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INFLUENCE OF WATER DEFICIT DURING GROWTH STAGES AND NITROGEN FERTILIZATION RATES ON PRODUCTIVITY, OIL CONTENT AND SOME WATER RELATIONS OF CANOLA CROP (*Brassica napus* L.) IN HEAVY CLAY SOILS.

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ABSTRACT

A field investigation was conducted at the experimental farm, Sakha Agricultural Research Station, Kafr El-Sheikh Governorate during the two successive winter growing seasons 2012/2013 and 2013/2014 to investigate the effect of irrigation treatments (water deficit, during the growth stages) and nitrogen fertilization rates on productivity, oil content and some water relations of canola crop in the North Middle Nile Delta region. The station is situated at 31^{0} 07^{-} N Latitude and 30^{0} 57^{-} E longitude. It has an elevation of about 6 metres above mean sea level (MSL). A split plot design with three replicates was used in this present study. The main plots were occupied by irrigation treatments which were I_1 (traditional irrigation, as practice by local farmers in the studied area, 6 irrigations), I_2 (sowing irrigation + first post planting irrigation (mohayaa) + one irrigation during flowering growth stage only, 3 irrigations), I_3 (sowing irrigation + mohayaa + one irrigation during seed filling only, 3 irrigations) and I_4 (sowing irrigation + mohayaa + one irrigation during flowering growth stage + one irrigation during seed filling only, 4 irrigations), while, sub- main plots were randomly assigned by nitrogen fertilization rates 15, 30, 45, and 60 kg N/ fed. for N_1, N_2, N_3 and N_4, respectively.

The main results can be summarized as follows:-

* The highest values for irrigation water requirements were recorded under irrigation treatment I_1 (Traditional irrigation) and the values are 63.16 cm (2652.72 m^3/ fed.) and 62.14 cm. (2609.88 m^3/fed.). Meanwhile, the lowest values were recorded under irrigation treatment I_3 and the values are 34.87 cm. (1464.54 m^3/ fed.) and33.70 cm. (1415.40 m^3/ fed.) in the first and second growing seasons, respectively. Generally, the values of irrigation water requirements in the two growing seasons can be descended in order $I_1 > I_4 > I_2 > I_3$. Concerning, water consumptive use, the highest values were recorded under irrigation treatment I_1 and the values are 36.80 cm. (1545.39 m^3/ fed.) and 36.40 cm. (1528.80 m^3/ fed.). Meanwhile, the lowest values were recorded under irrigation treatment I_3 and the values are 23.58 cm. (990.15m^3/ fed.) and 23.20 cm. (974.40 m^3/ fed.) in the first and second growing seasons, respectively. Generally, the values of water consumptive use can be descended in order $I_1 > I_4 > I_2 > I_3$ in the two growing seasons. The values of water consumptive use were slightly affected by nitrogen fertilization rates, where, the values can be descended in order $N_4 > N_3 > N_2 > N_1$ in the two growing seasons.

*Regarding, consumptive use efficiency (Ecu), water productivity (WP) and productivity of irrigation water (PIW), the highest overall mean values for Ecu were recorded under irrigation treatment I_4. Meanwhile, for WP and PIW were recorded under irrigation treatment I_3 and the values are 72.41 %, 1.42 kg/ m^3 and 0.97 kg/ m^3 for Ecu, WP and PIW, respectively. Concerning, the effect of nitrogen fertilization rates, the overall mean values for Ecu, WP, PIW can be descended in order $N_4 > N_3 > N_2 > N_1$.

Concerning, seed yield, some yield attributes, seed oil (%),oil yield (kg/ fed.), number of racemes and number of days to 50 % flowering were significantly affected by irrigation treatments except number of racemes in the two growing seasons and 1000 seed weight (g.) in the first season which not significantly affected by irrigation treatments, for all the studied parameters. The highest mean values were recorded under irrigation treatment I_1 in comparison with I_2, I_3 and I_4 in the two seasons. Concerning, the effect of nitrogen rates on canola studied characters, it gave highly significant effect in both seasons. Increasing nitrogen rates from 15 to 60 kg N/ fed. increased all characters except seed oil content which decreased by increasing nitrogen fertilization rates in the two seasons. Regarding, the interactions between irrigation treatments (I) and nitrogen fertilization rates (N), there was significant effect on seed yield kg/ fed., seed yield gm/ plant, number of days to 50 % flowering, seed oil content (%) and oil yield kg/fed. In the second season only and plant height in the two seasons, while, the other studied characters were insignificantly affected by the interaction between (I * N).

Keywords: - Canola crop- irrigation- nitrogen fertilization rates- oil content- water relations.

INTRODUCTION

Canola (Brassica napus L.) is known as rapeseed or oil seed rape. It is one of the most important oil crops in the world (*Bybordi, 2010*). Its oil contains 6 % saturated fatty acids and 94 % unsaturated fatty acids (high in mono – unsaturated fatty acids), it has 50 % less saturated fat than corn oil (*Weiss, 1983*). Canola is the third largest source of edible oil after soybean and palm oil (*FAS, USDA, 2014*) providing 14 % of the world supply.

Canola seeds contain approximately 45 % oil or more and produce meals with 35 to 40 % protein. The total cultivated area of canola all over the world is about 36.10 million hectare produced 70.31 MMT seeds and 26.47 MMT oil (*FAS, USDA, 2014*). So, it can produce edible oils able to cover the big oil gap in local production as the local production is covering less than 3 % of the total national consumption.

In Egypt, canola crop is no longer commercially grown till now in spite of the wide gap between the local production and national consumption of edible oil, while cultivation of this crop in Egypt is still facing many problems such as water stress, pricing and marketing system as well as high competition with winter crops. This gap presents powerful acceleration to increase the cultivation of canola and its industrial production in Egypt as it has a powerful growth and productivity in desert. So, it will be a promise winter oil crop in Egypt.

Under the importance of this crops. So, understanding the effects of irrigation on canola growth, development, productivity and seed quality especially in the newly reclaimed soils. Furthermore, increased competition for increasingly scarce water resources will impose greater efficiency in irrigation management practices. The most important factors affecting canola crop production is the irrigation water regime and adding nitrogen fertilization to plants. So, increasing yield of canola requires improving agricultural practices i. e. irrigation deficit and nitrogen fertilization rates to achieve higher seed yield and oil yields. *Shahin et al. (2000)* showed that increasing available soil water content increases plant height, weight of 1000 seeds, number of pods/ plant, weight of seeds/ plant and seed yield. Increasing nitrogen fertilizer application rate from 20 to 40 or 60 kg N/ fed. Increased the plant height, weight of seeds/ plant and seed yield. They also showed that the seasonal evapotranspiration of rapeseed amounted to 612.1, 503.1 and 425.7 mm for irrigation intervals 20, 30 and 40 days, respectively. They also added that nitrogen rates of 40 and 60 kg N/ fed. increased water use efficiency by 14.63 and 31.97 %, respectively, as compared to 20 kg N/ fed. Yield and yield components increased by increasing soil moisture content *(Sherif et al., 1995). Gammelvind et al. (1996)* showed that water stress in late vegetative and early reproductive growth stages reduced the photosynthetic rate in leaves.

Abdol- Amir and Abdol- Mehdi (2006) showed that number of pods per plant, seed and oil yield decreased as water stress increased. *Siag et al. (1993)* revealed that mean seed yield was 0.67 t/ ha. without irrigation and the highest was 1.35 t/ ha. with irrigation at branching and siliqua development. They also pointed out that water use efficiency was highest from a single irrigation at peak flowering. *Asghar et al., (2003)* revealed that seed oil content decreased with the increasing of irrigation frequencies and nitrogen rates up to 120 kg N/ ha. El- Mowelhi et al. (1999) revealed that the average of irrigation water applied for canola varieties in Delta, Egypt were 2618.9, 2408.6 and 2168.2 m^3/ fed. and water consumptive use was 1630.7, 1473.9 and 1329.7 m^3/ fed. when irrigation water was applied at 40 %, 60 % and 80 % depletion of the available water content, respectively. *Niazi, and Fooladmand (2006*) showed that the irrigation at cumulative evaporation value of 50 mm from class A pan resulted in a maximum seed yield of 3667 kg/ ha while a minimum yield of 2250 kg/ ha resulted from irrigation at 125 mm cumulative evaporation. The maximum and minimum seed oil contents were obtained at cumulative evaporation from class A pan of 125 mm and 50 mm treatment were 47.63 % and 44.60 %, respectively. *Bruck et al., (2001)* indicated that the low nitrogen supply will not only result in lower yield but will also reduce the water use efficiency. *Abd El-Rasool (2007)* indicated that increasing nitrogen fertilizer level up to 60 kg N/ fed. significantly increased plant height, number of branches/ plant, 1000 seed weight, seed yield/ plant, seed and oil yields/ fed. of canola.

Under the importance of canola crop and limitation of water resources. So, make rationalization for canola crop irrigation becomes a must. Therefore, the main targets for this present study were to:

1. Study water behavior of canola crop under the studied area,
2. Investigate the effect of irrigation treatments and nitrogen fertilization rates on canola yield, yield components, quality and some water relations,
3. Study the most sensitive growth stage for water stress under the studied area and crop and
4. Study the interaction effects between irrigation treatments and nitrogen fertilization rates on yield, yield components, quality and some water relations.

MATERIALS AND METHODS

A field trial was conducted at the experimental farm of Sakha Agricultural Research Station during the two successive winter growing seasons 2012/2013 and 2013/2014 to investigate the effect of irrigation treatments (water stress treatments) during the different growth stages and nitrogen application rates on yield, yield components, oil content and some water relations for canola crop in the North Middle Nile Delta region. The station is situated at 31^o-07' N latitude, 30^o-57' E longitude. It has elevation of about 6 metres above mean sea level (MSL). The site represents the conditions of circumstances of the Northern part of the Nile Delta region. Soil samples from different depths were taken from the studied site at each (15 cm soil depth) up to 60 cm. and analyzed for some physical and chemical properties in Tables (1and 2), respectively. The climatic conditions of the studied area represent the Middle part of the North Nile Delta at Kafr El-Sheikh Governorate. Some meterological data during the two growing seasons were presented in Table (3).

Table (1): The mean values of some physical properties of the studied experimental site.

Soil Depth, cm.	Particle Size Distribution			Texture class	F.C %	P.W.P %	AW (%)	Bd, Mg/m^3
	Sand%	Silt %	Clay %					
0 – 15	16.56	23.00	60.44	Clay	42.20	21.85	20.35	1.16
15 – 30	17.57	25.07	57.36	Clay	39.60	20.98	18.62	1.26
30 – 45	18.74	20.52	60.74	Clay	38.44	20.89	17.55	1.32
45 – 60	18.28	24.88	56.84	Clay	37.40	20.33	17.07	1.38
Mean	17.79	23.37	58.85	Clay	39.41	21.01	18.40	1.28

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 of some chemical properties of the studied experimental site.

Soil Depth, Cm	Ec, dS/m	PH (1: 2.5) soil water suspension	Soluble ions, meq/l							
			Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}
0-15	1.69	8.82	4.20	0.90	12.00	0.40	0.00	5.00	8.20	4.30
15-30	1.78	8.40	2.70	2.40	15.00	0.30	0.00	4.00	8.20	8.20
30-45	2.93	8.35	3.40	2.00	24.40	0.40	0.00	4.00	11.20	15.00
45-60	3.87	7.93	5.30	3.50	33.00	0.70	0.00	3.50	14.30	24.70
Mean	2.57	----	3.90	2.20	21.10	0.45	0.00	4.13	10.48	13.05

Physical and chemical characteristics of the studied site:-

Physical properties of the studied experimental site such as soil field capacity (F.C) was determined at the site. Permanent wilting point (PWP) and available water were determined according to *James (1988)* and soil bulk density was determined according to Klute, (1986). To study the soil texture, the particle size distribution was determined according to the International method, *Klute, (1986).* The obtained results indicated that the soil texture is clayey.

Chemical properties of the studied site such as total soluble salts (soil Ec, dS/ m), soil reaction (pH), both soluble cations and anions were determined according to the methods described by *(Jackson, 1973).* So4-- was calculated by the difference between soluble cations (meq/ L) and anions (meq/ L).

Table (3): Mean of some meteorological data for kafr El –Sheikh area during the two growing seasons.

a- 2012/2013 season.

Month	T (C^0)			RH (%)			W_s (m/sec) at 2 m height	Pan Evap., mm/ day.	Rain, (mm)
	Max.	Min.	Mean	Max.	Min.	Mean			
Nov.	25.32	15.47	20.40	89.53	61.80	75.67	0.66	1.87	28.20
Dec.	21.35	10.52	15.94	84.77	60.83	72.80	0.73	2.25	13.02
Jan.	19.22	7.62	13.42	91.06	65.35	78.21	0.52	1.99	78.74
Feb.	20.68	8.88	14.78	89.89	64.04	76.97	0.73	2.89	-------
Mar.	24.56	12.45	18.51	79.48	50.84	65.16	1.03	4.46	-------
April.	26.04	15.87	20.96	74.20	43.90	59.05	1.11	5.30	8.40
May	31.43	21.85	26.64	75.03	45.78	60.41	1.20	6.35	------

b- 2013/2014 season.

Month	T (C^0)			RH (%)			W_s (m/sec) at 2 m height	Pan Evap., mm/ day.	Rain, (mm)
	Max.	Min.	Mean	Max.	Min.	Mean			
Nov.	25.39	15.14	20.27	87.00	64.43	75.72	0.80	2.28	-------
Dec.	19.64	8.51	14.06	92.07	67.61	79.84	0.61	4.15	81.9
Jan.	20.34	7.55	13.95	93.69	70.55	80.55	0.54	1.60	20.7
Feb.	20.64	8.19	14.42	91.90	67.15	79.53	0.79	2.52	16.5
Mar.	22.94	11.71	17.33	86.10	56.80	71.45	0.96	3.14	26.2
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	-----

Source: Meteorological Station at Sakha Agricultural Research Station 31°-07' N latitude, 30°-57' E longitude with an elevation of about 6 metres a above mean sea level.

❖**The amount of rainfall is 128.36 mm (539.11 m^3/ fed.) and 165.50 mm (695.0 m^3/ fed.) in the first and second growing seasons, respectively.**

Experimental Layout:

The experimental design in this present study was a split plot with three replicates. Irrigation treatments were allocated in the main plots, while, nitrogen rates were randomly assigned to sub main plots. Irrigation treatments started after the first post planting irrigation (mohayaa), these treatments were I_1 (traditional irrigation, as practice by local farmers in the studied area, 6 irrigations), I_2 (sowing irrigation + first post planting irrigation (mohayaa)+ one irrigation during flowering growth stage only, 3 irrigations), I_3 (sowing irrigation + mohayaa + one irrigation during seeds filling only, 3 irrigations) and I_4 (sowing irrigation + mohayaa + irrigation during flowering growth stage +one irrigation during seeds filling, 4 irrigations). Nitrogen treatments (rates) were 15, 30, 45 and 60 kg N/ fed. The area of main treatment (irrigation treatments) was 86.4 m^2, while the area of sub main treatments (nitrogen fertilization treatments) was 7.2 m^2. Plots were isolated by ditches of 1.5 m in width to avoid lateral movement of water. Canola seeds Serw 4 cultivar were sown manually on 20^{th} and 16^{th} November in the first and second growing seasons, respectively. Planting was in hills 10 cm apart and seeding rate was 3 kg/ fed. plants were thinned to one plant per hill after 30 days from sowing before the first irrigation. The preceding crop was maize (Zea mays L) in the two growing seasons. Nitrogen fertilizer in form of Urea (46% N) was added according to the tested treatments as one dose immediately before (mohayaa irrigation). Phosphorus fertilization was added in the form of calcium superphosphate (15.5% P_2O_5) at rate 30 kg P_2O_5/ fed. during the tillage process. K_2O was added with 24 kg K_2O/ fed. before mohayaa irrigation. All recommended agricultural practices were performed through the two growing seasons. Canola plants were harvested on 25^{th} and 19^{th} April in the first and second growing seasons, respectively.

*** Data collection:-**

1- Irrigation water applied (IWA)

The amount of water applied was measured and calculated by using submerged flow orifice with fixed dimension was used to measure the amount of water applied, as the following equation *(Michael, 1978).*

$$Q = CA\sqrt{2gh}$$

Where:

Q = discharge through orifice, (L/sec),
C = coefficient of discharge (0.61),
A = cross - sectional area of the orifice, cm^2,
g = acceleration due to gravity, cm/ sec^2. (981cm/ sec^2) and
h = pressure head, causing discharge through the orifice, cm.

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 were taken from successive soil layers of the effective root zone; (0-15, 15-30, 30-45 and 45-60 cm.). This method is one of the direct methods of water consumptive use which based on soil moisture depletion (SMD) or so-called actual crop water consumed (ETc) as stated by Hansen *et al.,* (1979).

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

Where:

CU = Water consumptive use (m^3) in the effective root zone, 0.6 m,
i = number of soil layers (1-4),
Θ_2 = soil moisture percentage, 48 hours after irrigation,
Θ_1= soil moisture percentage before the next irrigation,
Dbi = soil bulk density (Mg/m^3) of the concerned layer,
D_i = soil layer thickness (15 cm) and
A= irrigation area (m^2).

3-Irrigation water efficiencies:

Water productivity (WP, kg/m^3)

Water productivity was calculated according to (Ali et al., 2007).

$$WP = \frac{Y}{CU}$$

Where:

WP = water productivity (kg /m^3),
Y = seed yield in kg/fed and
CU = seasonal water consumption use (m^3/ fed.).

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

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

PIW = Y / IWA

Where:

PIW = productivity of irrigation water (kg /m^3),
Y = Seed yield in kg/fed and
IWA = irrigation water applied (m^3 / fed.).

Consumptive use efficiency (Ecu, %):

Values of water consumptive use efficiency (Ecu, %) were calculated according to Doorenbos and Pruitt (1975).

Ecu = (ETc / IWA) *100

Where:

Ecu = Consumptive use efficiency (%),
ETc = Total evapotranspiration ~ consumptive use and
IWA = Irrigation water applied (m^3/ fed.).

Ten guarded plants were randomly chosen from the central area of each plot to avoid the border effect in order to determine yield, yield components and quality.

The studied parameters:

1. Number of days to 50% flowering,
2. Plant height (cm): was taken at the distance from the ground surface to the top of the plant,
3. Number of racemes,
4. Seed yield (g/ plant); was determined at harvesting ,
5. 1000 seeds weight (g),
6. Seed yield kg/ fed,
7. Seed oil content (%): The oil percentage was determined from three gragmmes seed sample using Soxholet method according to A.O.A.C. (1990) and
8. Oil yield (kg/ fed.): was determined by multiplying seed oil percentage by seed yield (kg/ fed.).

Statistical analysis:

The statistical analysis was estimated according to the method of Gomez and Gomez (1984) and treatment means values were compared against least significant differences test (L.S.D) at 5 % level.

RESULTS AND DISCUSSION

1-The amount of irrigation water requirements (IWR, cm. and m^3/fed.):

Irrigation water requirements consider the summation of seasonal water applied and amount of effective rainfall. Presented data in Table (4) clearly showed that the amount of irrigation water requirements of canola crop was affected by irrigation treatments (water stress) in the two growing seasons. The highest values were recorded under irrigation treatment I_1 (traditional irrigation, as practiced by local farmers in the studied area, control treatment) and the values are 63.16 cm. (2652.72 m^3/ fed.) and 62.14 cm. (2609.88 m^3/ fed.) in the first and second growing seasons, respectively. Meanwhile, the lowest values were recorded under irrigation treatment I_3 and the values are 34.87 cm. (1464.54 m^3/ fed.) and 33.70 cm. (1415.40 m^3/ fed.) in the first and second growing seasons, respectively. Generally, the values of irrigation water requirements in the two growing seasons can be descended in order $I_1 > I_4 > I_2 > I_3$.

Table (4): Effect of irrigation treatments and nitrogen rates on water requirements (IWR) for canola during the two growing seasons.

Irrigation treatments (I)	Nitrogen rates (N)	1st growing season		2nd growing season		The overall mean values during the two growing seasons	
		cm	m^3/ fed	cm	m^3/ fed	cm	m^3/ fed
I_1	N_1	63.16	2652.72	62.14	2609.88	62.65	2631.30
	N_2	63.16	2652.72	62.14	2609.88	62.65	2631.30
	N_3	63.16	2652.72	62.14	2609.88	62.65	2631.30
	N_4	63.16	2652.72	62.14	2609.88	62.65	2631.30
Mean		63.16	2652.72	62.14	2609.88	62.65	2631.30
I_2	N_1	35.07	1472.94	34.15	1434.30	34.61	1453.62
	N_2	35.07	1472.94	34.15	1434.30	34.61	1453.62
	N_3	35.07	1472.94	34.15	1434.30	34.61	1453.62
	N_4	35.07	1472.94	34.15	1434.30	34.61	1453.62
Mean		35.07	1472.94	34.15	1434.30	34.61	1453.62
I_3	N_1	34.87	1464.54	33.70	1415.40	34.29	1439.97
	N_2	34.87	1464.54	33.70	1415.40	34.29	1439.97
	N_3	34.87	1464.54	33.70	1415.40	34.29	1439.97
	N_4	34.87	1464.54	33.70	1415.40	34.29	1439.97
Mean		34.87	1464.54	33.70	1415.40	34.29	1439.97
I_4	N_1	45.27	1901.34	44.30	1860.60	44.79	1880.97
	N_2	45.27	1901.34	44.30	1860.60	44.79	1880.97
	N_3	45.27	1901.34	44.30	1860.60	44.79	1880.97
	N_4	45.27	1901.34	44.30	1860.60	44.79	1880.97
Mean		45.27	1901.34	44.30	1860.60	44.79	1880.97

Note:

Irrigation water requirements = (seasonal water applied + effective rainfall).

Increasing the values of irrigation water requirements of canola under irrigation treatment I_1 in comparison with other irrigation treatments (I_2, I_3 and I_4) may be due to decreasing irrigation intervals and hence increasing number of irrigations under the conditions of irrigation treatment (I_1, 6 irrigations) comparing with other irrigation treatments which exposed to water stress during various growth stages (3, 3 and 4 irrigations) for I_2, I_3 and I_4, respectively. Therefore, increasing the seasonal amount of water applied. The amount of effective rainfall is fixed which is 128.36 mm and 165.50 mm in the first and second growing seasons, respectively. Consequently, increasing the values of irrigation water requirements. These results are in a great harmony with those obtained by Ali et al. (2003), Ahmadi and Bahrani (2009), Moosavi (2012), Ansar et al. (2013) and Zareian et al. (2014). Data in the same table also illustrated that the amount of irrigation water requirements under irrigation treatment I_2 is higher than that under I_3 because of increasing vegetative growth. Therefore, increasing consumed water by plants to compensate the losses by transpiration through plant organs. So, increasing amount of seasonal water applied, and hence, increasing amount of irrigation water requirements. These results are in a great agreement with those reported by El-Mowelhi et al., (1999) and El- Bably and Awad (2007). They found that the highest values of irrigation water requirements are 61.51 cm., 54.08 cm. and 46.03 cm. (2583.42 m^3/ fed., 2271.36 m^3/ fed. and 1933.26 m^3/ fed.) which irrigated at 45%, 60% and 75% depletion of available soil moisture. Data in the same table declared that, the amount of seasonal water delivered (applied) was not affected by nitrogen fertilization rates.

2- Seasonal water consumptive use:

Water consumptive use or which so-called evapotranspiration is the combined upward movement of moisture from the soil to the atmosphere through transpiration from plant surface and evaporation from the soil surface. Data in Table (5) illustrated that the seasonal values of water consumptive use were clearly affected by irrigation treatments and slightly affected by nitrogen fertilization rates. Concerning, the effect of irrigation treatments, the highest values were recorded under irrigation treatments (I_1) and the values are 36.80 cm (1545.39 m^3/fed.) and 36.40 cm (1528.80 m^3/ fed.) in the first and second growing seasons, respectively. Meanwhile, the lowest values were recorded under irrigation treatment (I_3) and the values are 23.58 cm. (990.15 m^3/ fed.) and 23.20 cm. (974.40 m^3/fed.) in the first and second growing seasons, respectively. Generally, the seasonal values of water consumptive use can be descended in order I_1> I_4> I_2> I_3 in the two growing seasons. Increasing the values of water consumptive use under irrigation treatment (I_1) in comparison with other irrigation treatments I_2, I_3 and I_4 in the two growing seasons may be attributed to increasing amount of seasonal water applied and hence, increasing moisture content in the effective root zone. So, plants grow well with thick vegetative growth. Consequently, increasing exposed area to the sunlight in the late of growing season and hence, increasing the losses by transpiration from plant surfaces to compensate the water losses. Therefore, plants will take a large amount of water to keep healthy and protect themselves from wilting. So, increasing amount of seasonal consumptive use under the conditions of irrigation treatment (I_1) in comparison with other irrigation treatments I_2, I_3 and I_4 which exposed to water stress through the growing seasons. These results are in a great harmony with those obtained by *Al-Barrak (2006), El-Bably and Awad (2007), Moosavi (2012), Ansar et al. (2013), EAM et al. (2014) and Zareian et al. (2014).*

Table (5): Effect of irrigation treatments and nitrogen rates on seasonal consumptive use for canola during the two growing seasons.

Irrigation treatments (I)	Nitrogen rates (N)	1st growing season		2nd growing season		The overall mean values during the two growing seasons	
		cm	m^3/ fed	cm	m^3/ fed	Cm	m^3/ fed
I_1	N_1	36.18	1519.56	35.90	1507.80	36.04	1513.68
	N_2	36.80	1545.60	36.10	1516.20	36.45	1530.90
	N_3	36.90	1549.80	36.50	1533.00	36.70	1541.40
	N_4	37.30	1566.60	37.10	1558.20	37.20	1562.40
Mean		36.80	1545.39	36.40	1528.80	36.60	1537.10
I_2	N_1	24.20	1016.40	23.90	1003.80	24.05	1010.10
	N_2	24.30	1020.60	24.20	1016.40	24.25	1018.50
	N_3	24.70	1037.40	24.50	1029.00	24.60	1033.20
	N_4	25.10	1054.20	24.90	1045.80	25.00	1050.00
Mean		24.58	1032.15	24.38	1023.75	24.48	1027.95
I_3	N_1	23.10	970.20	22.80	957.60	22.95	963.90
	N_2	23.40	982.80	22.90	961.80	23.15	972.30
	N_3	23.70	995.40	23.30	978.60	23.50	987.00
	N_4	24.10	1012.20	23.80	999.60	23.95	1005.90
Mean		23.58	990.15	23.20	974.40	23.39	982.28
I_4	N_1	32.10	1348.20	31.90	1339.80	32.00	1344.00
	N_2	32.30	1356.60	32.20	1352.40	32.25	1354.50
	N_3	32.60	1369.20	32.50	1365.00	32.55	1367.10
	N_4	33.00	1386.00	32.80	1377.60	32.90	1381.85
Mean		32.50	1365.00	32.35	1358.70	32.43	1361.85

Regarding, the effect of nitrogen application rates on the seasonal amount of water consumptive use. Data in the same table showed that, nitrogen application rates have a slight effect on the seasonal amount of water consumptive use in the two growing seasons. The highest seasonal values were recorded under nitrogen application rate (N_4, the highest rate of application), comparing with, other nitrogen rates N_1, N_2 and N_3 in the two growing seasons. Generally, the seasonal values of consumptive use can be descended in order $N_4 > N_3 > N_2 > N_1$ in the two growing seasons. Increasing the seasonal values of water consumptive use under the highest nitrogen application rate could be attributed to enhance growth rate and photosynthetic activity as well as increasing plant canopy which reflected more growth, leaf area and increase transpiration. These findings are in a great agreement with those reported by *Sharaan et al. (2002), El-Bably and Awad (2007) and Mirzaei et al (2013).*

3- Irrigation water efficiencies:

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

Water productivity is generally is defined as crop yield per cubic metre of water consumption. Water productivity 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 less water resources. While, productivity of irrigation water is generally defined as crop yield per cubic metre of water applied. Presented data in Table (6) clearly showed that the overall mean values through the two growing seasons for WP and PIW were affected by both irrigation treatments and nitrogen application rates. Concerning, the effect of irrigation treatments, the highest overall mean values were recorded under irrigation treatment I_3 and the values are 1.42 kg/ m^3 and 0.97 kg/ m^3 for WP and PIW, respectively. Meanwhile, the lowest overall mean values were recorded under irrigation treatment I_1 (traditional irrigation method) and the values are 0.95 kg/ m^3 and 0.56 kg/ m^3 for WP and PIW, respectively. Generally, the overall mean values for WP and PIW can be descended in order $I_3 > I_2 > I_4 > I_1$ and the overall mean values for WP are 1.42, 1.35, 1.04 and 0.95 kg/ m^3, while for PIW the overall mean values are 0.97, 0.96, 0.76 and 0.56 kg/ m^3, respectively.

Table (6): Effect of irrigation treatments and nitrogen rates on water productivity (WP, kg/m3) and productivity of irrigation water (PIW, kg/ m^3) for canola during the two growing seasons.

Irrigation treatments (I)	Nitrogen rates (N)	1st growing season		2nd growing season		The overall mean values during the two growing seasons	
		WP	PIW	WP	PIW	WP	PIW
I_1	N_1	0.60	0.34	0.60	0.35	0.60	0.35
	N_2	0.99	0.58	1.00	0.58	1.00	0.58
	N_3	1.07	0.62	1.07	0.63	1.07	0.63
	N_4	1.14	0.67	1.13	0.68	1.14	0.68
Mean		0.95	0.55	0.95	0.56	0.95	0.56
I_2	N_1	0.69	0.48	0.70	0.49	0.70	0.49
	N_2	1.48	1.03	1.47	1.04	1.48	1.04
	N_3	1.58	1.11	1.58	1.14	1.58	1.13
	N_4	1.65	1.18	1.66	1.21	1.66	1.20
Mean		1.35	0.95	1.35	0.97	1.35	0.96
I_3	N_1	0.78	0.52	0.77	0.52	0.78	0.52
	N_2	1.49	1.00	1.51	1.03	1.50	1.02
	N_3	1.64	1.11	1.65	1.14	1.65	1.13
	N_4	1.72	1.19	1.73	1.22	1.73	1.21
Mean		1.41	0.96	1.42	0.98	1.42	0.97
I_4	N_1	0.60	0.42	0.60	0.43	0.60	0.43
	N_2	1.11	0.80	1.10	0.80	1.11	0.80
	N_3	1.19	0.86	1.19	0.88	1.19	0.87
	N_4	1.25	0.91	1.22	0.91	1.24	0.91
Mean		1.04	0.75	1.03	0.76	1.04	0.76

Increasing, the overall mean values for WP and PIW under irrigation treatment I_3 (which received 3 irrigations through the whole growing season) could be attributed to decreasing amount of water consumptive use and water applied in comparison with other irrigation treatments which received high number of irrigations. Consequently, increasing the amount of water consumptive use and water applied and hence, decreasing the overall mean values for water productivity and productivity of irrigation water. These results are in a great harmony with those obtained by *El-Mowelhi (1999), El-Bably and Awad (2007), Mirzaei et al (2013), Ansar et al. (2013) Zareian et al. (2014).*

Regarding, the effect of nitrogen rates (15, 30, 45 and 60 kg N/ fed.), the highest overall mean values for (WP) and (PIW) were recorded under the highest rate of nitrogen application (60 kg N/ fed.) under all irrigation treatments. Generally, the overall mean values for (WP) and (PIW) can be descended in order N_4> N_3> N_2> N_1. Increasing the overall mean values for (WP) and (PIW) under the highest nitrogen application rate could be attributed to increasing seed yield under the conditions of nitrogen treatment (N_4). The low nitrogen application rate not only results in lower yield but also reduce (WP) and (PIW). These results are in a great harmony with those reported by *Bruck et al., 2001, Butter et al.(2006), El-Bably and Awad (2007) and Ansar et al. (2013).*

Consumptive use efficiency (Ecu, %):

Presented data in Table (7) showed that, the values of consumptive use efficiency were clearly affected by both irrigation treatments and nitrogen application rates in the two growing seasons. Regarding, the effect of irrigation treatments on the values of Ecu in the two growing seasons, the highest values were recorded under irrigation treatment I_4 (which received 4 irrigations during the whole growing season) in the two growing seasons and the values are 71.79 and 73.03% in the first and second growing seasons, respectively. On the contrary, the lowest values were recorded under irrigation treatment I_1 (traditional irrigation 6 irrigations during the whole growing season) and the values are 58.26 and 58.58 % in the first and second growing seasons, respectively. Generally, the values of Ecu can be descended in order I_4> I_2> I_3> I_1 in the two growing seasons.

Increasing the values of Ecu in the two growing seasons under irrigation treatments I_2, I_3 and I_4 in comparison with traditional irrigation treatment (I_1) could be attributed to decreasing number of irrigations. Consequently, decreasing the amount of irrigation water applied under the conditions of these treatments because these treatments exposed to water stress through the growing season comparing with irrigation treatment (I_1) which received the highest number of irrigations and hence increasing the values of irrigation water applied. Therefore, decreasing the values of Ecu. These findings are in a great harmony with those obtained by *El-Bably and Awad (2007), Ansar et al. (2013) and Zareian et al. (2014).*

Concerning, the effect of nitrogen application rates on the values of consumptive use efficiency (Ecu). Data in the same Table clearly illustrated that, the highest overall mean values were recorded under the highest application rate of nitrogen (N_4) under all irrigation treatments.The overall mean values for Ecu can be descended in order I_4> I_2> I_3> I_1 under nitrogen fertilization rate (N_4) and the values are 73.47%, 72.24%, 69.87% and 59.38%, respectively. Increasing the values of Ecu under the highest application rate of nitrogen (N_4) in comparison with other nitrogen rates N_1, N_2 and N_3 in the two growing seasons might be due to under the highest rate of nitrogen application; plants grow well and form thick vegetative growth. So, the water losses by transpiration from plant surface increases and hence the amount of consumed water increases. Consequently, increase the values of water consumption. Meanwhile, the values of water applied were not affected by nitrogen application rates. So, increasing the values of Ecu. These results were confirmed by *El-Bably and Awad (2007), Ahmadi and Bahrani (2009), Moosavi (2012) and Ansar et al. (2013).*

Table (7): Effect of irrigation treatments and nitrogen rates on consumptive use efficiency (%) for canola during the two growing seasons.

Irrigation treatments (I)	Nitrogen rates (N)	1st growing season	2nd growing season	The overall mean values during the two growing seasons
I_1	N_1	57.28	57.77	57.53
	N_2	58.26	58.09	58.18
	N_3	58.42	58.74	58.58
	N_4	59.06	59.70	59.38
Mean		58.26	58.58	58.42
I_2	N_1	69.00	69.99	69.50
	N_2	69.29	70.86	70.08
	N_3	70.43	71.74	71.09
	N_4	71.57	72.91	72.24
Mean		70.07	71.38	70.73
I_3	N_1	66.25	67.66	66.96
	N_2	67.11	67.95	67.53
	N_3	69.97	69.14	68.56
	N_4	69.11	70.62	69.87
Mean		67.61	68.84	68.23
I_4	N_1	70.91	72.01	71.46
	N_2	71.35	72.69	72.02
	N_3	72.01	73.36	72.69
	N_4	72.90	74.04	73.47
Mean		71.79	73.03	72.41

Effect of irrigation treatments and nitrogen rates on
1-Seed yield (kg/ fed.):

Presented data in Table (8) clearly showed that the mean values of seed yield (kg/ fed) were significantly and highly significantly affected by irrigation treatments in the first and second seasons, respectively. and highly significantly affected by nitrogen fertilization rates in both seasons. Concerning, the effect of irrigation treatments, the highest mean values were recorded under irrigation treatment I_1 (traditional irrigation) in comparison with other irrigation treatments I_2, I_3 and I_4 which exposed to water deficit during various growth stages in the two growing seasons and the values are 1468.13 and 1456.07 kg/ fed. Meanwhile, the lowest mean values were recorded under irrigation treatment I_3 and the values are 1397.93 and 1384.20 kg/fed. in the first and second growing seasons, respectively.

Table (8): Effect of irrigation treatments and nitrogen rates on seed yield (kg/ fed.), plant height (cm.) and number of racemes/ plant for canola during the two growing seasons.

Irrigation treatments (I)	Nitrogen rates (N)	Seed yield (kg/ fed.)		Plant height (cm)		Number of racemes/ plant	
		1st growing season	2nd growing season	1st growing season	2nd growing season	1st growing season	2nd growing season
I_1	N_1	904.22	903.49	144.3	143.7	4.6	4.5
	N_2	1529.94	1513.53	148.7	148.0	8.4	8.6
	N_3	1651.67	1643.67	164.0	163.3	9.2	9.1
	N_4	1786.69	1763.58	167.0	166.3	10.3	9.6
Mean		1468.13	1456.07	156.0	155.3	8.1	8.0
I_2	N_1	705.29	700.50	142.3	143.0	4.7	4.6
	N_2	1514.12	1490.22	148.7	147.3	7.8	7.7
	N_3	1641.89	1630.23	157.0	156.0	9.1	9.0
	N_4	1743.34	1740.19	165.0	164.7	9.5	9.3
Mean		1401.16	1390.29	153.3	152.8	7.8	7.7
I_3	N_1	759.46	740.30	144.3	143.3	4.5	4.3
	N_2	1468.45	1453.53	147.0	146.3	7.9	7.7
	N_3	1627.66	1616.16	155.7	155.7	9.0	8.8
	N_4	1736.11	1726.82	164.0	162.3	9.5	9.4
Mean		1397.92	1384.20	152.8	151.9	7.7	7.6
I_4	N_1	806.70	800.41	145.3	143.7	4.7	4.6
	N_2	1511.86	1493.46	147.3	146.3	8.1	7.9
	N_3	1634.84	1630.25	164.3	163.7	9.2	9.1
	N_4	1728.88	1686.83	166.0	165.7	9.4	9.4
Mean		1420.57	1402.74	155.7	154.9	7.9	7.8
Overall mean for N levels	N_1	793.92	786.17	144.1	143.4	4.6	4.5
	N_2	1506.09	1487.68	147.9	147.0	8.0	8.0
	N_3	1639.01	1630.08	160.3	159.7	9.1	9.0
	N_4	1748.76	1729.36	165.5	164.8	9.7	9.4
LSD 0.05	Irrigation (I)	44.573*	14.929 ***	1.813**	1.226 ***	n.s	n.s
	Nitrogen (N)	46.608***	13.811***	2.278 ***	1.984 ***	0.325 ***	0.391***
	I * N	n.s	11.961***	1.973 *	1.718 ***	n.s	n.s

Generally, the mean values of seed yield (kg/ fed.) can be descended in order $I_1 > I_4 > I_2 > I_3$. Data in Table (8) also illustrated that, similarity the mean values of seed yield under irrigation treatment I_2 and I_3 because of the equality of irrigation numbers under the conditions of the two treatments. Increasing the mean values of seed yield under irrigation treatment I_1 in comparison with other irrigation treatments I_2, I_3 and I_4 might be attributed to elongation of plant cells, leaves area, number of racemes and effective lateral roots which reflected in increasing dry matter accumulation and increased seed weight and seed yield/ fed as well. Also, decreasing seed yield under stress conditions could be due to photosynthesis decrease caused by water deficit in soil and so less production of photosynthesis material required for seed filling. These results are in a great harmony with those obtained by *El-Mowelhi (1999), Shahin et al. (2000), Al-Barrak (2006), El-Bably and Awad (2007), Rad (2012), Moursi et al. (2013), Aiad et al. (2014) and Moursi et al. (2014).*

Regarding, the effect of nitrogen fertilization rate, data in the same table showed that, the mean values of seed yield kg/ fed were highly significantly affected by nitrogen fertilization rate, where the highest mean values were recorded under the highest rate of applied nitrogen (N_4), which gave 1748.76 and 1729.36 kg/ fed in the first and second seasons, respectively. While N_1 (15 kg/ fed.) gave the lowest seed yield/ fed. in the two seasons of study. Increasing N levels from 15 to 60 kg/ fed. significantly increased seed yield/ fed. in the two seasons Table (8). Concerning the interaction between the two factors, irrigation treatment I_1 (traditional irrigation) with nitrogen fertilizer rate 60 kg N/ fed. produced the highest seed yield/ fed in the two seasons. Increasing seed yield/ fed by increasing nitrogen fertilization rate might be attributed to increasing nitrogen rate enables the crop to produce rapid leaf growth , increasing dry matter accumulation which may positively contribute in seed filling and seed weight as well. This is reflected in efficient partitioning of assimilate into economic yield. Also, increasing nitrogen rate increases in metabolites resulted in increases more number of racemes, and heaviest seed, that reflected increases and seed yield/ plant and hence increased seed yield productivity/ fed. These results are in a great harmony with those obtained by *Al-Barrak (2006), El-Bably and Awad (2007), Ahmadi and Bahrani (2009), Ansar et al. (2013) and EAM et al. (2014).*

2-Yield attributes, seed oil (%) and oil yield (kg/ fed.):

Tabulated data in Tables (8 through 10) clearly illustrated that the mean values of the studied yield attributes, seed oil (%), oil yield (kg/ fed.), number of racemes and number of days to 50% flowering were significantly affected by irrigation treatments except number of racemes in the two growing seasons and 1000 seed weight (g) in the first season which insignificantly affected by irrigation treatments. All the abovementioned studied parameters recorded the highest mean values under irrigation treatment I_1 in comparison with other irrigation treatments I_2, I_3 and I_4 in the two growing seasons. Generally, the mean values of the abovementioned studied parameters can be descended in order $I_1 > I_4 > I_2 > I_3$ for plant height, number of racemes and seed yield/ plant. Meanwhile, $I_1 > I_4 > I_3 > I_2$ for 1000-seed weight, seed oil content and oil yield in the two growing seasons. Increasing the mean values of the abovementioned studied parameters under irrigation treatment I_1 comparing with other irrigation treatments. As clearly illustrated in Tables of yield, yield attributes, seed oil content and oil yield the difference between irrigation treatment I_1 (6 irrigations through the season) and I_4 (4 irrigation through the season) is very slight for all studied parameters. Decreasing these parameters under water deficit conditions in vegetative and early reproductive growth stages reduced the photosynthetic rate in leaves and in particular, number of siliquae/ plants (*Gammelvind et al.,* *1996*). The largest contribution to net photosynthesis by canola leaves occurred during the vegetative and early flowering stages (*Chongo and Mcvetty, 2001*). Higher water deficit causes a lower seed oil content (*Niazi and Fooladmand, 2006*). *El-Mowelhi (1999)* and *Shahin et al. (2000)* who concluded that yield and yield attributes of canola were gradually increased as a result of increasing the availability of soil moisture content. Also, these results are in a great harmony with those obtained by *El-Bably and Awad (2007), Ansar et al. (2013) and EAM et al. (2014).*

Table (9): Effect of irrigation treatments and nitrogen rates on 1000-seed weight (g), seed yield (g/ plant) and number of days to 50% flowering for canola during the two growing seasons.

Irrigation treatments (I)	Nitrogen rates (N)	1000-seed weight (g)		seed yield (g/ plant)		number of days to 50% flowering	
		1st growing season	2nd growing season	1st growing season	2nd growing season	1st growing season	2nd growing season
I_1	N_1	3.43	3.50	16.67	16.30	103.00	102.67
	N_2	3.80	3.80	28.20	27.97	103.33	103.33
	N_3	4.13	4.20	30.47	30.40	104.00	103.67
	N_4	4.30	4.23	33.00	32.63	106.00	105.33
Mean		3.92	3.93	27.08	26.83	104.08	103.75
I_2	N_1	3.47	3.40	14.00	13.33	101.00	100.67
	N_2	3.73	3.63	27.07	26.97	102.00	101.33
	N_3	3.87	3.80	30.00	29.70	102.67	101.67
	N_4	3.93	3.83	32.00	32.00	105.00	103.67
Mean		3.75	3.67	25.77	25.50	102.67	101.83
I_3	N_1	3.47	3.40	13.00	12.67	100.67	100.33
	N_2	3.80	3.80	27.53	27.40	102.33	101.33
	N_3	4.00	4.07	30.27	29.93	103.00	102.33
	N_4	4.17	4.13	32.13	31.73	103.33	102.67
Mean		3.86	3.85	25.73	25.43	102.33	101.67
I_4	N_1	3.37	3.50	14.87	14.53	100.33	100.00
	N_2	3.90	3.90	27.87	27.80	102.67	102.00
	N_3	4.10	4.07	30.13	29.93	104.67	104.33
	N_4	4.23	4.20	31.87	31.83	105.00	104.67
Mean		3.90	3.92	26.18	26.03	103.17	102.75
Overall mean for N levels	N_1	3.43	3.45	14.63	14.21	101.25	100.92
	N_2	3.80	3.78	27.67	27.53	102.58	102.00
	N_3	4.03	4.03	30.22	29.99	103.58	103.00
	N_4	4.16	4.10	32.25	32.05	104.83	104.08
LSD 0.05	Irrigation (I)	n.s	0.133 **	0.819 **	0.552 ***	0.756 ***	0.596 ***
	Nitrogen (N)	0.267 **	0.169 ***	0.927 ***	0.542 ***	0.988 ***	0.885 ***
	I * N	n.s	n.s	n.s	0.469 *	n.s	0.766 *

Regarding, the effect of nitrogen fertilization rates, data in the same Tables revealed that, all the abovementioned studied parameters were highly significantly affected by nitrogen fertilization rates. Increasing nitrogen fertilization rate from 15 to 60 kg N/ fed. increased the studied mentioned parameters except seed oil (%) which decreased by increasing nitrogen rate to 60 kg N/ fed. These results could be attributed to role of nitrogen in increasing growth, yield and yield attributes which reflected increase protein content in the seeds and the relation between oil and protein content is negatively correlated. These results are in a great agreement with those reported by *Mekki (2003), Malhi et al., (2006), Abdel-Ati (2006), Abd El-Rasool (2007), El- Bably and Awad (2007), Ansar et al. (2013) and EAM et al. (2014).*

The interaction between irrigation (I) and nitrogen rates (N) had insignificant effect on most studied parameters except seed yield (g/ plant), seed yield (kg/ fed.) number of days to 50% flowering, seed oil (%) and oil yield (kg/ fed.) which were significantly affected by interaction between (I * N) in the second season and plant height in the two seasons.

Table (10): Effect of irrigation treatments and nitrogen rates on seed oil (%) and oil yield (kg/ fed.) for canola during the two growing seasons.

Irrigation treatments (I)	Nitrogen rates (N)	Seed oil (%)		oil yield (kg/ fed.)	
		1st growing season	2nd growing season	1st growing season	2nd growing season
I_1	N_1	46.43	46.63	420.33	421.31
	N_2	45.90	45.57	702.24	689.82
	N_3	45.60	45.33	753.13	745.10
	N_4	44.87	44.63	801.68	787.08
Mean		45.70	45.54	669.35	660.83
I_2	N_1	46.53	46.10	328.16	322.93
	N_2	45.53	44.67	689.52	665.68
	N_3	44.87	44.37	736.66	723.25
	N_4	43.83	44.13	764.16	768.01
Mean		45.19	44.82	629.63	619.97
I_3	N_1	46.67	45.90	354.47	339.81
	N_2	45.57	45.13	669.05	656.05
	N_3	44.87	44.40	730.23	717.58
	N_4	44.63	44.30	774.88	764.98
Mean		45.44	44.93	632.16	619.61
I_4	N_1	46.60	46.20	375.81	369.79
	N_2	46.00	45.77	695.48	683.52
	N_3	45.17	45.13	738.28	735.79
	N_4	44.30	43.90	766.01	740.55
Mean		45.52	45.25	643.89	632.41
Overall mean for N levels	N_1	46.56	46.21	369.69	363.46
	N_2	45.75	45.28	689.07	673.77
	N_3	45.13	44.81	739.58	730.43
	N_4	44.41	44.24	776.68	765.16
LSD 0.05	Irrigation (I)	n.s	0.268 ***	21.949 **	7.500 ***
	Nitrogen (N)	0.554 ***	0.227 ***	23.819 ***	7.173 ***
	I * N	n.s	0.197 *	n.s	6.212 ***

CONCLUSION AND RECOMMENDATIONS

In Egypt, under the current situation of water and the shortage of oil production which may be reached more than 95 % of the country needs. So, rationalization of irrigation water and cultivation winter oil crops such as canola (Brassica napus L.) are becoming a must. Therefore the present study recommends that under water scarcity and the importance of this crop, canola crop can be irrigated three or four irrigations instead of traditional irrigation (6 irrigations) to maximize both water productivity (WP), productivity of irrigation water (PIW) and consumptive use efficiency (Ecu), also, under these conditions, the decreasing in yield and other yield attributes are very slight and not significant in comparison with traditional irrigation (control 6 irrigations). So, we can save irrigation water by about 1000-1200 m^3/ fed. and keep the productivity without significant decreasing.

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تـأثير نقص المياة خـلال فترات نمـو النبـات ومعدلات التسميد النتروجينـى علـى الانتاجيـة ومحتوى الزيت وبعض العلاقات المائية لمحصول الكانولا فى الأراضى الطينية الثقلية.

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**** قسم بحـوث المحاصيل الزيتيـة – معهد بحـوث المحاصيل الحقليـة- مركـز البحـوث الزراعيـة- الجيـزة- مصر.**

أجريت هذة الدراسة فى المزرعة البحثية بمحطة البحوث الزراعية بسخا – محافظة كفر الشيخ خلال موسمى النمو 2013/2012 ، 2014/2013 بهدف دراسة تـأثير معـاملات الرى (نقص الميـاة خـلال فترات نمـو النبـات) ومعدلات التسـميد النتروجينـى علـى انتاجيـة ومحتوى الزيت وبعض العلاقـات المائيـة لمحصـول الكانولا بمنطقة شمال وسط الدلتا. تم استخدام تصميم القطع المنشقة مرة واحدة فى ثلاثة مكررات حيث وزعت معاملات الرى فى القطع الرئيسية والتى كانت I_1 (6 ريات، رى عادى) وهى معاملـة الكنترول، I_2 (3 ريـات، زراعة+ محاياه+ رية فى مرحلة التزهير)، I_3 (3 ريات، زراعـة+ محايـاه+ ريـة فـى مرحلـة امتلاء البذور،I_4 (4 ريـات، زراعـة+ محايـاه+ ريـة فـى مرحلـة التزهيـر+ ريـة فـى مرحلـة امـتلاء البـذور).. بينمـا المعـاملات وزعت معاملات التسميد النتروجينى فى المعاملات تحت الرئيسية والتى كانت 15، 30، 45، 60 كجم ن/ فدان للمعملات N_1، N_2 ، N_3، N_4 على الترتيب.

أهم النتائج يمكن تلخيصها فيما يلى:

- سـجلت معاملـة الـرى I_1 (رى عـادى) أعلـى القيم بالنسـبة لميـاه الـرى المضـافة والقيم كانـت 63.16 سـم (2652.72 م^3 / فدان) و 62.14 سم (2209.88 م^3 / فدان) بينما أقل القيم سجلت تحت معاملة الرى I_3 والقـيم 34.87 سـم (1464.54 م^3/ فـدان) ، 33.70 سـم (1415.40 م^3/ فـدان) فـى الموسـم الأول والثانى على الترتيب. كمية مياه الرى المضافة يمكن ترتيبها تنازلياً كما يلى $I_1 > I_2 > I_3 > I_4$ فى كلا موسمى الدراسة.
- بالنسبة لقيم الأستهلاك المائى سجلت أعلاها تحت معاملة الرى I_1 والقيم كانت36.80 سم (1545.39 م^3/ فدان) ،36.40 سم (1528.80 م^3 / فدان) ولكن أقل قيم الأستهلاك المـائى سـجلت تحت معاملـة الـرى I_3 والقيم 23.58 سم (990.15 م^3 / فدان) ، 23.20 سم (974.40 م^3 / فدان) فى الموسم الأول والثـانى على الترتيب قيم الأستهلاك المائى تأثرت بشكل بسيط بمعدلات التسميد النتروجينى حيث القيم يمكن ترتيبها تنازلياً كما يلى $N_4 > N_3 > N_2 > N_1$ فى كلا موسمى النمو.
- قيم كفـاءة الأسـتهلاك المـائى ، كفـاءة انتاجيـة وحدة الميـاه المسـتهلكة والمضـافة سـجلت أعلـى القيم بالنسـبة لكفاءةالاستهلاك المـائى تحت معاملـة الـرى I_4 بينمـا القيم بالنسـبة لكفـاءة وحدة الميـاه المسـتهلكة والمضـافة سجلت تحت معاملة الرى I_3 والقيم 72.41% ، 1.42 كجم/ م^3 و 0.97 كجم/ م^3 لكفاءة الاستهلاك المـائى ، وكفاءة انتاجية وحدة المياه المستهلكة والمضـافة علـى الترتيب بالنسـبة لتـأثير معدلات التسميد النتروجينـى على الكفاءات المدروسة يمكن ترتيبها كما يلى $N_4 > N_3 > N_2 > N_1$ فى كلا موسمى الدراسة.
- محصول البذورومكوناته ومحتوى الزيت فـى البذوروكذلك محصـول الزيت كجم/ فدان سجلت أعلـى القيم تحت معاملـة الـرى I_1 والتسميد النتروجينى 60 كجم ن/ فدان وتنـاقص محتوى البـذور من الزيت بزيـادة التسـميد النتروجينـى حتـى 60 كجـم ن/ فـدان . بينمـا زادت انتاجيـة الفـدان مـن الزيـت بزيـادة التسـميد النتروجينى الى 60 كجم ن/ فدان.
- التفاعل بين معاملات الرى (I) والتسميد النتروجينى (N) أعطى تـأثير معنوى علـى محصـول البذور كجم/ فدان ، محصول البذور جم/ نبات ، عدد الأيام حتى 50% من التزهير ،محتوى البذور من الزيت (%) ومحصول الزيت كجم/ فدان فى الموسم الثانى فقط ، طول النبات فى موسمين النمو بينمـا بـاقى الصفات المدروسة تأثرت بشكل غير معنوى بالتفاعل بين معاملات الرى والتسميد النتروجينى (N * I).