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RESPONSE OF CANOLA (*Brassica napus* L.) TREATED WITH SOME SOIL CONDITIONERS TO DROUGHT STRESS

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مقدم إلى

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RESPONSE OF CANOLA (*Brassica napus* L.) TREATED WITH SOME SOIL CONDITIONERS TO DROUGHT STRESS

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ABSTRACT

. A split plot in randomized complete block design with four replicates was used. The main plots were assigned to three irrigation intervals, i.e. irrigation each 7, 14 and 21 days, where the amount of irrigated water were 8400, 6800 and 6000 m^3/ha, respectively, (Table 1).

This study was performed during the winter seasons of 2001 and 2002 at the Agricultural and Veterinary Training and Research Station, King Faisal University. The purpose was to investigate the effect of organic manures (60, 80 and 100 m^3/ha) and gypsum (0, 5 and 10 t/ha) on growth and yield of canola "CV Pactol" under different irrigation intervals (7, 14 and 21 days, where the amount of irrigated water were 8400, 6800 and 6000 m^3/ha/season).

The main findings revealed that irrigation intervals significantly affected all estimated characters, except stem diameter. Irrigation every 7 days induced marked increases in plant height, number of branches and pods/plant, number of seeds/pod, weight of seeds/plant, seed and oil yields/ha and water use efficiency. On the other side, exposure canola plants to drought by prolonging irrigation intervals to 21 days produced the lowest means of the aforementioned traits.

Organic manure had marked effects on number of pods/plant, number of seeds/pod, weight of seeds/plant, seed and oil yields/ha and water use efficiency. The application of organic manure with rates of 60, 80 and 100 m^3/ha was associated with seed yields of 3.202, 3.622 and 3.897 t/ha, respectively.

Gypsum application with the rate of 10 ton/ha significantly improved most of estimated growth characters as well as seed and oil yields/ha and water use efficiency. Seed yield increased from 3.023 to 3.452 and 4.245 t/ha and oil yield increased from 1110.6 to 1277.2 and 1583.1 kg/ha with increasing gypsum rates from 0 to 5 and 10 t/ha.

The interaction between irrigation intervals and organic manure levels significantly affected seed and oil yields/ha as well as water use efficiency. The highest values of seed and oil yields/ha and water use efficiency were produced with irrigating canola every 7 days and adding the organic manure at a rate of 100 m^3/ha. Meanwhile, the lowest values of aforementioned traits were produced with irrigation canola every 21 days and adding the lowest level of organic manure (60 kg t/ha).

The interaction between irrigation intervals and gypsum levels had marked effects on seed and oil yields/ha as well as water use efficiency. Irrigating canola every 7 days and adding gypsum at the rate of 10 t/ha produced the highest seed and oil yields/ha and water use efficiency. On the contrast, the lowest averages of aforementioned traits were obtained with irrigation every 21 days in case of no gypsum application.

In general, it can be concluded that maximum seed and oil yields/ha as well as water use efficiency could be achieved with irrigating canola plants every 7 days and adding 100 m^3/ha organic manure and 10 t/ha gypsum.

KEYWORDS: Canola, Soil conditioners, Gypsum, Organic manure, Seed yield, Oil Yield, Water use efficiency, Irrigation intervals and Seed oil%.

INTRODUCTION

Canola (*Brassica napus* L.) is a member of the mustard (*Brassicaceae*) family and has become one of the most important sources of vegetable oil in the world (Alberta Agriculture, 1984). In addition to oil production, leaves and stems of canola provide high quality forage because of its low fibre and high protein content (Wiedenhoeft and Bharton, 1994). It is considered as one of these crops with high water utilization efficiency and drought tolerance. A promising future is being sought for canola production in arid regions (Howell, 2000). Canola can also tolerate moderately saline soil conditions (Al-Thabet, 2003). Little information is available on the water requirements for growing canola under the dry environmental conditions of Saudi Arabia, particularly with regard to increasing seed yield and raising water use efficiency through the application of organic manure and gypsum as soil amendments.

Growth and productivity of canola declined under water stress conditions. Flasinski and Rogozinska (1985) reported that water stress progressively decreased seed formation. Riley (1989) reported that soil water depletion was greatest during flowering and pod development. 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 seed weight increased after drought during flowering. The straw yield was less affected by drought. Hashem *et al*. (1998) found that seed yield in plants stressed at early vegetative, late vegetative and flowering stages were 59, 74 and 88%

lower than the unstressed plants, respectively. Drought stress reduced leaf photosynthesis by 67-97%. Leilah and Al-Khateeb (2003) under Saudi Arabia conditions, reported that irrigation canola every 7 days with the rate of 500 m3/irrigation/ha or every 14 days with the rate of 650 m3/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.

Application of organic fertilizers improves physical, chemical and microbial properties of soils. Adding compost in particular increases the contents of organic carbon and microbial biomass, the cation exchange capacity, and the biological activities of soils (Perucci, 1992; Avnimelech *et al*., 1993; Giusquiani *et al*., 1995; Jörgensen *et al*., 1996 ; Subbiah and Kumaraswamy, 2000; Leifeld, *et al.* , 2002). Williamson *et al.* (1982) stated that 100 t/ha or more of dry organic matter should be incorporated to 15 cm depth of soil in order to achieve about 3-6% organic matter content which is the level expected in a normal soil. Sabrah, *et al* (1993) at Saudi Arabia, showed that the soil conditioners improved nitrogen uptake, yield components and yield quality of wheat. The extent of improvement varied, depending on the type of soil conditioner used and rate of urea.

Gypsum is a relatively common mineral that is widely available in agricultural areas and has a number of specialized agronomic uses, principally as a Ca source on legumes and as a soil conditioner on sodic soil (Ma *et al.* 1989). Jarwal *et al* (2001) stated that crop type strongly influenced the effect of gypsum on soil exchangeable sodium percentage (ESP). After two years, gypsum reduced ESP only in the top 10 cm of soil following a wheat-safflower sequence whereas ESP was reduced to a depth of 50 cm following a chickpea-canola rotation. It is suggested that that canola may have facilitated the movement of gypsum down the profile or induced biological reclamation.

The objectives of this investigation were to determine the optimal amount of irrigation water, the convenient rate of organic manure application, and the proper gypsum application rate for maximizing vegetative growth, seed and oil yields/unit area and to improve water use efficiency of canola "CV Pactol" planted under dry environmental conditions of Al-Hassa (Latitude 25° 15' 49" N, longitude 49° 41' 46" W and altitude 151 m).

MATERIALS AND METHODS

Two field experiments were conducted during the winter seasons of 2001 and 2002 at the Agricultural and Veterinary Training and Research Station, King Faisal University. A split plot in randomized complete block design with four replicates was used. The main plots were assigned to three irrigation intervals, i.e. irrigation each 7, 14 and 21 days, where the amount of irrigated water were 8400, 6800 and 6000 m^3/ha, respectively, (Table 1). Watering regimes were applied 35 days from sowing, where during the 35 days, all the experimental plots received similar amounts of water delivered at similar intervals. The plots received during this period a total amount of water 2000 m^3/ha. This amount was given into 4 irrigations, one heavy irrigation of 800 m^3/ha at sowing, and 3 subsequent lighter irrigations of 400 m^3/ha each. The plants were then irrigated for a further period of 115 days. The volumes of water for each of the three watering regimes were as shown in Table (1).

The sub plots were assigned to three organic manure levels (60, 80 and 100 mm^3/ha), while the sub-sub plots were assigned to two gypsum levels (5 and 10 ton/ha), in addition to the control, i.e. without gypsum application.

Samples from the experimental soil were taken at random from the upper 30 cm of the soil surface for physical and chemical analysis. Results of soil analysis over the two seasons revealed that the soil was sand in texture with pH = 7.3, ECe = 4.8 dsm-1, N, Na, K and Ca contents were 15.8, 13.7, 24.6 and 11.0 Mmeq/L, respectively.

Well seed-bed preparation was done through two perpendicular ploughs, harrowing, good levelling and ridges establishment. Ridging at the rate of 10 ridges/two inches (row width =70 cm) was applied. The experimental area was divided through irrigation channels and alleys construction into equal units, having 5 ridges, each of 70 cm width and 3.5 m in length.

Dry planting on ridges, 20 cm apart on one side of ridges was done on the last week of October in both seasons. Seeding rate was 6.0 kg/ha. Sowing irrigation (the first one) was done, immediately after seeding. The surface furrow irrigation was used in this study. Other irrigations were performed as previously mentioned, according the proposal of study. At 20 days after planting, plants were thinned to secure two plants / hill and thinned again after 10 days to secure one plant / hill. No mineral fertilizers were added to this investigation, which the used soil amendments (gypsum and organic manure) were only added as previously mentioned. Weeds were hand-weeded, at 30, 45 and 60 days after sowing. Other normal recommended agronomic practices for canola production were followed.

Studied characters: At harvest, ten guarded plants were taken at random from each experimental unit and the following characters were determined:

Plant height (cm),

Stem diameter (cm),

Number of branches / plant,

Number of pods / plant,

Number of seeds / pod,

1000-seed weight (g)

Seed weight / plant (g).

Plants in the two central ridges in each plot were harvested for seed yields/m^2, which were converted to record seed yields in tons/ha. Seed oil percentage was estimated on dry weight basis using the soxhelt apparatus and petroleum ether as an organic solvent, according to A.O.A.C. (1984). Oil yield (kg/ha) was calculated by multiplying seed yield / ha by seed oil percentage.

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

WUE (kg/m3) = Seed yield (kg/ha)/ volume of irrigation water (m3/ha)

Statistical analysis: Obtained data in the two seasons were subjected to the proper analysis of variance of the split-split plot design, according to the method published by Gomez and Gomez (1984). The treatment means were compared at 0.05 % level of significant using the Bayesian Least Significant Difference test, as published by Waller and Duncan (1969). Computations were done using SAS (2001).

Table (1): Amount of water in the evaluated four irrigation regimes:

Watering interval	Amount of water (m^3/ha) received before treatments were imposed	Amount of water (m^3/ha) received after treatments were imposed	Amount of water (m^3/ha) received during the season.
7 days	2000	6400	8400
14 days	2000	4800	6800
21 days	2000	4000	6000

RESULTS

1. **Irrigation interval effects**: Data listed in Tables (2) show that plant height and number of branches/plant were significantly affected by irrigation intervals. Irrigation every 7 days resulted in significant increase in plant height and number of branches/plant. However, the lowest means of aforementioned traits were noticed with the irrigation every 21 days. Stem diameter was not significantly affected by irrigation intervals and this was clear in the two seasons of study. Number of pods/plant and seeds/pod were markedly decreased as irrigation intervals increased (Table 3). Seed weight/plant markedly decreased as irrigation intervals increased and this was obvious in both seasons. The exposure of canola plants to drought with increasing irrigation intervals from 7 to 14 and 21 days significantly decreased seed weight / plant over both seasons from 7.6 to 5.3 and 4.2 g, respectively.

Data presented in Table (4) reveal that seed index (1000-seed weight) was markedly decreased as drought stress increased as result of increasing the irrigation from 7 to 14 and 21 days, and this was obvious in both seasons.

Seed oil content Table (4) was significantly affected by irrigation interval in both seasons of study. Irrigation canola every 14 days resulted in the highest seed oil content, however, increasing the period from 14 to 21 days resulted in marked reduction in seed oil content. Irrigation canola weekly surpassed it in seed oil content, compared with the irrigation every 21 days. This trend was similar in the two seasons. In both seasons, seed yields/ha were markedly decreased as irrigation intervals increased. The reduction in seed yield reached its maximum with prolonging irrigation interval to 21 days. The reduction in seed yield associated to the increase in drought stress which resulted with the increase of irrigation intervals from

7 to 14 and 21 days was 43.22 and 76.89 % in the first season and 42.59 and 81.64% in the second season, respectively.

Oil yields / ha were significantly affected by irrigation intervals and this was true in both seasons. Data in Table (5) reveal that oil yields/ha were markedly decreased as irrigation intervals increased from 7 to 14 and 21 days. The decrease in oil yield due to the increase in irrigation intervals and exposure canola plants to drought reached 38.20 and 95.36 % in the first season and 37.51 and 88.54 % in the second season, respectively.

Harvest index significantly decreased as irrigation interval increased. It decreased from 8.3% to 7.4 and 6.7% in the first season and from and 8.7% to 7.5 and 6.7% in the second season with increasing the irrigation interval from 7 to 14 and 21 days, respectively, as shown in table (5).

WUE, defined as seed yield divided by the total amount of applied water, was markedly affected by irrigation intervals in the two seasons. Data depicted in Fig. (1) appears that values of water use efficiency was decreased as irrigation interval increased. Over both seasons of study, irrigation canola weekly was the best in this concern, where WUE reached 0.57, 0.49 and 0.45 kg seeds/m^3water, every 7, 14, and 21 days respectively.

2. Manure level effects: Data presented in Table (2) show that organic manure rates did not induce significant effects on plant height, stem diameter and number of branches/plant, in both seasons of study. However marked increases in number of pods/plant and seeds/pod as well as seed weight/plant were increased as organic manure increased from 60 to 100 m^3/ha, but the differences in number of seeds/pod due to the increase in manure rates from 80 to 100 m^3/ha did not reach the level of significant at 5 % level of probability (Table 3). In the two seasons, there were no marked effects in 1000-seed weight and seed oil content due to organic manure treatments. However, slight insignificant increases were noticed with increasing organic manure rates for both aforementioned traits. As shown in Table (4), seed yield / ha was significantly affected by the examined organic manure rates and this was obvious in both seasons of study. Each increase in manure rates from 60 to 80 and 100 m^3/ha was associated with marked increases in seed yield/ha, which increased from 3.230 to 3.614 and 3.920 ton/ha in the first season and from 3.173 to 3.629 and 3.874 ton/ha in the second season, respectively. Oil yield/ha in both seasons followed the same trend of seed yield/ha in its response to organic manure rates. Data in Table (5) show that raising manure rates from 60 to 80 and 100 m^3/ha resulted in increases of oil yields/ha from 1175.6 to 1341.1 and 1454.2 kg/ha, respectively.

Table (2): Plant height, Stem diameter, and number of branches/plant as affected by irrigation intervals, organic manure and gypsum levels in the first (I) and second (II) seasons.

Treatments	Plant height(cm)		Stem diameter (cm)		Branches/plant	
	I	II	I	II	I	II
Irrig. intervals						
7 days	210	184	2.35	2.04	13.25	12.28
14 days	187	169	2.15	2	11.19	11.5
21 days	177	157	2.06	1.9	10.72	10.75
Lsd (5%)	2.2	2.2	N.S	N.S	0.7	0.6
Manure levels						
60 m^3/ha	191	169	2.16	1.98	11.25	11.17
80 m^3/ha	190	170	2.12	1.98	11.75	11.39
100 m^3/ha	193	171	2.28	1.99	12.17	11.97
Lsd (5%)	N.S	N.S	N.S	N.S	N.S	N.S
Gypsum levels						
0 ton/ha	188	168	2.11	1.97	10.81	11.39
5 ton/ha	192	169	2.2	1.97	11.72	11.11
10 ton/ha	194	173	2.25	2.01	12.64	12.03
Lsd (5%)	2.7	2.2	N.S	N.S	0.8	0.5

Table (3): Number of Pods/plant, seeds/pod and weight of seed/plant as affected by irrigation intervals, organic manure and gypsum levels in the first (I) and second (II) seasons.

Treatments	Pods/plant		Seeds/pod		Seed wt. (g/ plant)	
	I	II	I	II	I	II
Irrig. intervals						
Irrig. intervals	124.8	132.8	21.1	20.0	7.6	7.5
7 days	92.8	96.8	19.6	18.8	5.3	5.3
14 days	85.5	89.2	18.5	17.4	4.3	4.2
21 days	5.0	3.7	0.5	0.6	0.4	0.3
Lsd (5%)	5.0	3.7	0.5	0.6	0.4	0.3
Manure levels						
60 m^3/ha	94.7	99.3	19.3	18.1	5.2	5.0
80 m^3/ha	101.8	107.4	19.8	18.8	5.8	5.8
100 m^3/ha	106.6	112	20.2	19.3	6.2	6.2
Lsd (5%)	2.3	3.1	0.5	0.5	0.2	0.3
Gypsum levels						
0 ton/ha	93	97.1	18.8	18.0	4.9	4.7
5 ton/ha	101	107.1	19.4	18.4	5.5	5.5
10 ton/ha	109	114.6	21.0	19.9	6.8	6.8
Lsd (5%)	2.1	1.7	0.4	0.4	0.3	0.2

Table (4): 1000-seed weight, seed oil % and seed yield (tan/ha) as affected by irrigation intervals, organic manure and gypsum levels in the first (I) and second (II) seasons.

Treatments	1000-seed wt		OIL%		Seed yield ton/ha	
	I	II	I	II	I	II
Irrig. intervals						
7 days	2.8	2.8	37.2	37.2	4.755	4.741
14 days	2.9	2.8	38.5	38.6	3.32	3.325
21 days	2.7	2.6	33.6	35.9	2.688	2.61
Lsd (5%)	0.1	0.1	0.6	0.4	0.191	0.173
Manure levels						
60 m^3/ha	2.8	2.7	36.1	37.1	3.23	3.173
80 m^3/ha	2.8	2.7	36.3	37.2	3.614	3.629
100 m^3/ha	2.8	2.8	36.9	37.4	3.92	3.874
Lsd (5%)	N.S	N.S	N.S	N.S	0.143	0.148
Gypsum levels						
0 ton/ha	2.8	2.6	36.2	37.0	3.072	2.974
5 ton/ha	2.8	2.7	36.4	37.4	3.46	3.443
10 ton/ha	2.9	2.9	36.8	37.3	4.231	4.259
Lsd (5%)	N.S	N.S	0.3	0.3	0.144	0.118

Table (5): Oil yield, harvest index and water use efficiency (WUE)as affected by irrigation intervals, organic manure and gypsum levels in the first (I) and second (II) seasons.

Treatments	Oil yield (Kg /ha)		Harvest index		WUE	
	I	II	I	II	I	II
Irrig. intervals						
7 days	1768.8	1766.3	8.3	8.7	0.57	0.57
14 days	1280.0	1284.4	7.4	7.5	0.49	0.49
21 days	905.4	936.8	6.7	6.7	0.45	0.44
Lsd (5%)	77.7	64.5	0.6	0.5	0.04	0.03
Manure levels						
60 m^3/ha	1174.6	1176.5	7.3	7.7	0.45	0.44
80 m^3/ha	1325.3	1356.9	7.5	7.5	0.50	0.50
100 m^3/ha	1454.3	1454.1	8.0	8.0	0.55	0.54
Lsd (5%)	45.9	57.3	0.4	0.4	0.02	0.02
Gypsum levels						
0 ton/ha	1118.6	1102.6	7.1	7.0	0.43	0.42
5 ton/ha	1266.1	1288.3	7.3	7.6	0.48	0.48
10 ton/ha	1569.5	1596.7	8.2	8.6	0.59	0.59
Lsd (5%)	55.6	49.3	0.3	0.4	0.02	0.02

Harvest index was significantly increased as organic manure increased and this was true in both seasons. The increase in manure rates from 60 to 80 and 100 m^3/ha resulted in increasing the harvest index from 7.3 to 7.5 and 8.0 %, respectively overall both seasons.

Water use efficient (WUE) was markedly increased as organic manures increased. The application of 60, 80 and 100 m^3/ha manure result in WUE of 0.45, 0.50 and 0.54 kg seeds/m3 water, respectively.

3. Gypsum rate effects: The statistical analysis of data in both seasons revealed that plant height and number of branches/plant were significantly affected by gypsum rates. On the other hand, stem diameter was not affected by gypsum application, as shown in Table (2). Application of gypsum either with the rate of 5 or 10 ton/ha resulted in marked increases in plant height and number of branches/plant, compared to the control, i.e. without gypsum application. In the two seasons, numbers of pods/plant was significantly increased from 95 to 104 and 111 pods/plant with increasing gypsum rates from 0 to 5 and 10 ton/ha, respectively. Number of seeds/pod followed the same trend of pods/plant, which increased with the application of gypsum (Table 3). Weight of seeds/plant was increased with gypsum addition. Seed weight/ plant increased from 4.9 to 5.5 and 6.8 g in the first season and increased from 4.7 to 5.5 and 6.8 g in the second season, with increasing gypsum rates from 0 to 5 and 10 ton/ha, respectively (Table 3). 1000-seed weight did not significantly affect with the gypsum application in both seasons. Seed oil percentage was slightly increased from 36.6 in the control, i.e. without gypsum application to 36.9 and 37.1% with the addition of gypsum at rates of 5 and 10 ton /ha, in both seasons. Seed yields/ha were significantly affected by gypsum application in the two seasons (Table 4). Over both seasons of study, seed yields increased from 3.023 to 3.452 and 4.245 ton/ha with increasing gypsum rates from 0 to 5 and 10 ton/ha, respectively.

Data in Table (5) show that averages of oil yields/ha, harvest index and water use efficiency were significantly affected by gypsum application in the two seasons. The addition of 5 and 10 ton gypsum / ha resulted in increasing oil yields/ha from 1110.6 in the control (0 gypsum) to 1338.6 and 1454.2 kg/ha with the application of 5 and 10 ton gypsum / ha. Theses figures represent 20.52 and 30.9 %, respectively. Harvest index was markedly increased with the application of gypsum and this increase reached the level of significant at 5% level of probability with increasing gypsum rates from 5 to 10 ton / ha. Similar trend was noticed with the water use efficiency, which increased with the gypsum addition and also increased with increasing gypsum rate from 5 to 10 ton/ha.

4. Interaction effects: The interaction between irrigation intervals and organic manure rates significantly affected seed and oil yield/ha as well as water use efficiency. Over both seasons, the highest seed oil yield/ha

(5.194 t/ha), oil yields (1951.9 kg/ha) and water use efficiency (0.62 kg seeds/m^3 water) were produced with irrigating canola every 7 days adding the highest organic manure (100 m^3/ha), as graphically illustrated in Figures (1, 2 & 3). Meanwhile, the lowest values of seed and oil yields/ha and the water use efficiencies were obtained from plots irrigated every 21 days and fertilized with the lowest organic manure rate (60 m^3/ha).

Data depicted in Figures (4, 5& 6) illustrated that seed and oil yields/ha as well as water use efficiency were significantly affected by the interaction between irrigation interval and gypsum levels. Maximum values of seed yield (5.962 ton/ha), oil yield (2229 kg/ha) and water use efficiency (0.71 kg/m^3) were obtained with irrigating canola plants every 7 days and adding gypsum at the rate of 10 ton/ha. On the other side, minimum values of seed and oil yields/ha and water use efficiency were obtained with irrigating canola every 21 days in case of no gypsum application.

DISCUSSION

Most of estimated growth characters and seed yield per plant and hectare were increased with irrigation interval of 7 days. A great reduction in growth and yield of canola plants were obvious with the exposure of plants to drought which resulted by increasing the irrigation interval in the present study. The reduction in growth and yield with the drought could 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, additional moisture will result in no further increase in yield and may cause yield reduction through poor soil aeration

Fig. (1): Seed yield (t/ha) as affected by the interaction between irrigation intervals and organic manure rates, over both seasons. Bars represent LSD (5%).

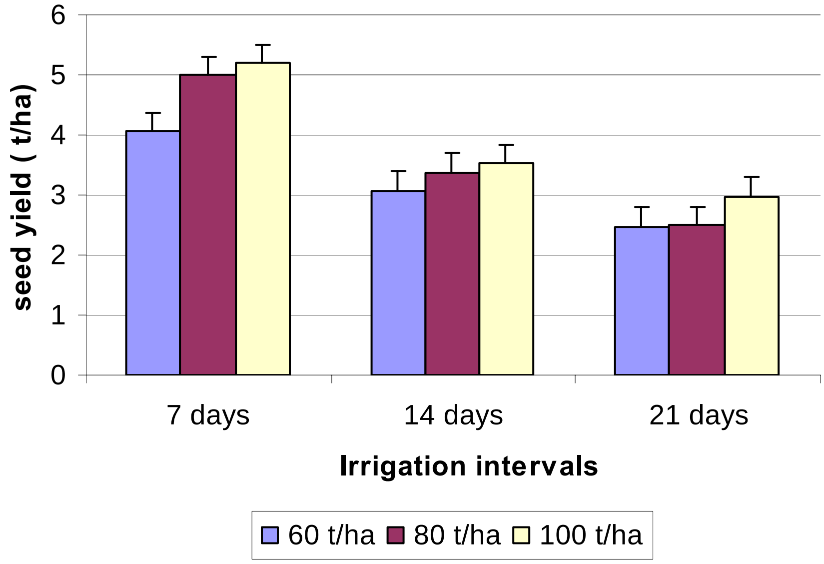


Fig. (2): Oil yield (kg/ha) as affected by the interaction between irrigation intervals and organic manure rates, over both seasons. Bars represent LSD (5%). 132

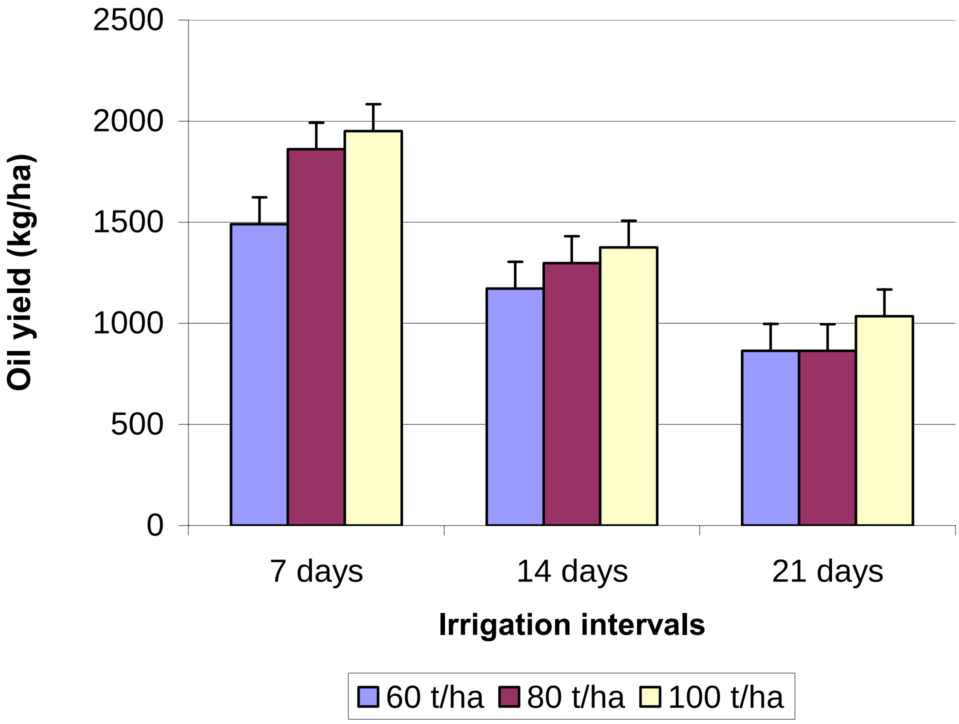


Fig. (3): Water use efficiency, WUE (kg seeds/m3 water) as affected by the interaction between irrigation intervals and manure levels, over both seasons. Bars represent LSD (5%). 0.06

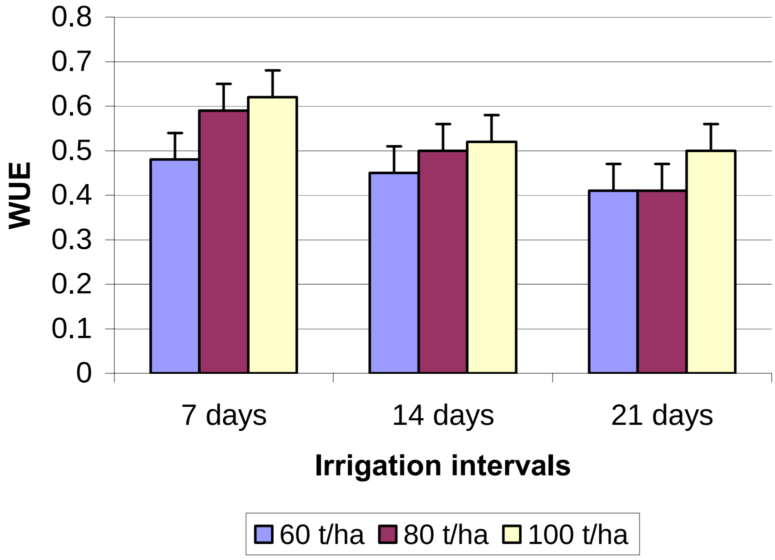


Fig. (4): Seed yield (t/ha) as affected by the interaction between irrigation intervals and gypsum levels, over both seasons. Bars represent LSD(5%). 0.25

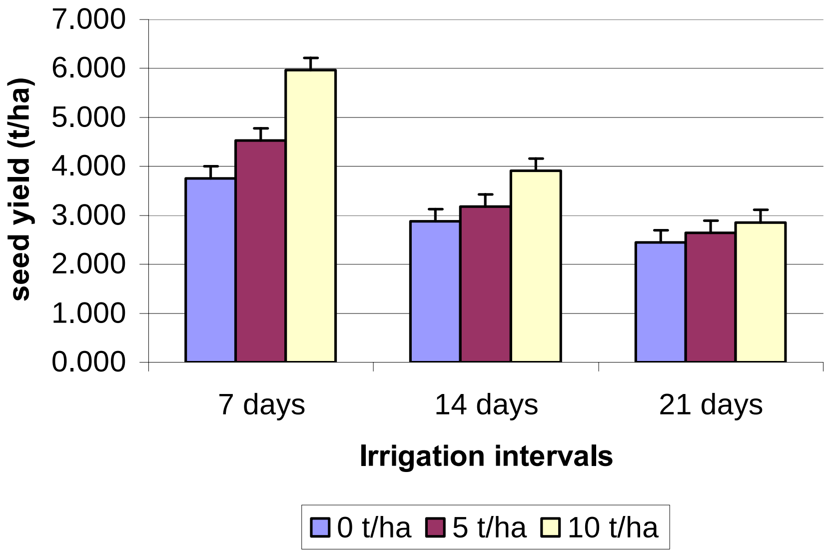


Fig. (5): Oil yield (kg/ha) as affected by the interaction between irrigation intervals and gypsum levels, over both seasons. Bars represent LSD (5 %). 99.7

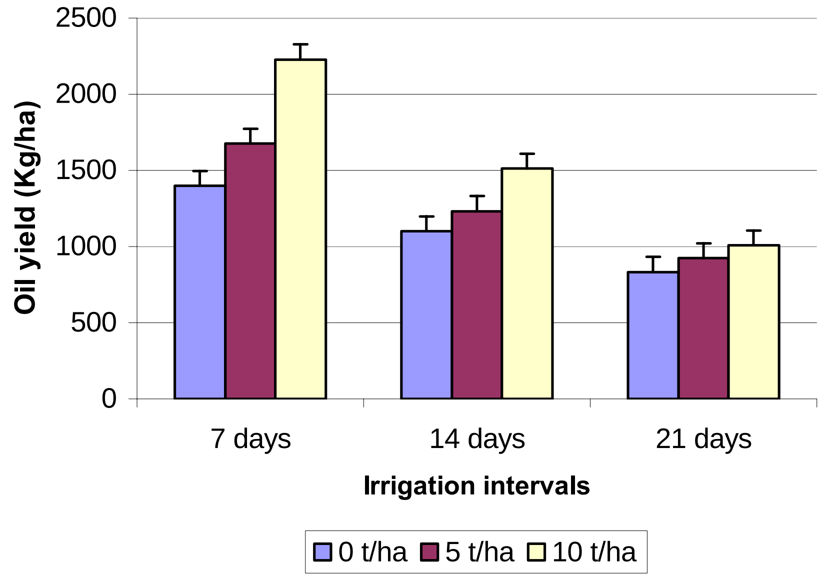
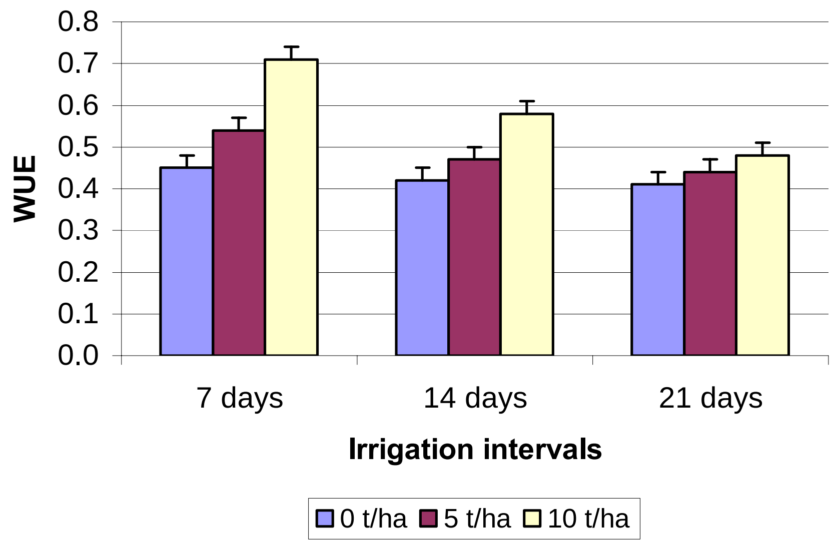


Fig. (6): Water use efficiency, WUE (kg seeds/m3 water) as affected by the interaction between irrigation intervals and gypsum rates, over both seasons. Bars represent LSD (5 %). 0.04



and/or increased plants lodging and insects infestation. Similar results were confirmed by Andersen *et al.* (1996) and Leilah *et al.* (2002). Seed oil content (Table 4) was decreased with the increase of irrigation interval, i.e. with the exposure of canola plants to drought. The adequate supply of water enhances the carbohydrate accumulation, and this in turn increases 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.

It is evident from data presented in the present study (Tables 2,3,4 and 5) that most of growth characters as well as seed and oil yields/ha were improved with increasing the applied organic manure rates. Water use efficiency also increased with increasing the organic manure rates. The increase in growth and seed yield /ha of canola with increasing organic manure rates might be attributed to the role of organic manure in increasing the contents of organic carbon (OC), microbial biomass, and the biological activities of soils, which induce marked increases of the cultivated crops (Jörgensen *et al*, 1996; Subbiah and Kumaraswamy, 2000 and Leifeld, *et al*, 2002). In some traits, the differences between organic manure rates were slight and did not reach the level of significant and this can be attributed to the huge rate of the lowest manure rate used in the present study (60 m^3/ha).

Data obtained from the present study and listed in Tables (Tables 2,3,4 and 5) show that seed and oil yields of canola were increased with the application of gypsum, since gypsum is known as a soil amendment and widely uses to improve soil structure. Gypsum is an excellent kick-starter, gains in crop production and longer-term improvements in soil structure through amelioration of soil sodicity are possible if gypsum application and other soil management practices are combined. Gypsum is used on saline soils to improve soil structure (Ma *et al.* 1989). Similar results were reported by Jarwal *et al* (2001) who stated that gypsum application (especially at the higher rates 10 t/ha) had a beneficial effect on seedling establishment of canola and significantly increased canola seed yield. The significant increase in seed and oil yields achieved with the application of 5 and 10 t/ha rates of gypsum might be attributed to the role of gypsum in increasing most of yield attributing variables as number of pods/plant and seeds/pod, weight of seeds/plant and hence seed yield/ha. Similar conclusions were reported by Jarwal *et al* (2001) who stated that the application of gypsum (5 and 10 t/ha) reduced the exchangeable sodium percentage (ESP). They also explained that Calcium also acts as a regulator of the balance of particularly the micronutrients, such as iron, zinc, manganese and copper, in plants. It also regulates non-essential trace elements. Calcium prevents excess uptake of many of them; and once they are in the plant, calcium keeps them from having adverse effects when their levels get high. They also suggested that the tap root system of crops as canola may facilitate the movement of water and dissolved gypsum down the profile. Further investigation into the mechanism responsible for this is warranted as this has important practical implications for increasing the effectiveness of gypsum application in improving soil structure and crop productivity on the highly saline soils.

Gypsum application increased water-use efficiency of canola in both seasons. This might be attributed to its role in improving water infiltration rates, hydraulic conductivity and better water storage in the soil which leads to deeper rooting and better water-use efficiency by plants.

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إستجابة نبات الكانولا لبعض محسنات التربة تحت الظروف الجفافية

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نفذت هذه الدراسة بمحطة التدريب والأبحاث الزراعية والبيطرية، جامعة الملك فيصل بالأحساء خلال موسمي ٢٠٠٢/٢٠٠١ و ٢٠٠٣/٢٠٠٢ لتقييم تأثير إضافة مستويات مختلفة السماد العضوي (٦٠ ، ٨٠، ١٠٠ م^{٣} /هكتار) والجبس الزراعي (صفر، ٥، **١٠** طن/هكتار) تحت فترات ري مختلفة (٧، ١٤ و ٢١ يوم باستهلاك مائي قدره (٨٤٠٠، ٦٨٠٠ و ٦٠٠٠ م^{٣} ماء/هكتار/موسم) وذلك على النمو والمحصول وكفاءة استخدام ماء الري في نبات الكانولا.

أشارت نتائج الدراسة أن فترات الري أثرت معنوياً على جميع الصفات المدروسة، ما عدا صفة سمك الساق. وقد أدى الري كل ٧ أيام إلى إحداث زاد معنوية في طول النبات، عدد الأفرع والقرون /نبات، عدد البذور/قرن، وزن بذور النبات، محصول البذور والزيت / هكتار ، معامل االحصاد وكفاءة استخدام المياه. على النقيض من هذا، فقد أدى تعرض النباتات للجفاف بريها كل ٣ أسابيع إلى نقص واضح في الصفات سالفة الذكر.

أثرت إضافة السماد العضوي معنويا على عدد القرون/نبات، عدد البذور/قرن، وزن بذور النبات، محصول البذور والزيت للهكتار، دليل الحصاد وكفاءة استخدام المياه. وأدت إضافة السماد العضوي بمعدل ١٠٠ م^{٣}/هكتار إلى زيادة معنوية في جميع الصفات سالفة الذكر. وأدت إضافة السماد العضوي بمعدل ٦٠ ، ٨٠، ١٠٠ م^{٣} /هكتار إلى الحصول على محصول بذور بلغ على مدار الموسمين ٣,٢٠٢ ، ٣,٦٢٢ ، ٣,٨٩٧ طن/هكتار، على التوالي.

أدت إضافة الجبس الزراعي بمعدل ١٠ طن جبس زراعي/هكتار إلى تحسن ملحوظ في صفات النمو والمحصول كما زادت من كفاءة استخدام المياه. فقد زاد محصول البذور على مدى موسمي الدراسة من ٣,٠٢٣ إلى ٣,٤٥٢ و ٤,٢٤٥ طن/هكتار ومحصول الزيت من ١١١٠,٦

إلى ١٢٧٧,٢ و ١٥٨٣,١ كجم/هكتار بزيادة الجبس من صفر إلى ٥ و ١٠ طن/هكتار، علـى التوالي.

أثر التفاعل بين فترات الري ومستويات السماد العضوي معنويا على محصول البـذور والزيت/ هكتار وكفاءة استخدام المياه، وقد أدت معاملة الري كل ٧ أيام مـع إضـافة التـسميد العضوي بمعدل ١٠٠ م^{3}/هكتار إلى الحصول على أعلى محصول بذور وزيت وكذلك أدى إلى زيادة كفاءة استخدام مياه الري. وعلى العكس من هذا، فقد بلغت متوسطات الصفات سالفة الذكر أدناها بالري كل ٢١ يوما وإضافة أقل مستوى من السماد العضوي (٦٠ م^{3}/هكتار).

أثر التفاعل بين فترات الري ومستويات الجبس الزراعي معنويا على محصول البـذور والزيت/ هكتار وأيضا على كفاءة استخدام المياه. وقد بلغت متوسطات هذه الـصفات أقـصاها بالري كل ٧ أيام مع إضافة الجبس الزراعي بمعدل ١٠ طن/هكتار. وعلى النقيض، فقد بلغـت متوسطات الصفات سالفة الذكر أدناها بإطالة فترة الري إلى ٢١ يوما في حالـة عـدم إضـافة الجبس الزراعي.

التوصية: لزيادة إنتاجية الكانولا ورفع كفاءة استخدام ماء الري تحت ظروف منطقة الإحساء يوصى بالري كل ٧ أيام والتسميد العضوي بمعدل ١٠٠ م^{3}/هكتار وإضافة الجـبس الزراعـي بمعدل ١٠ طن/هكتار .