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EFFECT OF IRRIGATION INTERVALS AND NITROGEN FERTILIZER RATE ON GROWTH, YIELD AND CHEMICAL COMPOSITION OF *Ricinus communis* L. UNDER NORTH SINAI CONDITIONS

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ABSTRACT

A field experiment was conducted, during 2004/2005 and 2005/2006, at the Experimental Field and Laboratories of North Sinai Research Station, Desert Research Centre, at El-Sheikh Zowayed, North Sinai Governorate, Egypt to investigate the effect of irrigation intervals (every 10, 15, 30 days, and rainfed treatment) and nitrogen fertilizer rates (0, 100, 200, and 300 kg/fed./season as ammonium sulphate) on vegetative growth, seed yield, fixed oil production and chemical composition of *Ricinus communis* L.

Data indicated that irrigation every 10 days significantly increased vegetative growth (plant height and herb fresh and dry weights), seed yield/ plant, seed index, oil yield per plant and per feddan, total carbohydrates and N contents in the leaves compared with rainfed or irrigation every 30 days which gave the lowest values.

Nitrogen fertilization at 300 kg/ fed significantly increased plant height, fresh and dry weights/ plant, seed yield/ plant, seed index, fixed oil yield/ plant and per fed., total carbohydrates and N contents in the leaves in both seasons.

The combined effect between irrigation every 10 days and nitrogen fertilization at 300 kg/ fed gave the highest values of plant height, fresh and dry weights/ plant, seed yield/ plant, seed index, fixed oil yield/ plant and per fed. and total carbohydrates contents in the leaves in both seasons, while the rainfed treatment combined with the unfertilized control gave the lowest values.

Key words: *fixed oil, irrigation, nitrogen fertilization, Ricinus commanis.*

1. INTRODUCTION

Castor bean (*Ricinus communis* L.) is a sub-tree belonging to the family Euphorbiaceae which is a large family of 240 genera and around 6,000 species. Probably native to Africa, castor bean has been introduced and is cultivated in many tropical and subtropical areas of the world, frequently appearing spontaneously. Plants grow best on fertile, well-drained soils which are neither alkaline nor saline; sandy and clay loam being best. Fruits are harvested when fully mature, in about 95–180 days depending on the cultivar. Castor bean is cultivated for the seeds which yield fast-drying, non-yellowing oil, used mainly in industry and medicines. Hydrogenated oil is utilized in the manufacture of waxes, polishes, carbon paper, candles and crayons. 'Blown Oil' is used for grinding lacquer paste colors, and when hydrogenated and sulfonated is used for preparation of ointments. Castor oil pomace, the residue after crushing, is used as a high-nitrogen fertilizer (Reed, 1976). Castor bean plants could be considered anodyne, antidote, aperient, bactericide, cathartic, cyanogeneic, discutient, emetic, emollient, expectorant, insecticide, lactagogue, larvicidal, laxative, poison, purgative, tonic, etc. Ricinoleic acid has served in contraceptive jellies. Ricin, a toxic protein in the seeds, acts as a blood coagulant. Castor oil is used externally for treatment of dermatitis and eye ailments (Duke and Wain,1981).

Water affects markedly, either directly or indirectly, most plant physiological processes; Bhosekar (1992) on *Ricinus communis*, Ishwar and Ganpat (1992) on *R. communis*, El- Shafie *et al*. (1994) on roselle, Naguib and Hussein (1995) on roselle, Reddy *et al.* (1996) on *Ricinus communis*, Hammam (1996) on anise (*Pimpinella* *anisum*), Youssef (1997) on *Cuminum cyaminum*, Sidky *et al*. (1998) on roselle, Firake *et al*. (1999) on castor (*Ricinus communis*) cv. GAU CH-1, Mohamed (2000) on *Carum carvi*, Osman (2000) on coriander, Attia (2003) on guar, Akbarinia *et al*. (2005) on *Nigella sativa*, Nagabhushanam and Raghavaiah (2005) on castor hybrid DCH-177 (Deepak)].

Nitrogen fertilization affects growth, yield and active constituents of castor bean plants [Devi *et al*. (1990), Patel *et al*. (1991), Wali *et al*. (1991), Bhosekar (1992), Paikaray *et al*. (1992), Mathukia and Modhwadia (1993, and 1995), Hikwa and Mugwira (1997), Akbari *et al*. (2001); Khandelwal *et al*. (2003) on *Lawsonia inermis*. Kadam *et al*, (2006); Lakshmi and Reddy (2006); Silva *et al*. (2007); Tank *et al*. (2007), and Venugopal *et al*. (2007)]

The aim of this study was to determine the effect of irrigation intervals and nitrogen fertilizer rate on growth, yield and chemical composition of *Ricinus communis* L. under North Sinai conditions.

2. MATERIALS AND METHODS

2.1. Field experiment

The present study was carried out during the two successive seasons of 2004/2005 and 2005/2006 at the Experimental Field and Laboratories of North Sinai Research Station, Desert Research Centre, at El-Sheikh Zowayed, North Sinai Governorate. The objective of this work was to study the effect of irrigation intervals and nitrogen fertilization rates on growth, yield and chemical composition of *Ricinus communis* L.

The seeds of castor bean (*Ricinus communis* L.) var. red were obtained from the Egyptian Desert Gene Bank (DRC). The seeds were sown on a sandy soil on the 1st of July 2004 and 2005, at 100 cm between rows and 100 cm between hills, in 16 treatments, each with three replicates. The replicate contained 10 plants in one row. The seedlings were irrigated using a drip irrigation system as needed until they were completely established.

The layout of the experiment was a split plot design, in which irrigation intervals represented the main plot, while nitrogen fertilization rates represented the sub plots. The treatments started four months after sowing and continued for eight months.

Four irrigation intervals were used : Rainfed (control), 10, 15 and 30 day intervals. A drip irrigation system was used, with a water discharge rate of 4L/dripper/ hour. Each plant has two drippers and each treatment was irrigated for two hours.

Ammonium sulphate (20.5% N) as soil dressing was used at the rates of 0, 100, 200 and 300 kg/ fed. in three doses/ season. The first dose was added four months after sowing, the second dose was added after 45 days from the first and the third dose was added after 45 days from the second dose. All the plants received calcium super phosphate (15.5% P_2O_5) at 100 kg/fed during soil preparation and potassium sulphate (48% K_2O) at 100 kg/fed as a constant rate divided into two equal doses, added with the first and second doses of ammonium sulphate.

2.2. Water and soil analysis

Physical and chemical analysis of soil and chemical properties of irrigation water used (Tables, A and B) were analyzed as described by (Jackson,1973).

Harvesting of the mature inflorescences was carried out from the first week of May until the last week of June.

Data on plant height, fresh and dry weights/ plant, seed yield/ plant, seed index, fixed oil percentage, fixed oil yield per plant and per fed., total carbohydrates and nitrogen contents in the dried leaves were recorded.

The fixed oil percentage in seed samples was determined adopting the Method described in A.O.A.C. (1995). Nitrogen content was determined by Micro-Kjeldahl method as described by Pregl (1945). Total carbohydrate contents were determined in the dried herb using the method described by Chaplin and Kennedy (1994).

Meteorological data for ElSheikh Zoweyed, El-Arish, North Sinai regian during both season are shown in Tables (C and D).

Data recorded were statistically analyzed using the Least Significant Difference (L.S.D.) test at the 5% level, as described by Snedecor and Cochran (1982).

3. RESULTS AND DISCUSSION

3.1. Vegetative growth

3.1.1. Plant height

The data in Table (1) show that irrigation intervals had a significant effect on plant height in both seasons. Irrigation every 10 days gave the tallest plants in the first and second seasons, compared with other irrigation intervals. Generally, the shortest and moderate irrigation intervals significantly increased plant height compared with rainfed treatment in both seasons. Similar results were obtained by El- Shafie *et al*.

Water and soil analysis

Table (A): Mechanical and chemical properties of the used soil.

Physical analysis				
Fine sand %	**Coarse sand %**	**Clay %**	**Silt %**	**Texture grade**
31.96	58.36	2.25	7.43	Sandy soil

Chemical analysis										
pH	**Ec (ds/m)**	**Soluble cations (meq/L)**				**Soluble anions (meq/L)**			**Available elements (ppm)**	
		Na^+	K^+	Ca^{++}	Mg^{++}	HCO^-_3	Cl^-	SO^-_4	N	P
8.47	0.90	4.50	0.25	4.08	0.82	1.91	3.00	4.74	12.00	7.00

Table (B): Chemical properties of irrigation water used.

pH	**Ec (mmhos/cm)**	**Soluble cations (ppm)**				**Soluble anions (ppm)**			
		Ca^{++}	**Mg^{++}**	**Na^+**	**K^+**	**CO_3^{--}**	**HCO_3^-**	**Cl^-**	**SO_4^{--}**
8.3	0.620	41.02	24.92	55.0	2.00	23.22	86.55	85.50	89.00

Table (C): Meteorological data for El-Sheikh Zowayed, El-Arish, North Sinai during 2004/2005 season.

Month	**Avg.Temp (˚C)**	**Et. (mm)**	**Avg. Ws (Km/h)**	**Total Rain (mm)**	**RH (%)**
7	25.774	3.505	12.766	----	94.619
8	26.064	3.192	13.378	----	91.99
9	25.023	1.427	10.009	----	88.516
10	23.137	0.941	10.803	0.762	95.238
11	18.933	0.704	14.313	75.946	90.161
12	13.199	0.568	11.383	99.314	88.49
1	13.032	0.791	16.484	53.594	86.465
2	13.439	0.867	16.165	38.862	87.023
3	15.834	1.289	12.896	28.702	88.023
4	18.198	1.712	15.085	2.540	86.196
5	20.177	2.064	13.351	----	91.432
6	23.531	2.455	12.346	----	94.297

Et = Evapotranspiration; Ws = Wind speed; RH = Relative humidity

Table (D): Meteorological data for El-Sheikh Zowayed, El-Arish, North Sinai during 2005/ 2006 season.

Month	**Avg Temp (˚C)**	**Et (mm)**	**Avg Ws (Km/h)**	**Total Rain (mm)**	**RH(%)**
7	25.702	2.461	12.913	----	97.649
8	26.784	1.857	12.014	----	94.995
9	25.636	1.43	11.983	1.016	91.137
10	22.422	0.655	11.858	----	88.11
11	17.673	0.365	12.485	22.86	86.836
12	15.261	0.176	10.543	27.178	95.073
1	12.931	0.459	13.648	26.67	93.066
2	13.931	0.490	13.325	49.022	92.46
3	15.513	0.634	13.053	1.524	90.248
4	18.24	1.435	14.526	27.686	93.704
5	20.179	2.511	11.732	----	98.144
6	23.409	3.097	11.861	----	96.575

Et = Evapotranspiration; Ws = Wind speed; RH = Relative humidity

(1994) on roselle, Hammam (1996) on anise, Osman (2000) on coriander, Attia (2003) on guar, Akbarinia *et al*. (2005) on black cumin, Nagabhushanam and Raghavaiah (2005) on castor bean plants.

Nitrogen fertilization rate had a significant zffect on plant height in the first season. Plant height gradually increased with increasing N rate. Whereas in the second season, nitrogen ertilization had no significant effect on plant height compared with the control. These results are in harmony with those obtained by Khandelwal *et al*. (2003) on *Lawsonia inermis*. They showed that increasing nitrogen rate increased plant height.

Concerning the interaction effect between irrigation intervals and N fertilization rates, the data revealed that the interaction had a significant effect on plant height. In both seasons, irrigation every 10 days and fertilization with N at 300 kg/fed gave the tallest plants, whereas rainfed treatment combined with no fertilizer (control) in the first season, and rainfed treatment combined with N2 in the second season gave the shortest plants.

3.1.2. Fresh and dry weights per plant

Data in Tables (2 and 3) indicate that plant fresh and dry weights were increased as the water irrigation intervals decreased. All irrigation treatments significantly increased plant fresh and dry weights/ plant. Irrigation every 30 days insignificantly increased fresh and dry weights/ plant in both seasons. While the shortest irrigation interval (10 days) gave the highest fresh and dry weights/ plant compared with the rainfed treatment in both seasons. Similar results were obtained by El- Shafie *et al*. (1994) on roselle, Hammam (1996) on anise, Sidky *et al*. (1998) on roselle, Mohamed (2000) on *Carum carvi*, Osman (2000) on coriander, Attia (2003) on guar; Akbarinia *et al*., (2005) on *Nigella sativa*, Nagabhushanam and Raghavaiah (2005) on castor bean. They showed that prolonging irrigation intervals decreased plant fresh and dry weights.

Concerning the effect of nitrogen fertilizer rates, the data show that, in the first season, no significant differences were recorded between N1 and N2 fertilization treatments and the control Meanwhile, the highest nitrogen rate (N3) gave significantly higher plant fresh and dry weights/ plant, compared with lower N rates. In the second season, raising nitrogen fertilization rates gradually increased plant fresh and dry weights with significant differences between the control and the highest nitrogen fertilizer rate (N3). These results are in agreement with those obtained by Khandelwal *et al*. (2003) on *Lawsonia inermis*, who showed that the highest fresh and dry weights/ plant were obtained by nitrogen application at 120 kg/ha.

The interaction between irrigation intervals and nitrogen fertilizer rates had a significant effect on plant fresh and dry weights in both seasons. Combining irrigation every 10 days with the highest nitrogen rate (N3) gave the highest fresh and dry weights plant in the first and second seasons. On the other hand, the lowest fresh weight was obtained with rainfed treatment combined with N1 treatment, while the lowest dry weights/plant were obtained with rainfed treatment combined with no nitrogen fertilization (N0) in the two seasons.

3.2. Seed production

3.2.1. Seed yield

The data presented in Table (4) show that, plants which depended on rain for their water requirement produced the lowest seed yield/plant with values of (16.52 and 16.33 gm/plant) in the two seasons, respectively. Irrigation every 30 days insignificantly increased seed yield per plant in the first and second seasons compared to rainfed system. Decreasing irrigation intervals from 30 days to 10 or 15 days significantly increased seed yield/plant compared to the rainfed system. The highest seed yield per plant was obtained from plants irrigated every 10 days. These results are in harmony with those obtained by Bhosekar (1992); Ishwar and Ganpat (1992); Reddy *et al.*, (1996); Firake *et al*., (1999); Nagabhushanam and Raghavaiah (2005) on castor bean; Mohamed (2000) on *Carum carvi*; Osman (2000) on coriander; Attia (2003) on guar and Akbarinia *et al*., (2005) on *Nigella sativa*.

Nitrogen fertilization using either low or medium rates insignificantly increased seed yield per plants compared to unfertilized plants in both seasons. While using the highest nitrogen rate (N3) gave the highest seed yield per plant (54.65 and 55.17 gm/ plant in the two seasons, respectively) compared to the unfertilized treatment, which gave 23.05 and 23.23 gm/ plant in both seasons, respectively. Similar results were obtained by Patel *et al.* (1991), Wali *et al*. (1991), Bhosekar (1992), Paikaray *et al.* (1992), Mathukia and Modhwadia (1993), Hikwa and Mugwira (1997), Akbari *et al*. (2001), Kadam *et al*. (2006), Silva *et al*. (2007), Tank *et al*. (2007) and Venugopal *et al*. (2007). They found that applying nitrogen fertilization to castor plants at the highest rates gave the highest seed yield.

Regarding the effect of the interaction between

Table (1): Effect of irrigation intervals and nitrogen fertilization on plant height (cm) of *Ricinus communis* L. plants during 2004/2005 and 2005/2006 seasons.

Nitrogen rates / Irrigation treatments	First Season, 2004/2005				
	N0	N1	N2	N3	Mean
Rainfed	87.76	107.00	113.40	117.50	**106.42**
10 days	151.00	150.90	145.30	159.00	**151.55**
15 days	124.40	130.80	119.60	128.80	**125.90**
30 days	95.48	108.60	111.60	102.00	**104.42**
Mean	**114.66**	**124.33**	**122.48**	**126.83**	
L.S.D. at 0.05 for:					
Irrigation intervals (A)	9.06				
N fertilization (B)	9.06				
Interaction (AXB)	18.11				
	Second Season, 2005/2006				
Treatments	**N0**	**N1**	**N2**	**N3**	**Mean**
Rainfed	79.01	89.50	69.39	87.83	**81.43**
10 days	117.30	104.90	135.80	157.50	**128.88**
15 days	116.90	129.40	128.70	138.90	**128.48**
30 days	112.10	108.20	86.92	107.80	**103.76**
Mean	**106.30**	**108.00**	**105.20**	**123.00**	
L.S.D. at 0.05 for:					
Irrigation intervals (A)	18.64				
N fertilization rate (B)	18.64				
Interaction (AXB)	37.28				

N0= control. N1= 100 kg/fed./season. N2= 200 kg/fed./season. N3= 300 kg/fed./season.

Table (2): Effect of irrigation intervals and nitrogen fertilization on fresh weight (gm) per plant of *Ricinus communis* L. plants during 2004/2005 and 2005/2006 seasons.

Nitrogen rates / Irrigation treatments	First season, 2004/2005				
	N0	N1	N2	N3	Mean
Rainfed	300.0	298.3	358.3	546.3	**375.8**
10 days	763.3	1500.0	1360.0	2900.0	**1631.0**
15 days	2140.0	780.0	896.7	1150.0	**1242.0**
30 days	390.0	394.0	489.0	1012.0	**571.2**
Mean	**898.3**	**743.1**	**776.0**	**1402.0**	
L.S.D at 0.05 for:					
Irrigation intervals (A)	588.3				
N fertilization rate (B)	588.3				
Interaction (AXB)	1177.0				
	Second season, 2005/2006				
Treatments	**N0**	**N1**	**N2**	**N3**	**Mean**
Rainfed	316.7	300.0	366.7	600.0	**395.8**
10 days	733.3	1600.0	1467.0	3167.0	**1742.0**
15 days	600.0	783.3	900.0	1250.0	**883.3**
30 days	550.0	400.0	483.3	1050.0	**620.8**
Mean	**550.0**	**770.8**	**804.2**	**1517.0**	
L.S.D. at 0.05 for:					
Irrigation intervals (A)	214.8				
N fertilization rate (B)	214.8				
Interaction (AXB)	429.5				

N0= control. N1= 100 kg/fed./season. N2= 200 kg/fed./season. N3= 300 kg/fed./season.

Table (3): Effect of irrigation intervals and nitrogen fertilization on dry weight (g)/ plant of *Ricinus communis* L. during 2004/2005 and 2005/2006 seasons.

Nitrogen rates / Irrigation treatments	First season, 2004/2005				
	N0	**N1**	**N2**	**N3**	**Mean**
Rainfed	52.83	64.51	53.76	104.1	**68.80**
10 days	154.8	321.5	261.4	619.4	**339.28**
15 days	117.1	138.7	131.6	211.6	**149.75**
30 days	59.35	72.92	75.87	198.0	**101.54**
Mean	**96.02**	**149.41**	**130.64**	**283.28**	
L.S.D. at 0.05 for:					
Irrigation intervals (A) 62.42					
N fertilization rate (B) 62.42					
Interaction (AXB) 124.80					
Second season, 2005/2006					
Treatments	**N0**	**N1**	**N2**	**N3**	**Mean**
Rainfed	54.24	62.27	57.19	115.3	**72.25**
10 days	156.8	350.5	286.4	689.5	**370.80**
15 days	122.4	142.0	136.6	234.7	**158.93**
30 days	99.20	73.59	75.73	201.3	**112.46**
Mean	**108.16**	**157.09**	**138.98**	**310.20**	
L.S.D. at 0.05 for:					
Irrigation intervals (A) 54.17					
N fertilization rate (B) 54.17					
Interaction (AXB) 108.30					

N0= control. N1= 100 kg/fed./season. N2= 200 kg/fed./season. N3= 300 kg/fed./season.

Table (4): Effect of irrigation intervals and nitrogen fertilization on seed yield (gm) per plant of *Ricinus communis* L. plants during 2004/2005 and 2005/2006 seasons.

Nitrogen rates / Irrigation treatments	First season, 2004/2005				
	N0	**N1**	**N2**	**N3**	**Mean**
Rainfed	8.77	16.14	4.92	36.25	**16.52**
10 days	37.87	55.77	55.93	100.0	**62.39**
15 days	21.45	25.05	28.74	47.58	**30.70**
30 days	24.10	14.58	13.73	34.75	**21.79**
Mean	**23.05**	**27.88**	**25.83**	**54.65**	
L.S.D. at 0.05 for:					
Irrigation intervals (A) 7.86					
N fertilization rate (B) 7.86					
Interaction (AXB) 15.73					
Second season, 2005/2006					
Treatments	**N0**	**N1**	**N2**	**N3**	**Mean**
Rainfed	8.58	16.04	4.36	36.36	**16.33**
10 days	38.33	56.11	56.13	101.20	**62.95**
15 days	22.21	27.19	28.75	48.42	**31.64**
30 days	23.79	14.41	13.63	34.67	**21.63**
Mean	**23.23**	**28.44**	**25.72**	**55.17**	
L.S.D. at 0.05 for:					
Irrigation intervals (A) 9.31					
N fertilization rate (B) 9.31					
Interaction (AXB) 18.62					

N0= control. N1= 100 kg/fed./season. N2= 200 kg/fed./season. N3= 300 kg/fed./season irrigation intervals and nitrogen fertilizer rates on the seed yield/plant, it is clear that, plants irrigated every 10 days and fertilized with the highest rate of nitrogen produced the highest seed yield/plant (100.00 and 101.20 gm/ plant in the two seasons, respectively). Also, using either low or medium nitrogen rate combined with irrigation every 10 days enhanced seed yield/plant compared to the other interactions. Whereas plants irrigated with rainfed system and fertilized with (N2) gave the lowest seed yield/ plant (4.92 and 4.36 gm/plant) in the first and second seasons, respectively.

3.2.2. Seed index (weight of 100 seeds)

The data in Table (5) show that short watering intervals resulted in the best seed index (weight of 100 seeds) in both seasons. Prolonging the irrigation intervals from 10 days to 15 days caused a reduction in seed index in both seasons compared with the shortest irrigation interval (every 10 days) , while irrigation every 30 days had no significant effect on seed index in both seasons compared with the rainfed system. These results are in accordance with the findings of Stafford and Mc Michael (1991) on guar. Bhosekar (1992) on *Ricinus communis* cv. Bhagya and Aruna, Firake *et al*. (1999) on castor (*Ricinus communis*) cv. GAU CH-1, Mohamed (2000) on *Carum carvi*, Osman (2000) on coriander, Attia (2003) on guar, Akbarinia *et al*. (2005) on *Nigella sativa*, Nagabhushanam and Raghavaiah (2005) on castor bean.

Concerning the effect of fertilization treatments, the data in Table (5) show that, there was insignificant effect due to applying low and medium levels of nitrogen on seed index compared to the unfertilized plants in both seasons. On the other hand, using the highest level of nitrogen (N3) significantly increased seed index in both seasons compared with unfertilized control. Similar results were obtained by Akbari *et al*. (2001), Kadam *et al*. (2006), Lakshmi and Reddy (2006), Silva *et al*., (2007), Tank *et al*. (2007) and Venugopal *et al*. (2007)on castor bean plants.

Regarding the combined effects of irrigation intervals and nitrogen fertilization rates, the results showed that, the combinations of irrigation every 10 or 15 days and different levels of N fertilizer gave a better seed index than the other combinations. Irrigation every 15 days and fertilization with the high level of nitrogen gave the highest seed index in the two seasons. Whereas rainfed system combined with N2 gave the lowest seed index in both two seasons.

3.3. Fixed oil production

3.3.1. Fixed oil percentage

The data presented in Table (6) show that, irrigation intervals had a significant effect on the fixed oil percentages in both two seasons. In the first season, fixed oil percentages obtained due to irrigation intervals every 10, 20 and 30 days were (38.84, 40.13 and 35.40 %) compared with 30.31 % for rainfed plants. While in the second season, the averages of fixed oil percentages were 37.69, 38.79 and 35.97 %) for the irrigation intervals every 10, 20 and 30 days, respectively compared with 42.38 % for the rainfed plants. Similar results were obtained by Nagabhushanam and Raghavaiah (2005) on castor hybrid DCH-177 (Deepak) grown under four irrigation regimes (irrigation at 15-days intervals and irrigation at IW/CPE [irrigation water/cumulative pan evaporation ratio] of 0.4, 0.6 and 0.8). They showed that oil content was not significantly influenced by irrigation regimes.

Concerning the effect of nitrogen fertilization treatments, the data in Table (6) show that, in the first and second seasons, nitrogen fertilization treatments significantly increased fixed oil percentages compared with the control, except nitrogen fertilization at a medium rate (N2) in the second season which decreased fixed oil percentage compared with the control treatment. The highest rate of nitrogen fertilization gave the highest values in both seasons. Similar results were obtained by Mathukia and Modhwadia (1995) on castor bean, they found that, seed oil content decreased with an increase in N application. On the other hand, Lakshmi and Reddy (2006) and Tank *et al*. (2007) on castor bean, they showed that, oil content was not significantly influenced by the different N rates.

Regarding the effect of the interaction between irrigation intervals and nitrogen fertilizer rates on fixed oil percentages, it is clear that, plants irrigated every 15 days combined with the highest rate of nitrogen (N3) produced the highest fixed oil percentage (45.82 %) during the first season. Whereas rainfed combined with nitrogen fertilizer at (N2) produced the lowest fixed oil percentage in the first season (18.11 %). In the second season rainfed combined with (N3) nitrogen fertilization treatment produced the highest fixed oil percentage (48.84 %). While irrigation every 30 days combined with nitrogen fertilization at the medium rate (N2) gave the lowest fixed oil percentage (29.79 %).

3.3.2. Fixed oil yield per plant and per feddan

It is evident from the data presented in Tables (7 and 8) that irrigation intervals had a significant

Table (5): Effect of irrigation intervals and nitrogen fertilization on seed index (weight of 100 seeds (gm) of *Ricinus communis* L. plants during 2004/2005 and 2005/2006 seasons.

Nitrogen rates / Irrigation treatments	First season, 2004/2005				
	N0	**N1**	**N2**	**N3**	**Mean**
Rainfed	34.03	30.71	23.28	35.75	**30.94**
10 days	37.38	33.95	36.61	38.72	**36.67**
15 days	29.68	32.11	37.01	38.98	**34.44**
30 days	29.44	28.39	27.29	38.02	**30.78**
Mean	**32.63**	**31.29**	**31.05**	**37.87**	
L.S.D. at 0.05 for: **Irrigation intervals (A)** 4.00 **N fertilization rate (B)** 4.00 **Interaction (AXB)** 8.00					
	Second season, 2005/2006				
Treatments	**N0**	**N1**	**N2**	**N3**	**Mean**
Rainfed	34.87	31.98	23.75	36.12	**31.68**
10 days	37.38	34.62	36.88	38.26	**36.78**
15 days	28.73	33.38	36.88	39.14	**34.53**
30 days	29.57	28.36	27.24	38.90	**31.02**
Mean	**32.63**	**32.09**	**31.18**	**38.10**	
L.S.D. at 0.05 for: **Irrigation intervals (A)** 5.33 **N fertilization rate (B)** 5.33 **Interaction (AXB)** 10.65					

N0= control. N1= 100 kg/fed./season. N2= 200 kg/fed./season. N3= 300 kg/fed./season.

Table (6): Effect of irrigation intervals and nitrogen fertilization on fixed oil percentage of *Ricinus communis* L. plants during 2004/2005 and 2005/2006 seasons.

Nitrogen rates / Irrigation treatments	First season, 2004/2005				
	N0	**N1**	**N2**	**N3**	**Mean**
Rainfed	35.67	29.38	18.11	38.06	**30.31**
10 days	32.12	42.67	41.35	39.23	**38.84**
15 days	31.39	43.31	40.00	45.82	**40.13**
30 days	32.50	29.84	36.86	42.41	**35.40**
Mean	**32.92**	**36.30**	**34.08**	**41.38**	
L.S.D. at 0.05 for: **Irrigation intervals (A)** 0.01 **N fertilization rate (B)** 0.01 **Interaction (AXB)** 0.02					
	Second season, 2005/2006				
Treatments	**N0**	**N1**	**N2**	**N3**	**Mean**
Rainfed	38.73	42.74	39.19	48.84	**42.38**
10 days	35.74	43.00	38.87	33.14	**37.69**
15 days	39.38	32.49	42.00	41.29	**38.79**
30 days	37.59	38.45	29.79	38.07	**35.97**
Mean	**37.86**	**39.17**	**37.46**	**40.33**	
L.S.D. at 0.05 for: **Irrigation intervals (A)** 0.01 **N fertilization rate (B)** 0.01 **Interaction (AXB)** 0.02					

N0= control. N1= 100 kg/fed./season. N2= 200 kg/fed./season. N3= 300 kg/fed./season.

Table (7): Effect of irrigation intervals and nitrogen fertilization on oil yield (ml)/ plant of *Ricinus communis* L. during 2004/2005 and 2005/2006 seasons.

Nitrogen rates / Irrigation treatments	First season, 2004/2005				
	N0	**N1**	**N2**	**N3**	**Mean**
Rainfed	3.130	4.743	0.890	13.80	**5.640**
10 days	12.16	23.80	23.13	39.23	**24.58**
15 days	6.727	10.85	11.49	21.80	**12.72**
30 days	7.830	4.347	5.057	14.74	**7.992**
Mean	**7.463**	**10.93**	**10.14**	**22.39**	
L.S.D. at 0.05 for: **Irrigation intervals (A)** 3.05 **N fertilization rate (B)** 3.05 **Interaction (AXB)** 6.11					
	Second season, 2005/2006				
Treatments	**N0**	**N1**	**N2**	**N3**	**Mean**
Rainfed	3.320	6.857	1.710	17.76	**7.411**
10 days	13.70	24.13	21.82	33.55	**23.30**
15 days	8.743	8.837	12.08	19.99	**12.41**
30 days	8.943	5.540	4.060	13.20	**7.936**
Mean	**8.676**	**11.34**	**9.916**	**21.13**	
L.S.D. at 0.05 for: **Irrigation intervals (A)** 3.57 **N fertilization rate (B)** 3.57 **Interaction (AXB)** 7.13					

N0= control. N1= 100 kg/fed./season. N2= 200 kg/fed./season. N3= 300 kg/fed./season.

Table (8): Effect of irrigation intervals and nitrogen fertilization on oil yield per feddan (L.) of *Ricinus communis* L. plants during 2004/2005 and 2005/2006 seasons.

Nitrogen rates / Irrigation treatments	First season, 2004/2005				
	N0	**N1**	**N2**	**N3**	**Mean**
Rainfed	12.51	18.97	3.563	55.19	**22.56**
10 days	48.66	95.19	92.51	156.9	**98.32**
15 days	26.93	43.40	45.97	87.20	**50.87**
30 days	31.33	17.40	20.23	58.94	**31.98**
Mean	**29.85**	**43.74**	**40.57**	**89.57**	
L.S.D at 0.05 for: **Irrigation intervals (A)** 12.22 **N fertilization rate (B)** 12.22 **Interaction (AXB)** 24.43					
	Second season, 2005/2006				
Treatments	**N0**	**N1**	**N2**	**N3**	**Mean**
Rainfed	13.28	27.43	6.837	71.03	**29.65**
10 days	54.79	96.51	87.26	134.2	**93.19**
15 days	34.98	35.34	48.31	79.97	**49.65**
30 days	35.77	22.16	16.24	52.80	**31.74**
Mean	**34.70**	**45.36**	**39.66**	**84.50**	
L.S.D. at 0.05 for: **Irrigation intervals (A)** 14.27 **N fertilization rate (B)** 14.27 **Interaction (AXB)** 28.53					

N0= control. N1= 100 kg/fed./season. N2= 200 kg/fed./season. N3= 300 kg/fed./season.

Table (9): Effect of irrigation intervals and nitrogen fertilization on total carbohydrates percentages (%) in dry leaves of *Ricinus communis*L. plants during 2004/2005 and 2005/2006 seasons.

Nitrogen rates / Irrigation treatments	First season, 2004/2005				
	N0	**N1**	**N2**	**N3**	**Mean**
Rainfed	21.67	23.50	25.27	33.11	**25.89**
10 days	31.75	41.51	50.23	56.65	**45.03**
15 days	23.50	24.54	33.73	52.53	**33.57**
30 days	19.69	21.72	26.89	36.19	**26.12**
Mean	**24.15**	**27.82**	**34.03**	**44.62**	
Second season, 2005/2006					
Treatments	**N0**	**N1**	**N2**	**N3**	**Mean**
Rainfed	23.55	24.54	25.69	38.69	**28.12**
10 days	36.97	48.98	50.18	54.62	**47.69**
15 days	26.68	30.91	36.03	52.58	**36.55**
30 days	23.03	24.07	26.58	30.39	**26.02**
Mean	**27.56**	**32.12**	**34.62**	**44.07**	

N0= control. N1= 100 kg/fed./season. N2= 200 kg/fed./season. N3= 300 kg/fed./season.

Table (10): Effect of irrigation intervals and nitrogen fertilization on nitrogen percentages in dry leaves of *Ricinus communis* L. plants during 2004/2005 and 2005/2006 seasons.

Nitrogen rates / Irrigation treatments	First season, 2004/2005				
	N0	**N1**	**N2**	**N3**	**Mean**
Rainfed	0.32	0.37	0.49	0.56	**0.43**
10 days	1.69	1.54	1.72	1.27	**1.55**
15 days	0.22	0.37	0.59	1.91	**0.77**
30 days	0.22	0.54	0.51	0.49	**0.44**
Mean	**0.61**	**0.70**	**0.83**	**1.06**	
Second season, 2005/2006					
Treatments	**N0**	**N1**	**N2**	**N3**	**Mean**
Rainfed	0.51	0.54	0.66	0.64	**0.59**
10 days	1.42	1.10	1.32	1.27	**1.28**
15 days	0.54	0.47	0.83	1.74	**0.89**
30 days	0.61	0.69	0.83	0.64	**0.69**
Mean	**0.77**	**0.70**	**0.91**	**1.07**	

N0= control. N1= 100 kg/fed./season. N2= 200 kg/fed./season. N3= 300 kg/fed./season.

effect on fixed oil yield/ plant and per feddan in both seasons. Irrigation every 10 days produced the highest increase in fixed oil yield per plant and per feddan in the two seasons. Irrigation every 15 and 30 days significantly increased fixed oil yield/ plant and per fed. in the two seasons. Whereas the lowest oil yield per plant and per fed. were obtained for the rainfed treatment in the first and second seasons. Firake *et al*. (1999) on castor bean, reported that daily application of water at 75% Ep through drip irrigation was the best treatment for oil yields which were increased by 50 to 51%, compared with border irrigation.

Nitrogen fertilization at different rates had a significant effect on oil yield/ plant and per fed. in both seasons. Supplying plants with the highest nitrogen rate (N3) resulted in the highest oil yield/plant and per fed. in the first and second seasons. Nitrogen fertilization at the low rate significantly increased fixed oil yield/ plant and per fed. in the first season compared to the control, while nitrogen fertilization at the low or medium rates insignificantly increased fixed oil yield per plant and per fed. In the second season compared with unfertilized control gave the lowest fixed oil yield/ plant and per fed. These increments were due to the effect of nitrogen fertilization on increasing the fixed oil percentage and seed yield/ plant and per fed. Similar results were obtained by Lakshmi and Reddy (2006) on castor bean. They showed that, oil content was not significantly influenced by the different N rates, whereas oil yield in seed and stalks increased significantly with increase in N rate up to 80 kg/ha. The difference between 80 and 120 kg N/ha was not significant.

Regarding the combined effect between irrigation intervals and nitrogen fertilization rates, it was observed that the highest fixed oil yield/ plant and per fed. were obtained due to irrigation every 10 days combined with the highest nitrogen rate (N3) in the two seasons. Whereas, the lowest fixed oil yield/ plant and per fed. in the two seasons were produced by plants that were rainfed and supplied with nitrogen fertilization at the rate of (N2).

3.4. Chemical composition

3.4.1. Total carbohydrate percentages

Data in Table (9) show that plants irrigated every 10 days had the highest total carbohydrates percentages in both seasons followed by plants irrigated every 15 days, compared with rainfed plants or the plants irrigated at long intervals (every 30 days) which gave the lowest total carbohydrate percentages in the first and second seasons, respectively. Similar results were obtained by Hammam (1996) on anise (*Pimpinella anisum*), Youssef (1997) on *Cuminum cyminum*, Osman (2000) on coriander and Attia (2003) on guar. They showed that irrigation at short intervals significantly increased total carbohydrate contents.

Concerning the effect of nitrogen fertilizer rate on the total carbohydrate content in the leaves, the highest values were obtained from plants fertilized with the highest N rate (N3) in the two seasons. Increasing nitrogen fertilizer rate gradually increased total carbohydrate percentages compared with unfertilized plants which gave the lowest values in both seasons. These results are in harmony with those obtained by Hammam (1996) on *Pimpinella anisum*, who showed that nitrogen application increased total carbohydrate contents.

Regarding the interaction effects between irrigation intervals and nitrogen fertilizer rates, the highest total carbohydrate content in the leaves was 56.65 % in the first season, resulted from the irrigation every 10 days combined with high nitrogen rate, followed by irrigation every 15 days with high nitrogen rate, and irrigation every 10 days with a medium nitrogen rate. These last two treatments gave values of 52.53 and 50.23 %, respectively. On the other hand, the lowest total carbohydrate content (19.69 %) resulted from combining irrigation every 30 days with no-nitrogen fertilization. In the second season, the highest total carbohydrate content (54.62 %) resulted from the interaction between irrigation every 10 days and the highest nitrogen fertilizer rate, followed by the interaction between irrigation every 15 days with the highest nitrogen rate and irrigation every 10 days with medium nitrogen rate; the values were 52.58 and 50.18%, respectively. On the other hand, the lowest total carbohydrate content (23.03%) resulted from combining irrigation every 30 days with no-nitrogen fertilization.

3.4.2. Nitrogen percentage

Data in Table (10) showed that the plants irrigated every 10, 15 and 30 days the had higher nitrogen percentages in the leaves in both seasons, compared with rainfed plants. Irrigation every 10 days gave the highest nitrogen contents in the leaves in both seasons. Similar results were obtained by Youssef (1997) on cumin, Sidky *et al*. (1998) on roselle, Osman (2000) on coriander and Attia (2003) on guar plants. They stated that short irrigation intervals increased nitrogen contents.

Concerning the effect of nitrogen fertilizer rates on nitrogen percentages in the leaves, it is clear that, in most cases, increasing nitrogen fertilization rate gradually increased nitrogen contents in the leaves in both seasons. Nitrogen application at the highest rate (N3) gave the highest N contents as compared with the unfertilized control in both seasons. The highest mean values were 1.06 and 1.07 % in the first and second seasons, respectively compared with 0.61 and 0.77 % in the leaves of unfertilized plants in both seasons, respectively.

These results are in agreement with those obtained by Mathukia and Modhwadia (1995) and Lakshmi and Reddy (2006) on castor bean. They showed that N contents was increased significantly with increasing nitrogen rate .

Regarding the effect of interaction between irrigation intervals and nitrogen fertilizer rates, data in Table (10) indicate that the highest nitrogen contents in the leaves resulted from irrigation every 15 days combined with the highest nitrogen rate(N3) in both seasons, whereas the lowest nitrogen content in the first season resulted from irrigation every 30 days combined with no-nitrogen fertilizer, while the lowest nitrogen content in the second season resulted from combining irrigation every 15 days with the low nitrogen fertilizer rate (N1).

In conclusion to obtain the best results on vegetative growth, seed production, fixes oil production and chemical constituents of castor bean plant in sandy soil we recommended the use of irrigation every 10 days and nitrogen fertilization at 300 kg/ fed./season.

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تأثير فترات الري ومعدلات التسميد النيتروجيني علي النمو والمحصول والتركيب الكيميائي للخروع *Ricinus communis* L. تحت ظروف شمال سينـاء

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ملخص

اجري هذا البحث خلال موسمي 2005/2004 ، 2006/2005 بمحطة التجارب التابعة لمركز بحوث الصحراء بالشيخ زويد، محافظة شمال سيناء، لدراسة تأثير فترات الري كل 10، 15 ، 30 يوما مقارنة بالزراعة المطرية ومعدلات التسميد النتروجيني صفر، 100 ، 200 ، 300 كجم أمونيوم سلفات/ فدان / موسم علي النمو الخضري ، ومحصول البذرة وإنتاج الزيت الثابت والتركيب الكيميائي لنبات الخروع.

وأوضحت النتائج إلي أن الري كل 10 أيام أدي الي زيادة معنوية في الصفات الخضرية(ارتفاع النبات ، الوزن الغض والجاف/نبات) ومحصول البذرة للنبات، ووزن 100بذرة ، ومحصول الزيت الثابت للنبات وللفدان وزيادة محتوي الأوراق من الكربوهيدرات الكلية والنتروجين في كلا الموسمين مقارنة بالزراعة المطرية أو الري كل 30 يوما.

أدي التسميد النتروجيني بمعدل 300 كجم/فدان إلي زيادة معنوية في ارتفاع النبات، الوزن الغض والجاف/نبات ومحصول البذرة للنبات، ووزن 100بذرة، ومحصول الزيت الثابت للنبات وللفدان وزيادة محتوي الأوراق من الكربوهيدرات الكلية والنتروجين في كلا الموسمين.

أدي التأثير المتداخل بين الري كل 10 أيام والتسميد النتروجيني بمعدل 300 كجم/فدان إلي الحصول علي أعلي القيم من حيث ارتفاع النبات ، الوزن الغض والجاف/نبات ومحصول البذرة للنبات، ووزن 100بذرة ، ومحصول الزيت الثابت للنبات وللفدان وزيادة محتوي الأوراق من الكربوهيدرات الكلية في كلا الموسمين مقارنة بالزراعة المطرية ونباتات المقارنة (غير المسمده) والتي أعطت أقل القيم.

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