2004).

Effect of nitrogen fertilizer rates

Regarding to nitrogen fertilizer rates, data revealed that there was a significant increase in all seed yield and its related characters studied i.e. number of fruiting branches/ plant, number of capsules/plant, 1000 seed weight (g), seed yield/plant (g), seed yield/ fed(kg), oil yield/fed (kg). and seed oil percentage due to adding nitrogen at N_3 (60 kg N/fed).The increment was 27.70, 31.64, 14.11, 77.35, 25.91, 5.54 and 33.54%. over the treatment received N_1 (30 kg N/fed.) for the previous traits respectively, as average for both seasons (Tables 5and 6).The differences between the treatments receiving N_2 (45) and N_3 (60 kg) were not significant. This significant increase could be attribute to the important role of nitrogen fertilization in increasing the capacity of the plant in building metabolites which led to an increase in dry matter accumulation in the different plant organs. These findings were in agreement with those obtained by Moursi and El- Hariri (1977), El-Kady et al (1995), El-Sweify *et al* (1997), Mostafa *et al* (1998), Bader *et al* (1998), Moawed and Abdel-Hamid (1999) and Nassar and El-Taweel (2001).

Soil Water Relations

Irrigation water applied (IWA)

The amounts of applied irrigation water as effected by irrigation levels and nitrogen fertilizer rates for the two flax cultivars during the two growing seasons and average over them are presented in Table 7 .The results showed that for each irrigation treatment the amounts of irrigation water was almost the same in the two seasons.

For an average both of seasons, the amounts of applied water for irrigation levels with nitrogen rates were highest when irrigation was given to wet the 60 cm soil depth to 100% of the field capacity (treatment I_1) which received about 2646.0m^3/fed. (63.00cm.). These amounts were less for treatment I_2 (80% of F.C.) which received about 2300.0.0 m^3/fed (54.76 cm.) and treatment I_3 (60% of F.C.) which received about 1983 m^3/fed (46.70 cm.) respectively as average for both seasons. Amounts of applied irrigation water for cultivars Sakha$_1$ and Sakha$_2$ were 54.53 and 55.11 cm. Respectively, as an average of the two seasons. From these results, it could be concluded that the changes in the crop production was affected significantly by how much water was applied where these amounts varied from 8.24 to 16.30 cm., but should be sufficient to replace moisture depleted from the root zone in order to avoid subjecting plant to moisture stress throughout the growing seasons. Also the results indicated that water saved from applying I_2 and I_3 treatments were 13.08 and 25.87% respectively, as average for both seasons. Many investigators reported that the water requirements for flax plant per m^3/fed was 1894, (El-Kady *et al,*1995) and 2390 m^3/fed (El-Sabbagh *et al,* 1998)

Water consumptive use or evapotranspiration (Eta)

Actual consumptive use values as affected by irrigation levels and nitrogen fertilizer rates for two flax cultivars for both seasons and over them are shown in Table 7. The results indicate that water consumptive use values were 41.81, 37.43 and 32.48 cm. for irrigation treatments I_1, I_2 and I_3 as average for the two seasons respectively. This trend showed that the increment in water consumptive use depends on the availability of soil moisture in the root zone. The results show that more available soil moisture provided a chance for more vegetative growth and this in turn caused more luxuriant use of water, which ultimately resulted in increasing transpiration. On the other hand, irrigation using treatment I_3 (60% F.C.) resulted in poor growth with less leaf area for transpiration. In this connection, Manner (1956) explained the positive yield response obtained to the sensitivity of flax roots and water stress. Israelsen and Hansen (1962) noticed that seasonal consumptive use by small grains was 36 cm. Doorenbos and Pruitt (1977) reported that following an irrigation, the crop will transpire as the predicted rate during the days immediately following irrigation with time, the soil become drier and the rate will decrease more and they obtained that evapotranspiration ranged from 300 – 450 mm for small grain crops. Brahim (1981)showed that the increase in evapotransoiration rate by maintaining soil moisture at high level can be attributed to excess available water in the root zone to be consumed by the plants. Misra *et al* (1991) stated that high soil water content, which extends the period of peak water depletion on by evapotronspiration, increases the rate and amount of seasonal water use. The above mentioned results are in harmony with those reported by Yusuf *et al* (1978), Bauder and Ennen (1981), El-kady (1985), Abd–Allah (1990), Albinet (1992), El-Kady *et al.* (1995), Shams El-Din *et al.* (1996), Mladenova (1998) and El-Sabbagh *et al.* (1998).

Regarding to flax cultivars it is clear that water consumed use for $Sakha_1$ and $Sakha_2$ cultivars were 36.86 and 37.62 cm. as average for both seasons respectively. This means that $Sakha_2$ cultivar used higher quantity of water than $Sakha_1$ cultivar. The difference was 0.76 cm.

From Table 7 it can be noticed that increasing nitrogen fertilizer rates from 30 to 45 and 60 kg N/fed. increased consumptive use (Eta) values. The increment were 3.78 and 6.39 % for 45 and 60 kg N/fed. compared to 30 kg N/fed. respectively. This result indicates that Eta value increased gradually as nitrogen levels increased. This may be due to that higher level of nitrogen fertilizer encourages plant growth, especially root growth and subsequent more water consumed. These findings are in agreement with those obtained by Moursi and El-Hariri (1977) and El-Kady *et al* (1995).

Crop water use efficiency (CWUE)

(CWUE) expressed as kg. for both seed and fiber yields per cubic meter of water consumed as affected by irrigation levels, flax cultivars and nitrogen fertilizer rates for both seasons and over them are shown in Table (7). Comparing with (CWUE) under different irrigation levels for seed and fiber yields date revealed that the maximum values of $CWUE_g$ and $CWUE_f$ were obtained from treatment I_3 and treatment I_2 respectively. The lowest values were obtained from treatment I_1 and treatment I_3 respectively as average for both seasons. Similar results were obtained by Yusuf *et al.* (1978), El-Kady (1985) and El-Sabbagh *et al* (1998).

Table 7. Irrigation water applied (IWA), Evapotronspiration (Eta), Crop water use efficiency (CWUE) and Field water use efficiency (FWUE) for both seed and fiber yields/fed as affect by irrigation levels and nitrogen rates for two flax cultivars in the two seasons and in combined

Characters / Seasons / Treatments	IWA (cm).			Eta (cm).			CWUE: Seed yield (kg/fed) / water consumed (m^3 /fed)			CWUE: Fiber yield (kg/fed)/ water/consumed (m^3 /fed)			FWUE: Seed yield (kg/fed.)/ /water applied (m^3 /fed)			FWUE: Fiber yield (kg/fed.)/ water applied (m^3 /fed)		
	2004/ 2005	2005/ 2006	mean	2004/ 2005	2005/ 2006	mean	2004/ 2005	2005/ 2006	mean	2004/ 2005	2005/ 2006	mean	2004/ 2005	2005/ 2006	mean	2004/ 2005	2005/ 2006	mean
Irrigation levels (I):																		
I_1 : 100% of F.C.	62.24	63.76	63.00	40.82	42.80	41.81	0.468	0.394	0.431	0.496	0.395	0.446	0.307	0.265	0.286	0.325	0.262	0.293
I_2 : 80% of F.C.	53.72	55.80	54.76	36.76	38.10	37.43	0.504	0.441	0.472	0.548	0.433	0.489	0.345	0.301	0.323	0.375	0.296	0.335
I_3 : 60% of F.C.	47.54	45.86	46.70	32.76	32.20	32.48	0.519	0.463	0.491	0.493	0.395	0.444	0.358	0.325	0.342	0.340	0.277	0.309
Cultivars: (C):																		
C_1 : $Sakha_1$	53.90	55.16	54.53	36.40	37.32	36.86	0.463	0.377	0.420	0.565	0.463	0.514	0.312	0.255	0.284	0.382	0.313	0.347
C_2 : $Sakha_2$	55.00	55.12	55.11	37.16	38.08	37.62	0.527	0.481	0.504	0.460	0.350	0.405	0.355	0.332	0.344	0.311	0.242	0.276
Nitrogen rates (N):																		
N_1 : 30 kg N/fed	54.35	54.53	54.44	35.29	36.75	36.02	0.445	0.377	0.411	0.465	0.350	0.407	0.288	0.254	0.271	0.302	0.236	0.269
N_2 : 45 kg N/fed	54.60	54.98	54.79	37.10	37.66	37.38	0.519	0.460	0.489	0.514	0.434	0.487	0.352	0.334	0.334	0.367	0.297	0.332
N_3 : 60 kg N/fed	54.55	55.91	55.73	37.95	38.69	38.32	0.520	0.450	0.485	0.529	0.342	0.480	0.355	0.312	0.333	0.361	0.309	0.335

Regarding to flax cultivars, it is clear that $Sakha_2$ cultivar had the highest $CWUE_s$ to produce seed yield while, $Sakha_1$ cultivar gave the greatest $CWUE_f$ for fiber yield. These results could be attributed to the highly significant differences among seed and fiber yields values for the two cultivars.

For nitrogen fertilizer rates, maximum $CWUE_s$ and $CWUE_f$ values were obtained when flax plant were fertilized with 45kg. N/fed (N_2) while, the lowest values were resulted from 30 kg. N/fed (N_1) for the same traits respectively as average for both seasons. The increase in seed and fiber yields/ fed. were achieved by applying 45 kg.N/fed. (N_2). This may be due to the productivity of seed and of fiber yields per unit volume of water consumed could be improved by increasing rate of applied nitrogen from 30 to 45 kg. N/fed. Further increase in rate to 60 kg N/fed. did not caused any significant increment of seed and fiber yield in this respect. Such results are in harmony with those obtained by El-Kady (1985), El Kady *et al* (1995) and Singh et al (2000).

Field water use efficiency (FWUE)

(FWUE) expressed as kg for both seed and fiber yields per cubic meter of water applied as affected by irrigation levels, flax cultivars and nitrogen fertilizers rates for two seasons and over them are presented in Table 7. The results revealed that irrigation using treatment I_3 produced the highest value of $FWUE_s$ while, treatment I_2 produced the highest value $FWUE_f$. However the lowest values of $FWUE_s$ and. $FWUE_f$ were obtained by treatment I_1.

Regarding to flax cultivars, it is clearly evident that $Sakha_2$ had the highest $FWUE_s$ which outyielded $Sakha_1$ sultivar by 21.13% of seed yield. On the other side $Sakha_1$ surpassed $Sakha_2$ in $FWUE_f$ by 20.46% of fiber yield as average for both seasons. These results may be due to the cultivars genetical make-up.

For nitrogen fertilizer rates, maximum values of $FWUE_s$ and $FWUE_f$ where obtained when flax plants were fertilized by 60 kg N/fed (N_3), while the lowest values were resulted from adding 30 kg. N/fed (N_1). This may be due to the increase in seed and fiber yields/fed as nitrogen rate increased from 30 to 60 kg N/fed. Table 7.

Percolation losses per cm. (PL)

Data in Table 8 showed PL (cm) for irrigation levels and nitrogen rates for two flax cultivars in the two seasons and in

Table 8. Percolation losses (PL) and water application efficiency (WAE) as affected by irrigation levels and nitrogen rates for tow flax cultivars in the two seasons and over them

Character	PL (cm)			WAE %		
Treatments \ Seasons	2004/ 2005	2005/ 2006	mean	2004/ 2005	2005/ 2006	mean
Irrigation levels (I):						
I_1 : 100% of F.C.	21.42	20.96	21.19	65.59	67.13	66.36
I_2 : 80% of F.C.	16.96	17.70	17.33	68.43	68.28	68.36
I_3 : 60% of F.C.	14.87	13.66	14.22	68.89	70.21	69.55
Cultivars (C):						
C_1 : Sakha1	1750	17.84	17.67	67.53	67.66	67.60
C_2 : Sakha2	17.94	17.04	17.49	67.44	69.05	68.27
Nitrogen rates (N):						
N_1 : 30 kg N/fed	19.05	17.78	18.42	64.93	67.39	66.16
N_2 : 45 kg N/fed	17.50	17.32	17.41	67.95	68.50	68.23
N_3 : 60 kg N/fed	16.60	17.22	16.91	69.57	69.20	69.39

combined. It can be observed from the data in Table 8 that the percolation losses (cm) of the amount applied water were higher for treatment I_1. while, the lowest value was recorded by treatment I_3 as averages of the two seasons, respectively.

Regarding flax cultivars, it is evident that $Sakha_1$ cultivar achieved the highest value of percolation losses, while $Sakha_2$ had the lowest value as average of two seasons.

Concerning nitrogen fertilization, data in the same table revealed that the highest value was recorded by applying N_1 (30 kg N/fed) while, the lowest value was obtained by adding N_3 (60 kg N/fed) as averages for both seasons.

Water application efficiency (WAE)

Values of water application efficiency (WAE) expressed in percent (%) as affected by irrigation levels and nitrogen fertilizer rates for two flax cultivars in the two growing seasons and over them are presented in Table 8. The results showed that the highest values of W.A.E was reached 69.55% for treatment I_3 (60% of F.C.) and the lowest ones was 66.36% resulting from the application of treatment I_1 as average for both seasons. Also the results indicated that 33.63, 31.64 and 30.45% of each $1m^3$. of irrigation water applied were not used by crop and returned to the system downstream via drainage or groundwater as a losses for the three treatments I_1, I_2 and I_3 respectively. The increase of W.A.E could be mainly due to the decrease of water losses.

Regarding to flax cultivars, it is clear that $Sakha_2$ cultivar achieved the highest value of W.A.E (68.27%) while, $Sakha_1$ cultivar gave 67.60% for the same character as an average of the two seasons. In this connection, it should be mentioned here that their result may be resulted in the increased consumptive use of $Sakha_2$ than that of $Sakha_1$ cultivar. With respect to nitrogen fertilizer rates WAE values increased gradually as nitrogen rates increase. This result may be due to that nitrogen encourages plant growth increasing photosynthesis activity and encouraging metabolic processes in flax plant.

Regression and correlation coefficients

Regression and correlation coefficients values between irrigation water applied cm (IWA), seed yield kg/fed (SY). Fiber yield kg/fed (FY), percolation losses per cm (PL), water application efficiency % (WAE), field water use efficiency per kg/cm of irrigation water applied for both seed ($FWUE_s$) and fiber ($FWUE_f$) yields for all irrigation levels and two flax cultivars as average for both seasons shown in Table 9.

Table 9. Regression and correlation coefficients between irrigation water applied (IWA) as the independent variable seed yield kg/fed (SY), fiber yield kg/fed. (FY), percolation losses/cm. (PL), water application efficiency %, field water use efficiences for seed ($FWUE_s$) and fiber ($FWUE_f$) yields for all irrigation levels and two flax cultivars as an average for both seasons

Dependent variables (Y)	Independent Variable (X)	Regression equations		Correlation Coefficient (r)
		Sakha₁ cultivar		
S Y	I WA	$Y_1 = 342.935 + 5.517\ X$	(1)	0.868**
F Y	I WA	$Y_2 = 247.98 + 10.02\ X$	(2)	0.971**
P L	I WA	$Y_3 = -5.768 + 0.434\ X$	(3)	0.998**
W A E	I WA	$Y_4 = 77.859 - 0.1931\ X$	(4)	- 0.989**
FWUEs	I WA	$Y_5 = 18.52 - 0.114\ X$	(5)	- 0.920**
$FWUE_f$	I WA	$Y_6 = 18.714 - 0.075\ X$	(6)	- 0.610*
		Sakha₂ cultivar		
S Y	I WA	$Y_1 = 526.126 + 4.913\ X$	(7)	0.917**
F Y	I WA	$Y_2 = 68.43 + 10.40\ X$	(8)	0.840**
P L	I WA	$Y_3 = -5.509 + 0.410\ X$	(9)	0.976**
W A E	I WA	$Y_4 = 77.654 - 0.1522\ X$	(10)	- 0.726**
FWUEs	I WA	$Y_5 = 24.06 - 0.172\ X$	(11)	- 0.989**
$FWUE_f$	I WA	$Y_6 = 17.48 - 0.106\ X$	(12)	- 0.860**

The data revealed that IWA is positively correlated with SY, FY and PL and negatively correlated with WAE, $FWUE_s$ and $FWUE_f$. Also the data showed that increasing IWA at a rate of one cm, enhanced 5.517 kg, 10.02 kg and 4.913 kg, 10.40 kg for SY and SF for $Sakha_1$ and $Sakha_2$ respectively. (equations 1, 2, 7 and 8). This finding indicated that soil moisture enhanced the growth of flax plant. Regarding equation 3 and 9 the data indicated that increasing IWA at a rate of one cm, increasing PL However FWUEs and $FWUF_f$ decreased (0.1931, 0.114 and 0.075) for $Sakha_1$ and (0.1522, 0.172 and 0.106) for $Sakha_2$ respectively (equations 4, 5, 6, 10, 11 and 12).

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بعض العوامل المؤثرة على المحصول وجودته وكفاءة إستخدام المياه فى الكتان

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لزيادة إنتاجية محصول الكتان وجودته وزيادة كفاءته لاستخدام المياه أجريت تجربتان حقليتان فى أرض طينية بمحطة بحوث المقننات المائية بالزنكلون بمحافظة الشرقية خلال موسمى الزراعة ٢٠٠٤/٢٠٠٥، ٢٠٠٥/٢٠٠٦ لدراسة استجابة صنفى الكتان سخا١، سخا٢ لمستويات رى مختلفة، ومعدلات مختلفة من السماد الأزوتى وفيما يلى أهم النتائج التى تم الحصول عليها كمتوسطات لموسمى الزراعة.

سجلت معاملة الرى عند ١٠٠% من السعة الحقلية (I_1) أعلى القيم لمحصول القش والصفات المرتبطة به، تلتها فى ذلك معاملة الرى ٨٠% من السعة الحقلية (I_2)، بينما سجلت معاملة الرى ٦٠% من السعة الحقلية أقل القيم. إحتل صنف الكتان سخا١ المركز الأول وتفوق محصولياً على صنف الكتان سخا٢ فى محصول القش والصفات المرتبطة به بينما سجل صنف الكتان سخا٢ أعلى القيم لمحصول البذور والصفات المرتبطة به. أدى إضافة ٤٥ كم نيتروجين للفدان إلى الحصول على أعلى القيم لمحصولى القش والبذور. وفيما يختص لمعاملات الرى فقد سجلت معاملة الرى رقم ١ (١٠٠% من السعة الحقلية) أعلى قيمد لمعدل الاستهلاك المائى، تلتها فى ذلك المعاملة رقم ٢ (٨٠% من السعة الحقلية). وفى هذا الخصوص فقد أعطى صنف الكتان سخا١ أعلى القيم لهذه الصفة مقارنة بالصنف سخا٢. سجلت معاملة الرى رقم ٣ (٦٠% من السعة الحقلية) أعلى القيم لكفاءة إستخدام المياه للمحصول وعلى مستوى الحقل لمحصول البذور، بينما أعطت المعاملة رقم ٢ (٨٠% من السعة الحقلية) أعلى قيمة لمحصول الألياف لنفس الصفات على الترتيب. من ناحية أخرى فقد سجل صنف الكتان سخا١ أعلى القيم لهاتين الصفتين لمحصول الألياف، بينما سجل صنف الكتان سخا٢ أعلى القيم لهاتين الصفتين لمحصول البذور على الترتيب. أدى زيادة التسميد الآزوتى إلى ٤٥ كجم نيتروجين/ فدان إلى الحصول على أعلى قيمة لصفتى كفاءة استخدام المياه لمحصولى البذور والألياف. من ناحية أخرى فقد سجلت معاملة الرى رقم ٣ أعلى قيمة لكفاءة الرى التطبيقية. وقد تفوق صنف الكتان سخا٢ أيضا على الصنف سخا١ لنفس الصفة. أدى استخدام معاملة الرى رقم ٣ أعلى قيمة لكفاءة الرى التطبيقية. وقد تفوق الصنف سخا٢ على الصنف سخا١ لنفس الصفة. سجلت المعاملة رقم ١ أعلى القيم من التسرب العميق، بينما سجلت المعاملة رقم ٣ أقل القيم. وقد أعطى صنف الكتان سخا٢ أقل القيم أيضاً. ومن ناحية أخرى فقد أدى زيادة التسميد النيتروجينى حتى ٦٠ كجم نيتروجين/ فدان إلى نقص قيم التسرب العميق.