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EFFECT OF DIFFERENT IRRIGATION INTERVALS ON GROWTH OF CANOLA (*BRASSICA NAPUS* L.) UNDER DIFFERENT SALINITY LEVELS

HUMAIRA GUL AND RAFIQ AHMAD

Biosaline Research Laboratory,
Department of Botany, University of Karachi, Karachi, Pakistan.

Abstract

Effect of different irrigation intervals on the growth of canola cv. Oscar under saline water irrigation of different sea salt concentrations was investigated. Plants were subjected to control (non-saline), 0.4 (EC 4.5 $dS.m^{-1}$) and 0.6% (EC 6.5 $dS.m^{-1}$) of sea salt concentrations. Vegetative growth was recorded in terms of plant height, number of leaves and branches, fresh and dry shoot biomass per plant, while reproductive growth was noted in terms of number of flowers and siliquae per plant; siliquae weight; seed number and weight per siliquae; seed number and weight per plant. Plant growth on vegetative as well as reproductive phases was proportionately inhibited with respect to increasing salinity in irrigation water. Vegetative and reproductive growth of the plants was much reduced under 6 days irrigation interval as compared to 2 or 4 days irrigation interval under non-saline as well as saline water irrigation.

Introduction

Rape and mustard are comparatively salt tolerant crops among oil-seeds grown at marginal soil in Pakistan. It is reported that they withstand soil salinity upto 7.9 $dS.m^{-1}$ (Gupta, 1990). *Brassica napus* (canola), a member of Brasicaceae family, is covered with more bloom than other species like *Brassica campestris* (toria or sarson). It is very late in maturity and remains green till about the middle of April. Canola has been especially developed for oil by the Canadian scientists. They have tried to reduce the amount of erucic acid in this newly bred variety. Canola oil is the lowest in saturated fat, containing only 6% saturated fat and is high in mono-saturated fat. This has 50% less saturated fat than corn oil (Weiss, 1983).

Drought and salinity are two environmental problems responsible for greater loss in agricultural productivity throughout the world (Ramagopal, 1993). Water availability is an essential factor influencing agriculture. Growth and photosynthesis are two of the most important processes suppressed, partially or completely, by water stress (Kramer & Boyer, 1995), hence both of them are major causes for limiting crop yield. Damage to plants caused by drought stress is variable depending on the level and duration of the stress and other environmental factors (Glantz, 1994). Drought in plants occur when the rate of transpiration is greater than rate of water absorption (Bray, 1997). Salt tolerance of plant must also be considered in the light of irrigation management. As soil water content decreases between irrigation, the ionic concentration in soil increases. If water becomes limiting, plant may experience matric stress as well as osmotic stress. Hoffman *et al.*, (1983) found in a three year study that yield of tall *fescue* fell significantly below that expected from salinity effects alone when matric potential was decreased. Experiments were therefore conducted to find the irrigation intervals that could give highest reproductive yield and further if there exist any difference between good quality water and saline water irrigation on this parameter.

Materials and Methods

This experiment was conducted in lysimeters (drum pot culture) which was designed by Boyko (1966) and further modified by Ahmad & Abdullah (1982). A set of 48 plastic drums was installed at cemented platform in a slightly slanting position, having a basal outlet for draining the excess amount of water. They were filled with 300 kg of coastal sand in each, capable of retaining 45 L of water at saturation. Any additional amount of water was easily leached out from the drainage outlet. The practice of over-irrigation avoided salt accumulation in the rhizosphere.

Experiment was divided into three sets.

i- First set of drums was irrigated with 10 L irrigation water at an interval of 2 days.
ii- Second set of drums was irrigated with 10 L irrigation water at an interval of 4 days.
iii- Third set of drums was irrigated with 10 L irrigation water at an interval of 6 days.

Out of 36, 12 drums were used in each set. Four drums of each set were subjected to the following three irrigation treatments, i) control (non-saline), ii) 0.4% (E.C 4.5 $dS.m^{-1}$) and iii) 0.6% (E.C 6.5 $dS.m^{-1}$) sea salt concentrations. Since germination of canola under saline conditions was found poor, seeds were directly sown in drum pots using non-saline water. Irrigation with water of different sea salt concentrations was started when the plants were of three-leaf stage. Three plants were kept in each drum.

Plant were harvested at three stages:

i) At the beginning of saline water irrigation.
ii) At grand period of growth.
iii) At final harvest.

Plant height was recorded at regular fortnight interval while leaf area and fresh and dry biomass was recorded in harvested plants. Relative growth rate (RGR) was calculated as outlined by Hunt (1982). Shoot/root ratio was calculated and expressed on dry weight basis at grand period of growth. Number of flowers and siliquae were recorded weekly. Siliquae weight, siliquae length, seed number and weight per siliquae, seed number and weight per plant recorded at the termination of experiment. A total number of flowers shed per plant was calculated as the difference between total flowers and siliquae per plant and expressed as the percentage of total flowers produced per plant.

Statistical analysis of the data was carried out as outlined by Little & Hills (1975) and Gomez & Gomez (1976). Data were analyzed using a computer program Costat 3.03. Mean separation of data was carried out using Duncan Multiple Range test (Duncan, 1955).

Results and Discussion

Vegetative growth: Fortnightly growth of cv. Oscar in terms of height as affected by irrigation water of different salinity levels and irrigation intervals exhibited significant ($P<0.001$) decrease in height with increase of salinity level in all irrigation intervals

(Fig. 1). At the end of experiment (12th fortnight) with reference to irrigation intervals, maximum height was found in control plants under 6 days irrigation interval. Whereas control plants irrigated at 4 and 2 days intervals occupied 2nd and 3rd position. In the 0.4% salinity treated plants the maximum height was obtained under 4 days irrigation interval whereas among the 0.6% salinity treated plants maximum height was found under 2 days irrigation interval at the end of the experiment. Stunted growth of canola under saline conditions is also confirmed by many workers (Francois, 1994; Ashraf & Sarwar, 2002). Growth of plant depends on cell expansion and enlargement which is probably most sensitive physiological aspect of a plant to water deficit leading to reducing plant productivity (Larson, 1992), which ultimately affect plant height. Phenolic compounds produced in plants during water stress also respond to reduce plant growth (Lyu & Blum, 1990; Blum *et al.*, 1991; Einhelling & Souza, 1992).

Curves for relative growth rate (RGR) calculated for plant height showed variation during different irrigation intervals (Fig. 1). In 2 days irrigation interval all plants irrespective to treatments showed high growth rate at 7th fortnight period which declines by 9th growth period in control and 0.4% salinity level and by 10th fortnight period in 0.6% salinity level. In 4 days irrigation interval higher rate was showed in control during 7th fortnight, 0.4% salinity treated plants showed high rate during 5th and 8th fortnight while 0.6% salinity treated plants showed high values in 7th, 8th and 9th fortnight. In 6 days irrigation interval control and 0.4% salinity treated plants showed maximum rate during 5th fortnight while 0.6% salinity treated plants showed it during 7th fortnight. Statistical analysis showed significant differences ($P<0.001$) of RGR with time, while it was non-significant with salinity and irrigation intervals.

Growth of plants in terms of shoot biomass production irrigated with water of different salinity levels and under different irrigation intervals showed significant reduction in fresh ($P<0.05$) and dry ($P<0.001$) shoot biomass in both the different irrigation interval and salinity levels (Fig. 2). Fresh shoot biomass at final harvest under non-saline as well as under saline conditions was high in 2 days irrigation interval than that of 4 and 6 days irrigation intervals. Dry shoot biomass showed significant decrease with increase in salinity levels. Reduction in dry matter with increased salt concentration in the rhizosphere was observed by Papadopoulos & Rending (1983) in tomato, Cooms & Pratt (1988) in *Phaseolus* species, Pessarakli & Huber (1991) in barley and tomato, Gill (1987) in alfalfa and Reddy & Vora (1983) in bajra.

Leaf area significantly ($P<0.001$) increased during second harvest in all salinity levels as well as different irrigation intervals (Fig. 3). It decreased with increase in salinity levels as compared to their respective control. There was not much difference in leaf area between 2 and 4 days irrigation interval under various salinity levels but under 6 days irrigation interval it was considerably reduced. Salinity induced osmotic stress is considered responsible for the reduced leaf area in canola and wild mustard (Huang & Redmann, 1995). It is now well accepted that osmotic adjustment plays a crucial role in plant adaptation to drought (Turner & Jones, 1980; Quisenberry, 1982).

Results for shoot/root ratio on dry weight basis of plants exhibited variation in values under various treatments over control in different harvests as well as in different irrigation intervals (Table 1). Variation in values in different harvest periods was significant at $P<0.001$ level while variation in values with salinity and irrigation intervals was non-significant. Plants subjected to severe droughts usually did not regain their full capacity to absorb water until several days after the soil is wetted (Kramer, 1980, 1983).

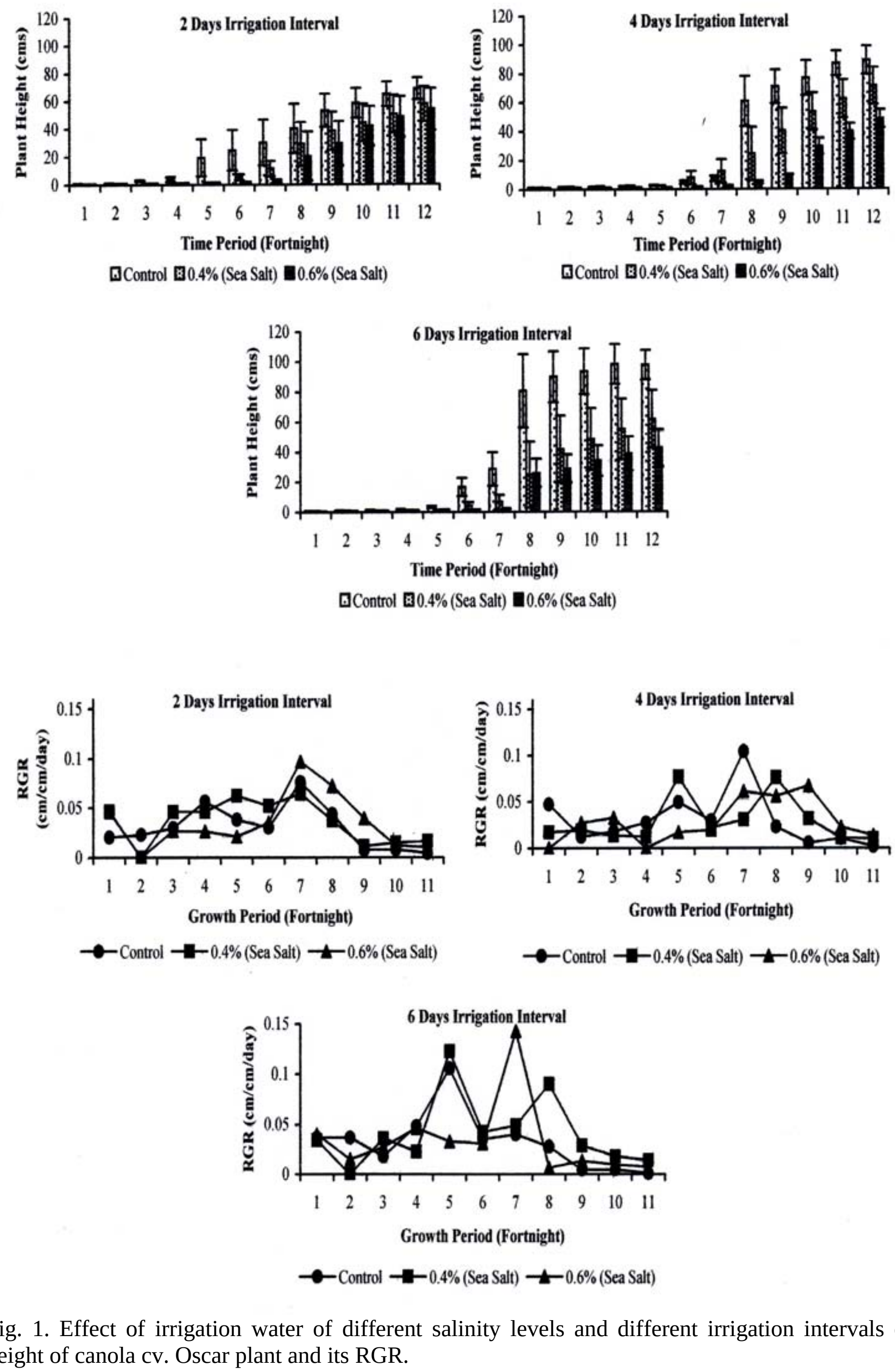
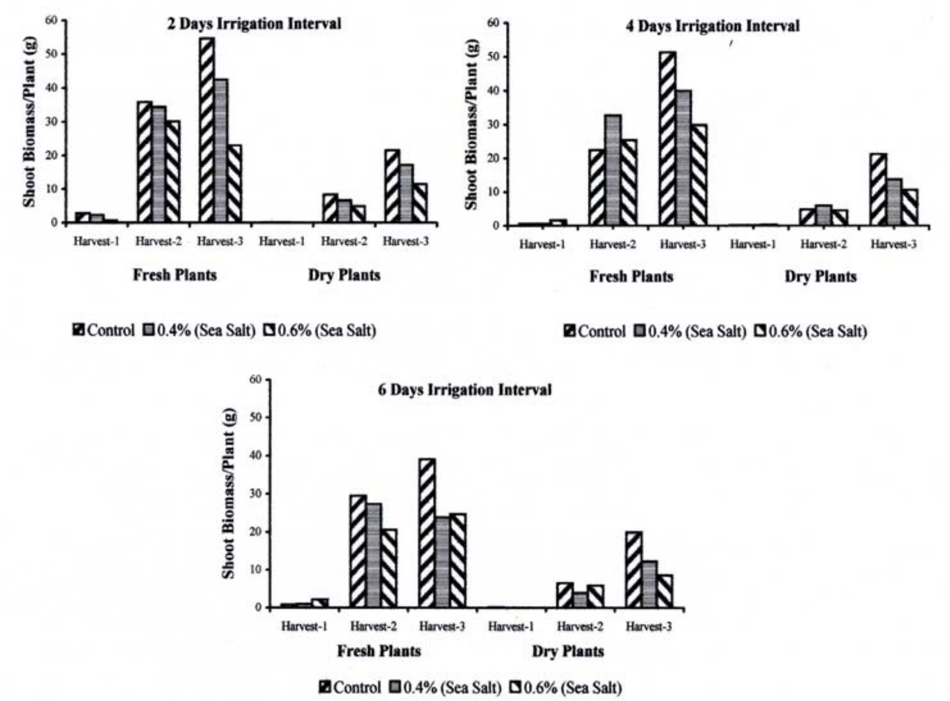
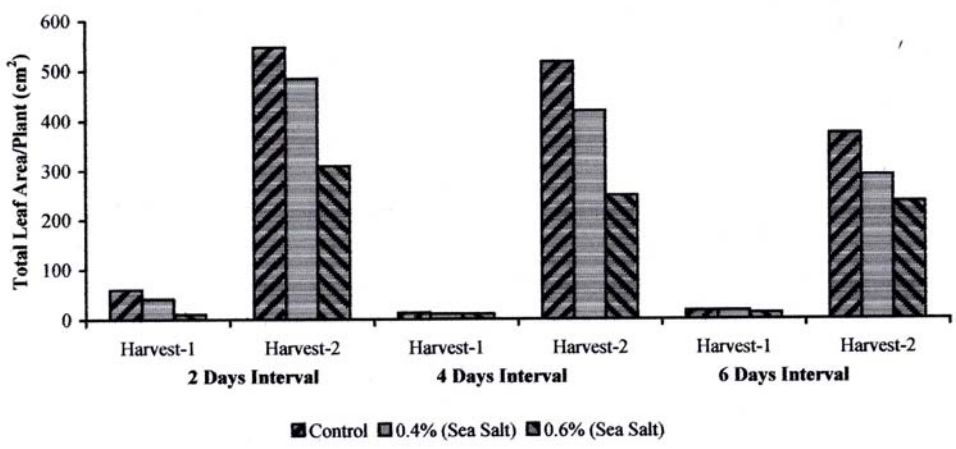


Fig. 1. Effect of irrigation water of different salinity levels and different irrigation intervals on height of canola cv. Oscar plant and its RGR.



H1: First Harvest **H2**: Second Harvest **H3**: Third Harvest

Fig. 2. Effect of irrigation water of different salinity levels and different irrigation intervals on shoot biomass (fresh & dry) of canola cv. Oscar.



H1: First Harvest **H2**: Second Harvest

Fig. 3. Effect of irrigation water of different salinity levels and different irrigation intervals on total leaf area per plant of canola cv. Oscar.

Table 1. Effect of irrigation water of different salinity levels on shoot/root ratio in Canola var. Oscar irrigated at different intervals.

Treatment	2 Days irrigation interval			4 Days irrigation interval			6 Days irrigation interval		
	Shoot Dry Wt (g)	Root Dry Wt (g)	Shoot / Root	Shoot Dry Wt (g)	Root Dry Wt (g)	Shoot / Root	Shoot Dry Wt (g)	Root Dry Wt (g)	Shoot / Root (g)
Control	35.871 a	8.287 a	4.769 a	26.393 a	7.411 a	3.538 a	29.547 a	11.817 a	3.459 a
	±16.056	±4.466	±0.576	±4.06	±0.700	±0.380	±13.397	±7.138	±0.759
0.4% (S.S)	34.360 a	7.883 a	5.506 a	32.699 a	5.838 ab	6.971 a	27.319 a	5.845 a	6.527 a
	±7.156	±2.422	±1.64	±1.561	±1.407	±2.242	±3.306	±2.668	±1.397
	(-4.212)	(-4.881)	(+15.448)	(+23.893)	(-21.223)	(+97.020)	(-7.541)	(-50.541)	(+88.663)
0.6% (S.S)	30.169 a	4.523 a	6.695 a	20.207 a	2.727 b	14.095 a	20.611 a	6.051 a	4.423 a
	±2.412	±0.251	±0.539	±5.372	±1.558	±6.538	±4.361	±1.923	±1.297
	(-15.895)	(-45.417)	(+40.397)	(-23.438)	(-63.200)	(+298.353)	(-30.243)	(-48.791)	(+27.847)
$LSD_{0.05}$	35.518	9.622	4.532	21.035	4.533	12.723	26.731	14.517	3.79

Means followed by different letters in the same column differ significantly at 95% probability level according to New Duncan's Multiple Range Test.
Figures in parentheses indicate % promotion (+) and reduction (-) over control.
S.S= Sea Salt

Reproductive growth: Plants irrigated with different salinity levels exhibited significant ($P<0.001$) decrease in different reproductive parameters as compared to non-saline control, while irrigation intervals exhibited significant ($P<0.001$) differences in these parameters over control even under saline conditions (Fig. 4). The seed weight per plant under non-saline water irrigation of 2 and 4 days intervals was almost same, whereas under 6 days irrigation interval it was significantly reduced. The same situation prevailed under irrigation with 0.4 and 0.6% sea salt dilution. It appears that considerable amount of water is depleted from root zone by leaching and evapo-transpiration during this interval. However, reduction in yield due to saline water irrigation over non-saline water is evident. Reduction in the yield may be due to cumulative effect of various factors like decline in number of flowers, pod setting (Bishnoi *et al.*, 1990; Sharma, 1992), decrease in seeds per pod and seed weight (Kumar *et al.*, 1980). Growth and yield of different crops is adversely affected by high level of salinity e.g., cotton (Mohiuddin, 1998) and wheat (Salam *et al.*, 1999).

Differences in number of flowers shed in different salinity treatment was non significant while in different irrigation intervals it was significant at $P<0.01$ level when statistically analyzed. Flower shedding percentage exhibited increase with increase in salinity treatment as compared to control and in irrigation interval (Table 2). Plants irrigated with 0.6% salinity level at the interval of 6 days showed highest shedding percentage (53%) while in rest of the treatments in other irrigation intervals it was between 20-35%.

Electrical conductivity of irrigation water, leachate and soil

Electrical conductivity of irrigation water, leachate and soil of plants irrigated with different salinity levels at different irrigation intervals exhibited that EC of leachate gradually increase with time at all irrigation intervals (Table 3). At 6 days irrigation interval EC of leachate at different salinity levels was greater than that of 2 and 4 days irrigation intervals. EC of soil had slight increase with time but remained low as compared to irrigation water. The presence of sodium in irrigation water increases the exchangeable sodium in the colloidal system of the soil. This results in the deterioration of soil physical properties and affect the plant growth and productivity (El- Saidi, 1997). There was slight change in the pH values in different salinity levels and different irrigation intervals.

Conclusion

The pattern of comparative reproductive yield (in terms of seed weight per plant) in Canola cv. Oscar during the 2 and 4 days irrigation interval was almost same under non-saline as well as saline water irrigation, whereas irrigation interval of 6 days depleted soil moisture of root zone below field capacity and as a result the yield was considerably low in both under non-saline and saline water irrigation. Hence it is the shortage of water that is to start with reducing the growth whereas exposure to saline water causes additional growth inhibition. Hence interval of 4 days seems to be sufficient for obtaining maximum yield under both the non-saline and saline water irrigation in soil of sandy texture.

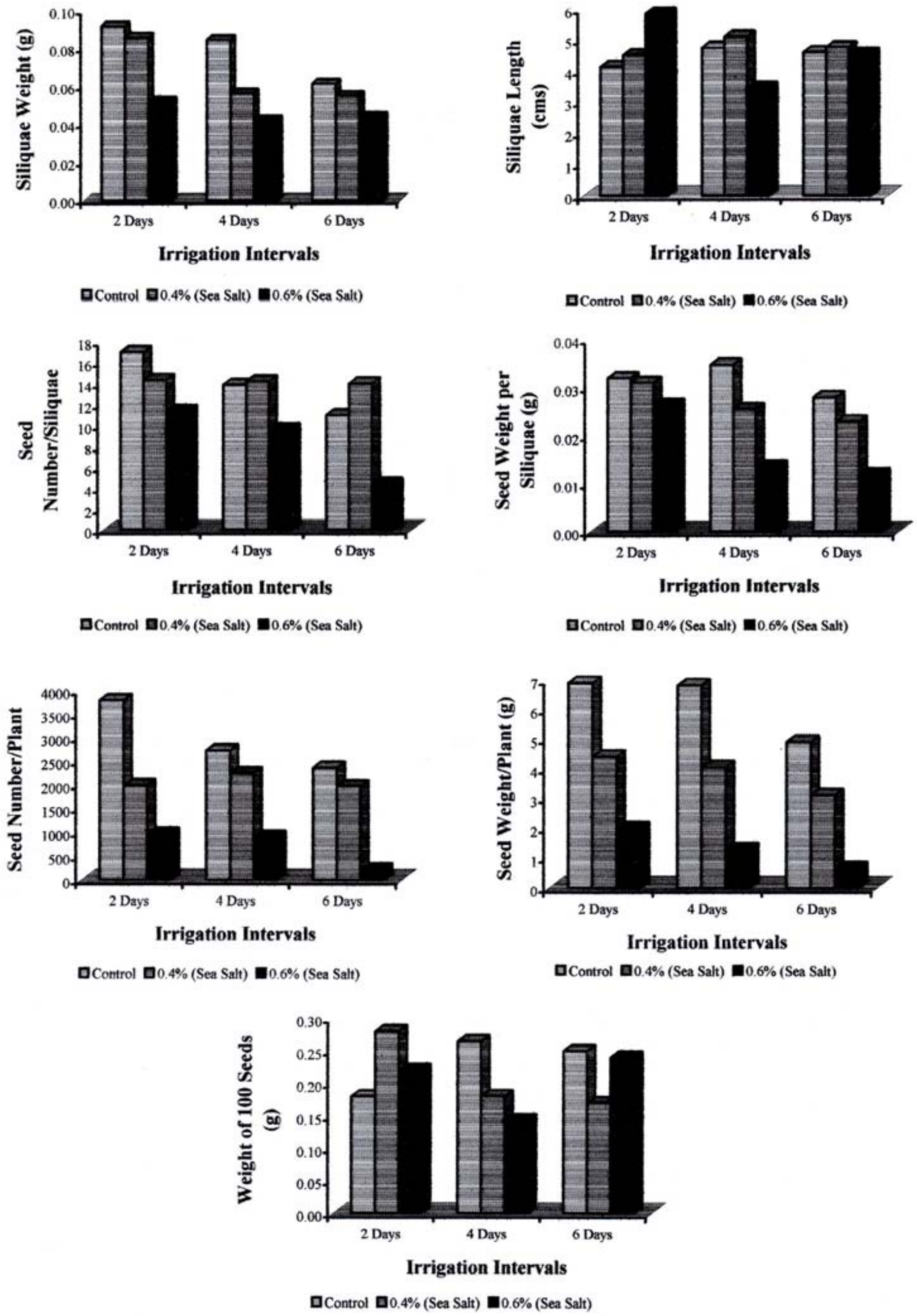


Fig. 4. Effect of irrigation water of different salinity levels and different irrigation intervals on various reproductive parameters of canola cv. Oscar.

Table 2. Effect of irrigation water of different salinity levels on total flowers, pods and flowers shed per plant in canola cv. Oscar irrigated at different irrigation intervals.

Treatment	2 Days irrigation interval				4 Days irrigation interval				6 Days irrigation interval			
	A	B	C	D	A	B	C	D	A	B	C	D
Control	254.500 a	209.750 a	44.750 a	18 a	244.250 a	191.500 a	52.750 a	22 b	218.000 a	160.000 a	58.000 a	27 b
	±13.344	±13.199	±2.428		±7.972	±6.487	±4.19		±17.449	±14.427	±3.628	
0.4% (S.S)	197.000 b	146.000 b	51.000 a	26 a	205.000 b	154.750 a	50.250 a	25 b	183.000 a	127.500 a	55.500 a	31 b
	±15.947	±13.114	±5.131		±8.346	±7.11	±3.52		±12.489	±13.105	±1.322	
	(-22.593)	(-30.393)	(+13.966)		(-16.070)	(-19.191)	(-4.739)		(-16.055)	(-20.313)	(-4.310)	
0.6% (S.S)	137.500 b	104.250 b	33.250 a	24 a	134.750 c	89.000 a	45.750 a	34 a	98.000 b	47.500 b	50.500 a	53 a
	±10.315	±7.909	±4.497		±3.35	±4.813	±3.119		±17.573	±10.874	±6.763	
	(-45.972)	(-50.298)	(-25.698)		(-44.831)	(-53.525)	(-13.270)		(-55.046)	(-70.313)	(-12.931)	
$LSD_{0.05}$	98.383	75.141	26.324	13.174	22.199	19.877	11.636	6.044	51.231	41.225	14.386	7.516

Means followed by different letters in the same column differ significantly at 95% probability level according to New Duncan's Multiple Range Test.
Figures in parentheses indicate % promotion (+) and reduction (-) over control.
S.S= Sea Salt
A= Total flowers per plant
B= Total siliquae per plant
C= Total flower shed per plant
D= Flower shedding (%)

Table 3. Electrical conductivity and pH values of irrigation water, leachate and soil as a result of salt accumulation during saline water irrigation of different salinity levels.

2 Days Interval						
Treatment	**Beginning of saline water irrigation**					
	Irrigation water		**Leachate**		**Soil**	
	EC ($dS.m^{-1}$)	**pH**	**EC ($dS.m^{-1}$)**	**pH**	**EC ($dS.m^{-1}$)**	**pH**
Control	0.475 c	7.333 a	0.700 b	7.288 a	0.700 c	7.550 a
	± 0.047	± 0.118	± 0.091	± 0.065	± 0.091	± 0.095
0.4% (S.S)	4.625 b	7.450 a	5.675 a	7.375 a	1.825 b	7.675 a
	± 0.175	± 0.064	± 2.003	± 0.085	± 0.085	± 0.066
0.6% (S.S)	6.325 a	7.363 a	4.450 ab	7.575 a	2.750 a	7.425 a
	± 0.268	± 0.104	± 0.86	± 0.214	± 0.119	± 0.072
$LSD_{0.05}$	0.599	0.315	4.031	0.443	0.318	0.252
	Grand period of growth					
Control	0.425 c	7.725 a	0.700 c	6.988 b	0.825 c	7.238 b
	± 0.024	± 0.032	± 0.091	± 0.031	± 0.165	± 0.065
0.4% (S.S)	4.650 b	6.775 b	8.625 b	6.925 ab	1.725 b	7.463 a
	± 0.202	± 0.43	± 0.686	± 0.11	± 0.11	± 0.042
0.6% (S.S)	6.700 a	6.588 b	11.525 a	7.463 a	2.875 a	7.425 ab
	± 0.173	± 0.068	± 0.919	± 0.071	± 0.094	± 0.082
$LSD_{0.05}$	0.493	0.807	2.125	0.383	0.406	0.21
	Termination of experiment					
Control	0.400 c	7.263 a	0.800 b	7.263 a	0.725 b	7.550 a
	0	± 0.023	± 0.182	± 0.08	± 0.11	± 0.234
0.4% (S.S)	4.375 b	7.288 a	10.925 a	7.388 a	1.750 b	7.913 a
	± 0.16	± 0.023	± 2.468	± 0.051	± 0.119	± 0.32
0.6% (S.S)	6.575 a	7.225 a	12.875 a	7.463 a	3.075 a	7.463 a
	± 0.143	± 0.087	± 1.847	± 0.139	± 0.537	± 0.338
$LSD_{0.05}$	0.397	0.173	5.705	0.311	1.037	0.963

Table 3. (Cont'd.)

4 Days Interval						
Treatment	**Beginning of saline water irrigation**					
	Irrigation water		**Leachate**		**Soil**	
	EC ($dS.m^{-1}$)	**pH**	**EC ($dS.m^{-1}$)**	**pH**	**EC ($dS.m^{-1}$)**	**pH**
Control	0.425 c	7.463 a	0.850 b	7.688 a	0.775 b	7.598 a
	± 0.024	± 0.08	± 0.272	± 0.15	± 0.193	± 0.184
0.4% (S.S)	4.700 b	7.350 a	1.525 a	7.413 a	1.350 b	7.128 b
	± 0.158	± 0.106	± 0.17	± 0.062	± 0.086	± 0.05
0.6% (S.S)	6.925 a	7.450 a	1.550 a	7.338 a	2.625 a	7.113 b
	± 0.143	± 0.108	± 0.086	± 0.1	± 0.554	± 0.051
$LSD_{0.05}$	0.397	0.316	0.614	0.353	1.095	0.359
	Grand period of growth					
Control	0.400 c	7.225 a	0.850 c	7.413 a	0.950 b	7.613 a
	0	± 0.126	± 0.064	± 0.082	± 0.064	± 0.4
0.4% (S.S)	4.950 b	7.613 a	8.275 b	7.213 a	1.750 b	7.700 a
	± 0.272	± 0.18	± 0.062	± 0.129	± 0.189	± 0.237
0.6% (S.S)	6.775 a	7.338 a	12.050 a	7.338 a	3.250 a	7.538 a
	± 0.131	± 0.082	± 0.306	± 0.129	± 0.433	± 0.221
$LSD_{0.05}$	0.558	0.435	0.59	0.371	0.88	0.952
	Termination of experiment					
Control	0.400 c	7.288 a	0.825 c	7.383 a	0.975 b	7.575 a
	0	± 0.116	± 0.062	± 0.217	± 0.165	± 0.247
0.4% (S.S)	4.925 b	7.663 a	8.000 b	7.425 a	1.625 b	7.650 a
	± 0.11	± 0.224	± 0.264	± 0.194	± 0.131	± 0.221
0.6% (S.S)	6.950 a	7.225 a	12.950 a	7.388 a	3.025 a	7.300 a
	± 0.306	± 0.092	± 0.906	± 0.25	± 0.466	± 0.25
$LSD_{0.05}$	0.602	0.497	1.755	0.71	0.945	0.768

Table 3. (Cont'd.)

6 Days Interval						
Treatment	**Beginning of saline water irrigation**					
	Irrigation water		**Leachate**		**Soil**	
	EC (dS.m^{-1})	**pH**	**EC (dS.m^{-1})**	**pH**	**EC (dS.m^{-1})**	**pH**
Control	0.425 c	7.688 a	1.100 b	7.250 a	1.000 c	7.650 a
	± 0.024	± 0.206	± 0.158	± 0.185	± 0.108	± 0.237
0.4% (S.S)	5.000 b	7.338 a	3.900 a	7.425 a	1.675 b	7.488 a
	± 0.500	± 0.197	± 0.743	± 0.187	± 0.103	± 0.139
0.6% (S.S)	6.950 a	7.375 a	3.950 a	7.525 a	2.625 a	7.475 a
	± 0.132	± 0.208	± 0.997	± 0.185	± 0.225	± 0.052
$LSD_{0.05}$	0.956	0.653	2.316	0.596	0.498	0.516
	Grand period of growth					
Control	0.425 c	7.450 a	0.925 b	7.238 a	1.100 c	7.395 a
	± 0.024	± 0.106	± 0.047	± 0.062	± 0.147	± 0.093
0.4% (S.S)	4.700 b	7.425 a	16.750 a	7.363 a	2.350 b	7.338 a
	±0.204	±0.123	±2.668	±0.031	±0.457	±0.023
0.6% (S.S)	6.825 a	7.488 a	17.600 a	7.300 a	3.775 a	7.313 a
	± 0.154	± 0.074	± 1.18	± 0.07	± 0.317	± 0.071
$LSD_{0.05}$	0.475	0.33	5.39	0.183	1.063	0.222
	Termination of experiment					
Control	0.450 c	7.575 a	1.100 b	7.688 a	1.025 b	7.525 a
	± 0.028	± 0.183	± 0.091	± 0.087	± 0.094	± 0.052
0.4% (S.S)	4.550 b	7.338 a	19.350 a	7.438 a	1.700 b	7.388 a
	± 0.028	± 0.114	± 4.453	± 0.239	± 0.091	± 0.171
0.6% (S.S)	6.600 a	7.200 a	17.125 a	7.238 a	3.275 a	7.163 a
	± 0.168	± 0.079	± 1.349	± 0.062	± 0.46	± 0.085
$LSD_{0.05}$	0.319	0.424	8.597	0.484	0.885	0.374

Means followed by different letters in the same column differ significantly at 95% probability level according to New Duncan's Multiple Range Test.

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