J. Agric. Sci. Mansoura Univ., 28 (2): 819 - 828, 2003

GROWTH AND YIELD OF CANOLA (*Brassica napus* L.) IN RELATION TO IRRIGATION TREATMENTS AND NITROGEN LEVELS

Leilah, A. A and S.A. Al-Khateeb
Crops and Range Dept., College of Agric. And Food Sci., King Faisal University, Al-Hassa, KSA

ABSTRACT

Two field experiments were conducted during 2000/2001 and 2001/2002 growing seasons at the Agricultural and Veterinary Training and Research Station, King Faisal University. Results indicate that the irrigation treatments significantly affected all estimated characters, except number of branches/plant. Irrigation canola every 7 days with the rate of 500 m^3/irrigation/ha or every 14 days with the rate of 650 m^3/irrigation/ha resulted in increasing plant height, stem diameter, number of pods/plant, number of seeds/pod, seed oil percentage as well as seed and oil yields/ha. Water use efficiency reached the highest value with the irrigation of canola plants every 14 days.

Nitrogen rates had significant effects on all estimated characters. The higher nitrogen rates (150-200 kg N/ha) were associated with an increase in all estimated characters, except seed oil percentage, which took the reverse trend. The interaction between irrigation intervals and nitrogen rates had significant effects on seed and oil yields/ha.

In general, it can be stated that Irrigation canola every 14 days and fertilizing with 200 kg N /ha produced the highest seed and oil yields/ha.

INTRODUCTION

Canola (*Brassica napus* L.) is a name applied to edible oilseed rape that has low erucic acid (less than two percent) and glucosinolates (less than 30 micromoles per gram of oil-free meal). Recently, canola is considered among the most important oil crops all over the world, ranking the second after soybean. It is considered as one of the new crops with high water use efficiency and higher drought tolerance that can be used for seed production in arid regions of the world. There is however little information available on the water requirements for growing canola under irrigation conditions, particularly in the Kingdom of Suadi Arabia.

El-Saidi *et al.* (1992) reported that plant height, number of branches/plant, dry weight/plant and seed oil content were significantly decreased by increasing water depletion up to 65% of maximum holding capacity. Sims *et al.* (1993) reported that canola yields in Montana increased greatly with increased availability of water, but lowered seed oil content. Andersen *et al.* (1996) in Denmark found that seed yield, number of pods/plant and seeds per pod were strongly decreased by drought, whereas the seed weight increased after drought during flowering. The straw yield was less affected by drought. Leilah *et al.* (2002) under Saudi Arabia conditions, reported that irrigation treatments had marked effects on seed yield and its components.

Nitrogen fertilization has an important role in canola yield and quality. Each increase in nitrogen rate up to 100 kg N/ha (Sheppard and Bates, 1980 and Taylor *et al.*, 1991) and 213 kg N/ha (Ibrahim *et al.*, 1989) was associated with marked increases in seed yield. Nuttal *et al.* (1992) found that seed yield was increased with increasing nitrogen rates from 45 to 134 kg N/ha, while seed oil content decreased from 45.0 to 42.4 %. N. Hocking *et al.* (1997) stated that the highest dry matter production and seed yields were obtained with 75 kg N/ha. They also added that seed oil content was not affected by nitrogen rates. Brennan *et al.* (2000) found that seed and oil yields were generally increased as N rate increased. Seed oil percentage was not generally correlated with seed yield, although oil yield increased in higher yielding crops. Cheema *et al.* (2001) and Hocking and Stapper (2001) stated that seed and oil yields were increased with increasing rate of fertilizer application up to 90 kg N/ha.

There is however little information available on the water requirements for growing canola under arid and semi-arid regions. The present investigation was setup to study the effect of irrigation treatments, nitrogen rates and their interaction on growth and yield of canola "variety Pactol".

MATERIALS AND METHODS

Two field experiments were conducted at the Agricultural and Veterinary Training and Research Station, King Faisal University during the two successive seasons of 2000/2001 and 2001/2002. Each experiment was laid out in split plot design with four replicates. The main plots were devoted to four irrigation treatments, i.e. irrigation at 7, 14, 21 and 28 days with the volumes of water namely 500, 650, 800 and 950 m3/ha/irrigation, consuming 11000, 7850, 6800 and 5800 m3/ha/season, respectively (Table 1). The sub plots were devoted to four nitrogen levels, i.e., 50, 100, 150 and 200 kg N/ha. Each sub plot included 5 ridges, each of 60 cm in width and 3.5 m in length, occupying an area of 10.5 m^2.

Table 1: Volumes of water in the evaluated four irrigation treatments:

Irrigation regime	Volume of water (m^3/ha) received before treatments application++	Volume of water (m^3/ha) received after treatments application	Total volume of water (m^3/ha) received during season+
Irrigation every 7 days	2000	9000	11000
Irrigation every 14 days	2000	5850	7850
Irrigation every 21 days	2000	4800	6800
Irrigation every 28 days	2000	3800	5800

+ Rainfall not included, however it was rare (may be neglected) during both seasons of study.

++ Volume of water before treatments application (2000 m^3/ha) was 1000 m^3/ha, immediately after sowing and two irrigations were applied at 10 and 20 days after sowing, each with 500 m^3/ha.

Soil analysis (the upper 30 cm of the soil surface) of the experimental site indicated that the soil was sand in texture with pH = 7.8, ECe = 4.4 dsm^{-1}, N, Na, K and Ca contents were 16.0, 14.1, 27.3 and 12.1 Mmeq / L, respectively. Because canola seeds are small, good seedbed preparation through two perpendicular plows, good harrowing, leveling and ridging. Thereafter, the experimental land was divided into main and sub-plots and the area de-marked for corridors, which separated the main plots.

Canola seeds were hand-planted on ridges, 60 cm apart and 15 cm between hills. Thereafter, the field area was watered. This was on the last week of October in both seasons. Plants were thinned two times, the first was done at 21 days after sowing to secure 2-3 plants/hill and the second was after 35 days from sowing to secure the healthy plant/hill. Nitrogen was applied as urea (46.6 % N) at the aforementioned levels. It was added into three equal portions, the first was added after the first thinning. The second portion was applied after the complete thinning and the rest was added after 60 days from sowing. Plots were weeded as needed through hand hoeing. Other normal agronomic practices for canola production were followed, except the studied treatments.

Estimated characters: At maturity, when canola plants turned a straw color and seeds became dark brown, ten guarded plants were randomly selected from each experimental unit, uprooted, tied and left to dry, thereafter the following characters were estimated: Plant height (cm), stem diameter (cm), number of branches/plant, number of pods/plant, number of seeds/pod, 1000-seed weight (g). Plants in the two central ridges in each plot were harvested for seed yields/m^2, which converted to record seed yields (t/ha).

Seed oil percentage was determined according to A.O.A.C.(1980), then the oil percentage was calculated on dry weight basis. Oil yield (t/ha), was calculated by multiplying seed yield (t/ha) by seed oil percentage.

Water use efficiency (WUE) for irrigation treatments was estimated using the following equation:

WUE (kg/m^3) = Seed yield (kg/ha)/ volume of irrigation water (m^3/ha)

Statistical analysis: Obtained data in the two seasons were subjected to the proper analysis of variance of the split plot design, according to Gomez and Gomez (1984). New Least significant difference (NLSD) at 0.05 % level of significant was used to compare the treatment means (Waller and Duncan, 1969). Computations were done using SAS (1996).

RESULTS AND DISCUSSION

1. Effect of irrigation treatments:

Data listed in Tables 1, 2 and 3 indicate that treatments had significant effects on all estimated characters, except number of branches/plant in both seasons. Irrigation canola every 7 days receiving the highest volume of water was associated with the highest plant height, stem diameter, number of pods / plant, number of seeds / pod, 1000-seed weight, seed oil content as well as seed and oil yields/ha.

Table (1): Averages of plant height (cm), stem diameter (cm) and number of main branches/plant as affected by irrigation intervals and nitrogen levels during 2000/2001 (I) and 2001/2002 (II) seasons.

Treatments	Plant height		Stem diameter		Branches/plant	
	I	II	I	II	I	II
Irrigation intervals:						
7 days	172.8	168.6	2.6	2.5	11.8	11.4
14 days	165.3	159.7	2.3	2.2	11.8	11.6
21 days	154.2	154.8	2.0	1.9	12.1	11.4
28 days	143.6	140.6	1.7	1.7	10.3	9.8
NLSD (5%)	9.6	6.2	0.2	0.2	N.S	N.S
N-levels (kg /ha):						
50	140.2	138.9	1.9	1.8	10.4	9.8
100	160.1	154.3	2.1	2.1	11.2	10.7
150	164.7	161.5	2.3	2.2	11.9	11.7
200	171.0	168.9	2.3	2.2	12.3	12.2
NLSD (5%)	6.0	5.8	0.1	0.1	0.7	0.7

Table (2): Number of pods/plant, seeds/pod, and 1000-seed weight as affected by irrigation intervals and nitrogen levels during 2000/2001 (I) and 2001/2002 (II) seasons.

Treatments	Pods/plant		Seeds/pod		1000-seed wt. (g)	
	I	II	I	II	I	II
Irrigation intervals:						
7 days	199.8	190.3	44.3	42.4	3.0	2.9
14 days	197.4	181.2	42.8	41.2	2.6	2.6
21 days	185.9	159.2	38.7	38.1	2.5	2.4
28 days	153.2	134.8	33.5	34.3	2.0	1.8
NLSD (5%)	21.0	17.2	2.4	2.8	0.2	0.2
N-levels (kg /ha):						
50	143.5	135.9	27.4	22.3	2.2	2.0
100	172.9	155.9	39.6	40.5	2.4	2.3
150	194.4	173.7	42.6	43.2	2.6	2.5
200	225.4	200.1	49.4	50.1	2.9	2.7
NLSD (5%)	12.8	8.7	1.7	2.1	0.1	0.1

Table (3): Seed oil content as well as seed and oil yields/ha of Pactol as affected by irrigation intervals and nitrogen levels during 2000/2001 (I) and 2001/2002 (II) seasons.

Treatments	Seed yield (t/ha)		Seed oil (%)		Oil yield (kg/ha)	
	I	II	I	II	I	II
Irrigation intervals:						
7 days	3.324	3.954	39.9	41.8	1326.3	1652.8
14 days	3.305	3.868	39.8	41.5	1315.4	1605.2
21 days	2.624	2.931	39.4	40.8	1033.9	1195.8
28 days	2.107	2.380	38.8	39.9	817.5	947.2
NLSD (5%)	0.219	0.197	0.7	0.8	101.7	99.4
N-levels (kg /ha):						
50	1.673	1.535	41.4	42.3	692.6	649.3
100	2.742	3.047	39.7	41.2	1088.6	1255.4
150	3.265	3.987	38.9	40.6	1270.1	1618.7
200	3.682	4.565	38.1	39.7	1391.8	1812.3
NLSD (5%)	0.189	0.160	0.4	0.5	97.2	84.6

Irrigation canola every 14 days came in the second rank, producing insignificant differences in numbers of pods/plant and seeds/pod, seed oil content as well as seed and oil yields / ha, compared with the irrigation every week.

The lowest means of all measured characteristics were shown with prolonging the irrigation intervals. The increase in seed oil content with the increase in volume of irrigation water can be ascribed to the adequate supply of water which enhances the carbohydrate accumulation, and this in turn increased seed oil percentage (Taiz and Zeiger, 1992). Similar results were confirmed by Abbas *et al.* (1999) and Leilah *et al.* (2002) who stated that seed oil content of canola was increased by shortening irrigation intervals, and hence increasing soil moisture availability.

Great reduction in seed and oil yields/ha was noticed with exposing canola plants to drought by increasing irrigation periods to three and four weeks, where the volume of irrigation water was decreased. Over both seasons, seed yields decreased from 3.639 to 3.587, 2.778 and 2.244 t/ha with prolonging irrigation period from 7 to 14, 21 and 28 days, respectively. This reduction in seed yield represented 1.46, 31.01 and 62.2% with prolonging irrigation period from 7 to 14, 21 and 28 days, respectively.

Oil yields/ha followed the same trend producing 1489.5, 1460.3, 1114.9 and 882.4 kg/ha showing a reduction of 2.00, 33.6 and 68.8 % with prolonging irrigation period from 7 to 14, 21 and 28 days, respectively. The reduction in seed yield/ha could be attributed to the reduction of pods/plant, seeds/pod and 1000-seed weight. The reduction in growth and seed yield with the drought can be attributed to the role of water deficit in inhibition photosynthesis and maintaining plant rigidity (Salisbury and Ross, 1994). Therefore, when the maximum potential is reached (irrigation every 7 days), additional moisture will result in no further increase in yield and may cause yield reduction through poor soil aeration and/or increased plants lodging and insects infestation. Similar results were confirmed by Andersen *et al.* (1996) and Leilah *et al.* (2002).

Water use efficiency (WUE) for the evaluated irrigation treatments were graphically depicted (Fig. 1) to recognize the ratio between seed yield and volume of irrigation water. It showed that irrigation canola plants every 14 days associated with the highest values of WUE in the two seasons of study. It also revealed that values of WUE were 0.33, 0.46, 0.41 and 0.39 kg seeds/m^3 water, over both seasons. From this result, it can be stated that irrigation canola every 14 days was the most benefit irrigation treatment under the conditions of this study.

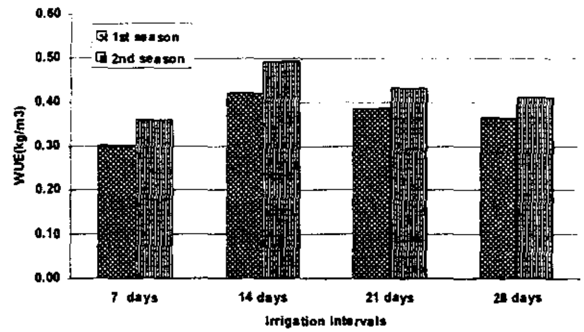

Fig. (1): Water use efficiency (WUE), kg/m^3, of canola in relation to the studied irrigation treatments

2. Effect of Nitrogen levels:

Canola responded strongly to nitrogen fertilizer rates producing significant effects on all estimated characters. Data listed in Tables 1, 2 and 3 show that plant height, stem diameter, number of pods/plant, number of seeds/pod, 1000-seed weight as well as seed and oil yields/ha were increased by increasing nitrogen rate from 50 to 200 Kg N/ha. Such increase in growth parameters with the increase of nitrogen rates can be attributed to the role of nitrogen as an important building substance from which the living material or protoplasm of every plant cell is made (Salisbury and Ross, 1994). The increase in number of pods /plant may be due to the active role of nitrogen in forming more flowering branches in which more flowers and eventually more pods can develop. Similar observations were reported by Taylor *et al.* (1991), Hocking *et al.* (1997) and Cheema *et al.* (2001).

Results in Table (3) indicate that seed oil contents in the two seasons were significantly decreased from 41.9 to 40.5, 39.8 and 38.9 % as nitrogen rates increased from 50 to 100, 150 and 200 kg N/ha. Over both seasons, nitrogen fertilization had a great role in enhancing seed and oil yields/ha. Seed yield/ha was significantly increased from 1.604 to 2.895, 3.626 and 4.124 t/ha and oil yields/ha from 663.4 to 1165.3, 1424.0 and 1592.5 kg/ha as nitrogen rates increased from 50 to 100, 150 and 200 kg N/ha, respectively. The increase in seed yield with the increase of nitrogen level could be attributed to the increase in seed yield components where increased with raising nitrogen levels. Taylor *et al.* (1991) and Nuttal *et al.* (1992) and Hocking and Stapper (2001) came to similar results. High levels of nitrogen usually show an abundance of shoot growth that reported in the present study. Although flowering and seed formation have been reported to be retarded by excess nitrogen (Salisbury and Ross, 1994).

Although the percentage of seed oil was decreased with the increase of nitrogen rate, the total oil produced per hectare increased because of the increased seed yield as shown in Table (3). The reduction in seed oil percentage with the increase of N fertilizer levels could be attributed to the disturbance of carbohydrates translocation mechanism (Salisbury and Ross, 1994). Alternatively, enzymes imbalance could also had high contribution in this concern (Salisbury and Ross, 1994). The adequate nitrogen promotes vigorous plant growth and development Therefore, plants with adequate nitrogen, in the absence of other limiting factors, develop a larger structure from a very early growth stage with increases in dry matter becoming progressively greater throughout the crop's growth. Taylor *et al.* (1991), Nuttal *et al.* (1992) and Hocking and Stapper (2001) came to similar results.

3. Interaction between irrigation treatments and nitrogen levels:

The interaction between irrigation treatments and nitrogen fertilizer rates had significant effects on seed and oil yields/ha in the two seasons of study. Data graphically illustrated (Fig. 2) reveal that the highest seed yield/ha was obtained with irrigation canola plants every 7 or 14 days and adding nitrogen fertilizer with the rate of 200 kg N/ha, while the lowest seed yield was noticed with the irrigation every 28 days and fertilization with the rate of 50 kg N/ha. Oil yield/ha was significantly higher under irrigation every 7 or 14 days and fertilization with 200 kg N/ha (Fig. 3). Great reduction in oil yield/ha was noticed with prolonging irrigation interval to 28 days and adding the lowest nitrogen fertilizer level (50 kg N/ha).

In general, it can be stated that canola "cv Pactol" can be successfully grown with high yield potential when irrigated every 7-14 days and fertilized with 200 kg N/ha under the environmental conditions of Al-Hassa Oasis.

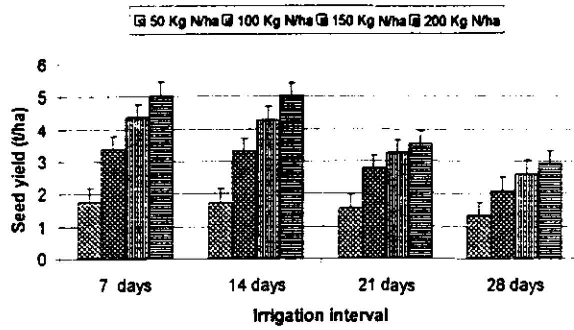

Fig. (2): Seed yield (t/ha) as affected by the interaction between irrigation treatments and nitrogen levels, over both seasons. Bars = NLSD (5 %).

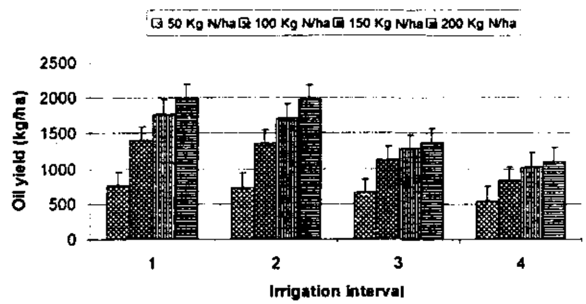

Fig. (3): Oil yield (kg/ha) as affected by the interaction between irrigation treatments and nitrogen levels, over both seasons. Bars = NLSD (5 %).

ACKNOWLEDGEMENT

The authors dedicate this work to the Deanship of the Scientific Research, King Faisal University for the fund of this work.

REFERENCES

Abbas, F.A.; M.A. ElEmam and N.A. Anton (1999). Effect of irrigation intervals on two rapeseed varieties. J. Agric. Sci., Mansoura Univ., 24 (4): 1549 – 1558.

Andersen, M.N; T. Heidmann and F. Plauborg (1996): The effects of drought and nitrogen on light interception, growth and yield of winter oilseed rape. Acta Agriculturae Scandinavica. Section B, Soil and Plant Science. 46: 1, 55-67.

A.O.A.C. (1980). Official Methods of Analysis of the Association Official Analysis Chemists, 13th Ed, Washington, D.C., USA.

Brennan, R.F; M. G. Mason and G. H. Walton (2000). Effect of nitrogen fertilizer on the concentrations of oil and protein in canola (*Brassica napus*) seed. J. Plant Nutri., 23: 3, 339-348.

Cheema, M.A.; M. A. Malik; A. Hussain; S. H. Shah and S.M.A. Basra (2001). Effects of time and rate of nitrogen and phosphorus application on the growth and the seed and oil yields of canola (*Brassica napus* L.). J. Agron. and Crop Sci., 186: 2, 103-110.

El-Saidi, M.T.; A.A. Kandil and B.B. Mekki (1992): Effect of different levels of water supply on growth, yield and fatty acids contents of some cultivars of oil seed rape (*Brassica napus* L.). Proc. 5th Conf. Agron., Zagazig, 13-15 Sept., Vol. (2): 889-907.

Gomez, K.A. and A.A.Gomez.1984.Statistical Procedures for Agricultural Research, 2nd Ed. John Wiley and son Ltd., New York. 680 p.

Hocking P.J.; P.J. Randall and D. DeMarco (1997): The response of dryland canola to nitrogen fertilizer: partitioning and mobilization of dry matter and nitrogen, and nitrogen effects on yield components. Field Crops Research, 54: 2-3, 201-220

Hocking, P.J and M. Stapper (2001). Effects of sowing time and nitrogen fertiliser on canola and wheat, and nitrogen fertiliser on Indian mustard. I. Dry matter production, grain yield, and yield components. Australian Journal of Agricultural Research. 52: 6, 623-634.

Ibrahim, A. F., E. O. Abusteit, M. A. Elmentwally (1989): Response of rapeseed (*Brassica napus*) to growth, yield, oil content and its fatty acid to nitrogen rates and application times. J. Agron. Crop Sci., 162,107112.

Leilah, A. A; S. A. Al-Khateeb; A. A. Al-Naiem and S. S. Al-Thabet (2002). Response of some canola (*Brassica napus*,L.) cultivars to drought. Agricultural and Water Resources Development Symposium in the Reign of the two Holy Mosques King Fahad Bin AbdulAziz-God Protect Him, 14 - 16 D.Qadah, 1422H (28 - 30 Jan., 2002 G).

Nuttal, W.F.; A.P. Moulin and L.J. Townley-Smith (1992): Yield response of canola to nitrogen, phosphorus, precipitation and temperature. Agron. J., 84: 5, 765-768

Salisbury, F.B. and Ross C. W. (1994): Plant physiology. Wadsworth publishing Company. Belmont, California Berkeley. California Agric. Exp. Station.

SAS Institute (1996). SAS/STAT User's Guide: Statistics. Version 7. SAS Institute, Inc Cary, NC. USA.

Sheppard, S. C. and T. E. Bates (1980): Yield and chemical composition of rape in response to nitrogen, phosphorus and potassium. Can. J. Soil. Sci., 60:153162.

Sims, J.R., D.J. Solum; D.M. Wichman; G.D. Kushnak; L.E. Welty; G.D. Jackson, G.F. Stallknecht, M.P. Westcott, and G.R. Carlson (1993). Canola variety yield trials. Montana State University Ag. Expt. Sta., Bozeman, Montana Ag. Research, 10:15-20.

Taiz, L. and E. Zeiger (1992). Plant Physiology. The Benjamin Comunigs publishing Company, Inc.

Taylor, A.J.; C.J. Smith and I. B. Wilson (1991). Effect of irrigation and nitrogen fertilizer on yield, oil content, nitrogen accumulation and water use of canola (*Brassica napus* L.). Fertilizer Research, 29: 3, 249-260

Waller, R.A. and D.B. Duncan (1969). A bays rule for symmetric multiple comparison problem. Amer. Stat. Assoc. J. December : 1485 - 1503.

تأثير معاملات الري ومستويات النتروجين على نمو ومحصول الكانولا

عبد الرحيم عبد الرحيم ليله و سليمـــــان بن علي الخطيب
قسم المحاصيل والمراعي، كلية العلوم الزراعية والأغذية، جامعة الملك فيصل

أقيمت تجربتان حقليتان بمحطة التدريب والأبحاث الزراعية والبيطرية، جامعـــة الملـــك فيصل بالأحساء خلال موسمي ٢٠٠٠/٢٠٠١ و ٢٠٠١/٢٠٠٢ وذلك لإلقاء الضوء على تأثير نظم الري ومستويات السماد النتروجيني على نمو ومحصول الكانولا " صنف باكتول". وقـــد أشـــارت نتائج الدراسة أن معاملات الري أثرت معنويا على جميع الصفات المدروسة، ما عدا صفة عـــــدد أفرع النبات. وقد أدى ري نباتات الكانولا كل ٧ أيام بمعدل ٥٠٠ م٣/هكتار/رية أو كل ١٤ يومـــا بمعدل ٦٥٠ م٣/هكتار/رية إلى زيادة معنوية في طول النبات، سمك الساق، عدد القرون/نبـــات، عدد البذور/قرن، نسبة الزيت بالبذور، محصول البذور والزيت للهكتار وقد أظـــهرت النتـــائج أن أعلا كفاءة استخدام لماء الري نتجت مع الري كل ١٤ يوما بمعدل ٦٥٠ م٣/هكتار. كما أظـــهرت النتائج أن زيادة التسميد النيتروجيني قد أحدث زيادة معنوية في جميع الصفات المدروسة، حيـــث أدت إضافة السماد النيتروجيني بمعدل ٢٠٠ كجم ن/هكتار إلى زيادة ملحوظة في نمو ومحصـــول الكانولا، إلا أن نسبة الزيت بالبذور قد نقصت بزيادة مستوى السماد النيتروجيني. كمـــا أشـــارت النتائج أن التفاعل بين فترات الري ومستويات السماد النيتروجيني أثر معنويا على محصول البذور والزيت/ هكتار، وقد أدت معاملة الري ٧ أو ١٤ يوما مع التسميد بمعدل ٢٠٠ كجم ن / هكتار إلى الحصول على أعلى محصول بذور وزيت.

توصي الدراسة بنجاح زراعة الكانولا "الصنف باكتول" تحت ظروف محافظة الأحســاء وإنتاج محصول مرتفع من البذرة والزيـــت عندمـــا يتـــم الـــري كـــل ١٤ يومـــا بمعـــدل ٦٥٠ م٣/هكتار/رية والتسميد بمعدل ٢٠٠ كجم ن / هكتار.