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GROWTH AND YIELD OF CANOLA IN RESPONSE TO WATER SALINITY

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ABSTRACT

Two pot experiments were performed at the Faculty of Agriculture and Food Sciences, King Faisal University, Al-Hassa, during the two winter seasons of 2000/2001 and 2001/2002 to study the effect of three NaCl concentrations (5, 10 and 15 dSm^{-1}) in addition to the control (tap water) on growth, and yield of three canola cultivars, namely Al-Serw4, Al-Serw 8 and Pactol. Factorial experiment laid out in randomized complete block design with eight replicates was used. The main results revealed that wide variations were found between canola cultivars in their tolerance to salinity, expressed in the measurements of growth and yield readings. Al-Serw 8 was relatively more tolerant to high salinity concentration, compared with Pactol and Al-Serw4. Increasing NaCl concentration in irrigation water resulted in marked reduction in all estimated traits. Seed weight/plant was significantly affected by the interaction between canola cultivars and NaCl concentrations. The highest seed weight/plant was obtained from the variety Pactol when irrigated with the tap water. Meanwhile, in case of high concentrations of 10 and 15 dSm^{-1}, Al-Serw 8 was the high yielder one. Thus, it can be recommended that Pactol cultivar was suitable in normal conditions and Al-Serw 8 in case of salinity stress conditions of soil and irrigation water.

INTRODUCTION

Commercial varieties of canola were developed from two species, they are Argentine type (*Brassica napus*) and Polish type (*Brassica campestris*). Both species of canola produce seed that is high in poly unsaturated fatty acids (oleic, linoleic, and linolenic). Improved canola cultivars contain both high oil content about 40 % and 23% protein content compared to 20 and 40 %, respectively, for soyabean (Oplinger *et al.*, 1989). Recently, there are many new untraditional canola cultivars introduced by the Canadian Canola Council. Canola cultivars are markedly vary in their tolerance to water salinity. Some of Canola cultivars are known with its high tolerance to grow successfully under wide variations of environmental conditions as the reverse soil and water conditions (Ashraf and Mahmood 1990; Kumar *et al.*, 1992; Huang and Redmann 1995a and Wright *et al.*, 1996). Abbas *et al.*, (1999) stated that Pactol CV was significantly superior in plant height, number of branches/plant, number of pods/plant, seed yield/plant, seed yield/fad and seed oil content, compared to another tested CVs. Finally, Leilah *et al.* (2002) stated that canola cultivars significantly varied in all estimated characteristics, except number of seeds/pod and seed oil percentage. Pactol CV recorded the highest number of pods/plant and 1000-seed weight. Al-Serw 8 surpassed the other two-tested canola cultivars in plant height, stem diameter, seed weight/plant and harvest index. Al-Serw 4 recorded the highest number of branches and pods/plant. Maximum seed and oil yield/ha were produced from Pactol and Al-Serw8 without marked differences in the two seasons.

Salinity is a major factor reducing canola plant growth and productivity, especially in the arid and semiarid climates. Francois (1994) found that relative seed yield of canola species *B. napus* and *B. campestris* were not affected by soil salinity up to 11.0 and 9.7 dSm^{-1}, respectively and the vegetative growth of both species was unaffected by soil salinity up to 10.0 dSm^{-1}. The results placed both canola species in the salt-tolerant category. Redmann *et al.* (1994) stated that salinity treatments significantly reduced leaf area, shoot and root biomass in evaluated canola varieties. The growth reduction in canola under salt stress resulted from a combination of ion toxicity and altered water relations that caused large accumulation of sodium (Na) and magnesium (Mg) ions, and reduced calcium (Ca) and potassium (K) concentration in the shoots and roots. Moreover, water potential, osmotic potential, transpiration, stomatal conductance and hydraulic conductance decreased as salinity increased (Huang and Redmann 1995b). Noureldin *et al.* (1995) in a field experiment, rape cv. Cressor and Liraspa were grown on soils with salinity levels of 7.76, 10.13 or 22.4 mmhos / cm. The crops were irrigated every 21 days throughout growth or every 21 d until flowering and thereafter every 42 days till maturity, and received 0, 0.5 or 1 ton S/feddan. All treatments received a basal dressing of NPK. They found that seed yield decreased with increasing salinity. The application of 1 ton S gave the highest seed yield in all soils in Cressor while Liraspa seed yields were not affected by S rate in the most saline soil. Seed yields were not significantly affected by irrigation regime. Liraspa is salt tolerant and gave higher seed yields in the saline soils. [1 feddan = 0.42 ha].

The objectives of this study were to determine varietal differences in growth, yield and seed oil content and the effect of different NaCl concentrations on the performance of three canola cultivars.

MATERIALS AND METHODS

Two pot experiments were performed in Faculty of Agriculture and Food Sciences, King Faisal University during the two winter seasons of 2000/2001 and 2001/2002. The purpose was to study the effect of three salinity levels (5, 10 and 15 dSm^{-1}) obtained by dissolving NaCl in tap water, in addition to the control (tap water with EC_e 1.8 dSm^{-1}) on growth and yield of three canola cultivars, namely Al-Serw4, Al-Serw 8 and Pactol. Factorial experiment laid-out in randomized complete block design with eight replicates was used. Four replicates were assigned to the vegetative characteristics and the others were assigned for yield and its component estimation. Canola plants were grown in plastic pots with 30 cm dimension. It was filled with sandy loam (1 part sand to 1 part loam). Ten seeds per each pot were sown on the second week of November in the two seasons of 2000 and 2001. After complete emergence, two weeks from sowing, seedlings were thinned to secure three plants/pot. After other two weeks, plants were thinned again to leave only one plant/pot.

During the experiment period, pots were watered every 2-3 days with sufficient amount of the evaluated solutions to restore the soil to field capacity plus in addition of the amount equivalent twice evapo-transpiration to insure adequate leaching. Custom irrigation system was designed, includes fiberglass tank with full capacity of 500 liters, and open square tank with dimension of 1.5

m in length, 1.0 m in width, and 30 cm in depth where pots were placed. Pumps were established to return the additional water to the tank for controlling the amount of water to keep it at the field capacity. Salinity solution was replaced monthly to keep salinity levels constant per each treatment. Plants were fertilized three times, at 25, 50 and 75 days after planting using organic liquid fertilizer "Al-Bostan" (N=65, P=45, K=50 g/L). Other agronomic practices, except the evaluated factors, were done in normal manners.

Canola plants were harvested at maturity, where lower leaves turned yellow and began to dry, seeds in pods on the main stem turned to be brownish-red in color with about 30 % moisture content. The following characteristics were estimated: Total weight (g/plant), number of branches / plant, number of pods / plant, number of seeds/pod, 1000-seed weight (g), harvest index (the proportion of seed weight to above-ground biomass) was estimated, according to Fageria (1992). Random samples of dry seeds were taken to estimate seed oil content using Soxholt apparatus according to the procedures of A.O.A.C (1984).

Obtained data were subjected to the proper technique of analyses of variance (ANOVA) as published by Gomez and Gomez (1984) and the treatment means were compared using the Baysian Least Significant Difference test (NLSD) as published by Waller and Duncan (1969). Computations and statistical analysis were done using the facility of computer and SAS software (SAS Institute 1995).

RESULTS AND DISCUSSION

A: Varietal Differences:

Results of the statistical analysis of data show wide variations in the evaluated canola cultivars in most of estimated traits in both seasons. Data listed in (Table 1) show that plant weight (Biomass) was significantly differed among the evaluated canola cultivars in both seasons. Al-Serw 8 ranked the first in this trait and Al-Serw 4 ranked the second, while Pactol came in the last rank and this was true in both seasons of study. It is clearly appear that there were significant differences among the evaluated canola cultivars in number of branches/plant. Al-Serw 8 ranked the first in this trait which significantly surpassed both of Pactol and Al-Serw 4 in tillering ability. Results show also that Al-Serw 8 significantly surpassed the other two evaluated CVs in numbers of pods/plant and seeds/pod. However, the differences in numbers of pods/plant and seeds/pod between Pactol and Al-Serw 4 cultivars were not significant.

The statistical analysis of data listed in Table (2) revealed that the tested canola cultivars significantly varied in 1000 seed weight, harvest index and seed weight/plant. Pactol recorded the highest seed index (1000 seed weight). Al-Serw 4 and Al-Serw 8 cultivars gave the same value of 1000-seed weight, in the first and second seasons. The highest harvest index mean was observed with Pactol variety, but the lowest mean was noticed with Al-Serw 8 in both seasons. This might be due to the low biological weight of plant (biomass) in Pactol and vice versa in Al-Serw 8. Data show also that significant differences were found between canola cultivars in weight of seeds/plant in the two seasons of study. Al-Serw 8 was the highest in seed weight/plant and followed by Pactol who ranked the second. Meanwhile, Al-Serw 4 was the lowest in seed weight/plant. Seed weights/plant were 4.4, 3.8 and 4.2 g in the first season and 6.1, 5.5 and 5.6 g in the second season for Al-Serw 8, Al-Serw 4 and Pactol, respectively. Seed oil content was not markedly varied between the evaluated canola cultivars in the two seasons. However, Al-Serw 8 was the highest in seed oil content. Pactol came in the second rank in this concern while Al-Serw 4 was the lowest one, without significant differences among these cultivars in the first and second seasons. The superiority of Al-Serw8 in seed production under the study condition could be due to the increase in number of pods/plant and seeds/pod which was also stated by Abbas *et al.* (1999) and Leilah *et al.* (2002).

B: Salinity effects:

Data presented in Table (1) indicated that total plant weight (Biomass) was significantly affected by salinity concentrations. It is shown that plant weight was decreased as salinity concentrations increased and this was obvious in both seasons. Number of branches/plant was significantly affected by NaCl concentrations. The difference in number of branches/plant for plants irrigated with the tap water and that irrigated with 5 dSm^{-1} NaCl did not reach the level of significance. Increasing levels of salinity recorded an obvious decrease in branching ability. Thus, minimum number of branches/plant was observed with the highest NaCl concentration (15 dSm^{-1}). Number of pods/plant followed the same trend of number of branches/plant. The highest pods/plant (161.8 and 175.3 in the first and second seasons) were observed with the irrigation of tap water. The concentration of 5 dsm^{-1} NaCl came in the second rank, producing 150.9 and 169.6 in the first and second seasons, respectively. Data in Table (1) show a sharp reduction in number of pods/plant with increasing NaCl concentrations was observed, and this was obvious in the two seasons of study.

Data listed in Table (2) show averages of 1000-seed weight, harvest index, seed weight/plant and seed oil content in response to NaCl concentrations. 1000-seed weight significantly decreased as concentration of water salinity increased, i.e. this reduction reached its maximum with the highest salinity concentration (15 dSm^{-1}). The harvest index was significantly affected by salinity concentrations of irrigation water in the two seasons. Seed weight/plant was markedly affected by the evaluated salinity concentrations. In the first season, seed weight/plant decreased from 6.51 g in case of irrigation with the tap water to 5.42, 2.87 and 1.72 g with the irrigation water of 5, 10 and 15 dSm^{-1} NaCl, respectively. Similar trend was also noticed in the second season, where seed weigh/plant decreased from 8.6 with the irrigation of tap water to 8.2, 4.2 and 1.8 g/plant by irrigation with water having salinity concentrations of 5, 10 and 15 dSm^{-1} NaCl, respectively. The reduction in seed weight/plant with the increase of water salinity concentration might be attributed to the lower number of pods/plant, number of seeds/pod and 1000-seed weight, and it raises the possibility that most of assimilate is used for vegetative growth rather than seed filling. These results are in similar with those obtained by Noureldin *et al.* (1995). Al-Thabet (1999) came to similar observations on faba bean.

Table 1: Total plant weight (g), number of branches and pods/plant and seeds/pod as affected by canola cultivars and salinity concentrations in the first (I) and second (II) seasons.

Treatments	Plant weight (g)		Branches/ plant		Pods/plant		Seeds/pod (No)	
	I	II	I	II	I	II	I	II
A: Canola cultivars:								
Al-Serw 8	49.01	47.8	6.4	6.3	111.4	123.1	14.4	16.2
Al-Serw4	34.18	28.13	5.6	4.7	109.2	121.8	12.5	15.2
Pactol	24.33	23.13	5.7	5.4	105.7	111.9	12.0	15.1
NLSD 5%	2.50	3.50	0.5	0.7	4.7	10.6	2.0	1.0
B: Salinity concentrations:								
Tw	47.01	43.97	7.1	6.7	161.8	175.3	14.1	16.1
5 dSm^{-1}	43.01	38.50	7.2	6.5	150.9	169.6	13.8	15.9
10 dSm^{-1}	32.73	30.23	5.5	4.9	81.8	85.6	12.4	15.0
15 dSm^{-1}	20.61	19.37	3.8	3.8	40.5	46.3	11.3	14.7
NLSD 5%	2.90	4.00	0.6	0.8	5.8	9.2	1.3	1.1

Table 2: 1000-seed weight (g), harvest index, seed weight (g/plant) and seed oil content as affected by canola cultivars and salinity concentrations in the first (I) and second (II) seasons.

Treatments	1000-seed weight (g)		Harvest Index (%)		Seed weight (g/plant)		Seed oil content	
	I	II	I	II	I	II	I	II
A: Canola cultivars:								
Al-Serw 8	3.0	3.2	8.98	12.76	4.4	6.1	34.38	34.48
Al-Serw4	3.0	3.2	11.35	19.55	3.8	5.5	33.33	33.40
Pactol	3.3	3.5	17.26	24.21	4.2	5.6	33.78	34.08
NLSD 5%	0.1	0.2	1.89	2.08	0.4	0.4	N.S	N.S
B: Salinity concentrations:								
Tw	3.4	3.6	13.85	19.63	6.51	8.6	39.43	39.73
5 dSm^{-1}	3.3	3.4	12.60	21.27	5.42	8.2	37.13	36.33
10 dSm^{-1}	2.9	3.2	8.77	13.89	2.87	4.2	31.60	31.83
15 dSm^{-1}	2.8	3.0	8.35	9.29	1.72	1.8	26.00	28.03
NLSD 5%	0.2	0.2	2.32	2.71	0.30	0.4	0.78	0.89

Seed oil content was significantly decreased as salinity concentration increased. This was clear in both seasons of experiment. In the first season, seed oil content decreased from 39.43% with the irrigation by tap water to 37.13, 31.60 and 26.00 % with the irrigation by water salinity of 5, 10 and 15 dSm^{-1}, respectively. Similar trend was obvious in the second season where seed oil % decreased from 39.73 % with the irrigation by tap water to 36.33, 31.83 and 28.03 % with the irrigation by water salinity of 5, 10 and 15 dSm^{-1}. Munns and Termaat (1986) indicated that one of the factors that cause shoot growth reduction in the long term exposure to salinity is the accumulation of a large amount of salt in the shoot as a result of prolonged transpiration especially in the old leaves, which induce toxicity. This process limits the supply of assimilates to the growing regions and could be the main factor in determining canola seed yield, such effects was reported by Huang and Redmann (1995a) with canola in early seedling growth.

C: Interaction of cultivars and salinity effects:

The interaction between canola cultivars and salinity concentrations had significant effects on seed weight/plant in the two seasons (Figs 1 and 2). Maximum seed weight/plant was produced from Pactol when irrigated with the tap water. On the other hand, the lowest seed weight/plant was produced from the same cultivar (Pactol) when irrigated with the highest salinity concentration (15 dSm^{-1} NaCl). It is also appeared from Figs (1 and 2) that Al-Serw 8 CV was the best under the higher salinity concentrations (10 and 15 dSm^{-1} NaCl), which surpassed the other two examined cultivars. The superiority of Al-Serw 8 under saline conditions might be attributed to its genetical composition since this variety was breeded under saline conditions of Al-Serw Station in Eygpt.

Generally, it can be stated that increasing salinity level caused marked reduction in canola growth, seed yield and oil content. However, it was shown that canola could be successfully grown under salinity concentration of 10 dSm^{-1}. The evaluated cultivars significantly differed in growth and yield as well as in the tolerance to salinity level, expressed as growth and yield. Al-Serw 8 was more tolerant to salinity than the commercial variety (Pactol) and Al-Serw 4. Under the normal irrigation water, Pactol was the recommended, while under salinity conditions, Al-Serw 8 may be the best cultivar to be cultivated because of its tolerance to salinity.

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Fig. 1: Seed weight (g/plant) in relation to the interaction between salinity concentrations and canola CVs in the first season. Bars represent NLSD (5%)

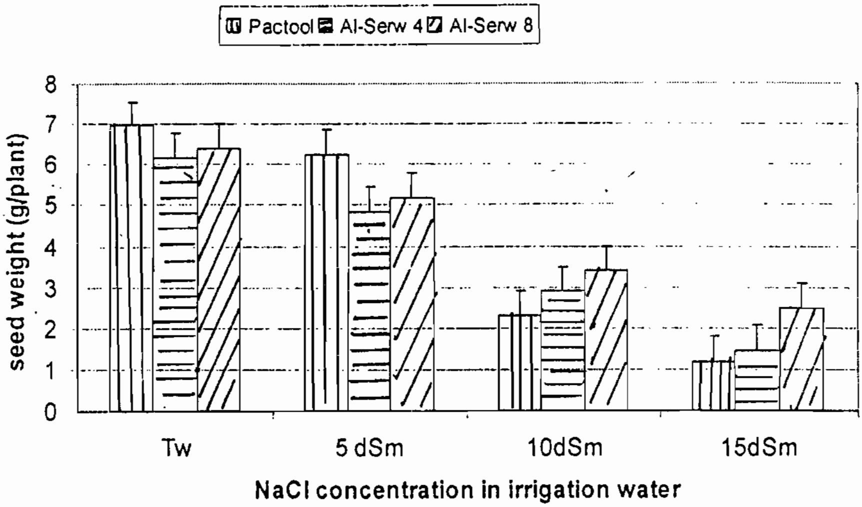
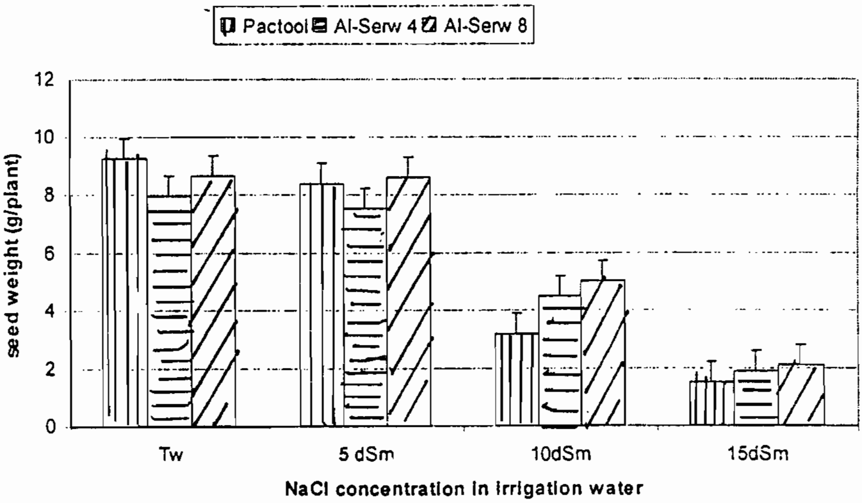


Fig. 2: Seed weight (g / plant) in relation to the interaction between salinity concentrations and canola CVs in the second season. Bars represent NLSD (5%).



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تأثير ملوحة ماء الري على نمو ومحصول الكانولا

سامي بن سعد الثابت
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أقيمت هذه الدراسة بكلية العلوم الزراعية والأغذية، جامعة الملك فيصل بالأحساء خلال الموسمين الشتويين ٢٠٠٠ / ٢٠٠١ و ٢٠٠١ / ٢٠٠٢ لدراسة تأثير تركيز الأملاح في ماء الري (٥، ١٠، ١٥ ملليموز كلوريد صوديوم بالإضافة إلى معاملة المقارنة (ماء الري العادي) على نمو ومحصول ثلاثة أصناف من الكانولا (السرو ٤ ، السرو ٨ ، باكتول). وقد نفذت الدراسة كتجربة عاملية في تصميم القطاعات الكاملة العشوائية ذو ٨ مكررات.

أفادت نتائج الدراسة وجود اختلاف معنوي بين أصناف الكانولا في درجة تحملها لتركيزات ملوحة ماء الري (معبرا عن ذلك بقياسات النمو ومحصول البذور)، حيث أشارت النتائج إلى تحمل صنف الكانولا السرو ٨ للمستويات العالية من ملوحة ماء الري نسبيا مقارنة بالسرو ٤ وباكتول. كما أشارت النتائج أن زيادة مستويات ملوحة ماء الري أدت إلى إحداث نقص واضح في الصفات المقاسة خلال موسمي الدراسة. وقد تأثر محصول النبات من البذور بالتفاعل بين أصناف الكانولا وملوحة ماء الري. ونتج أعلى محصول بذور للنبات من الصنف باكتول عندما كان يروي بالماء العادي، في حين سجل الصنف السرو ٨ أعلى محصول من البذور، مقارنة بالصنف باكتول والسرو ٤ تحت مستويات ملوحة ماء الري العالية(١٠ و ١٥ ديسمنز/م).

وعليه، توصي الدراسة بزراعة الصنف باكتول تحت ظروف التربة وماء الري العادي وزراعة الصنف السرو ٨ في حالة وجود مستويات معتدلة من الملوحة في ماء الري أو التربة.