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EFFECT OF DIFFERENT SOWING DATES ON THE VEGETATIVE AND REPRODUCTIVE GROWTH OF CANOLA (*BRASSICA NAPUS* L.) CULTIVARS UNDER DIFFERENT SALINITY LEVELS

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Abstract

Effect of sowing date was investigated on the growth of canola (*Brassica napus* L.) cv. Oscar and Rainbow under saline water irrigation of different sea salt concentrations. Plants were sown at different dates and 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, fresh and dry shoot biomass per plant, while reproductive growth was noted in terms of number of flowers and siliquae seed number and weight per plant. Plant growth on vegetative as well as reproductive phases was found proportionately inhibited with respect of increasing salinity in irrigation water.

As far as proper sowing time of Canola in Sind is concerned, the cv. Oscar sown from mid September to late October gave equally good yield in terms of seed weight per plant under non-saline conditions whereas yield in cv. Rainbow sown early (2^{nd} week of September) was much reduced and the seeds sown during late September till early October gave comparatively better yield. Both of these cultivars when sown on above-mentioned dates and irrigated with different sea salt dilutions showed more or less same pattern of comparative yield as that of good quality water irrigation, though the amount of seed formation per plant was reduced according to the degree of salinization. The yield obtained from the seeds sown in the month of November was considerably reduced in both the cultivars. Maximum temperature has been 36 ^{0}C, minimum 24 ^{0}C and relative humidity 46% during the month of October which appears to be best season for growing Canola.

Introduction

Salinity is a general problem and of special concern in countries with low rainfall and hot temperatures like Pakistan. Such countries have high standard of irrigation practices and the farmers try to get the maximum production from irrigation water. Total estimated population of Pakistan is about 1.5 million and it will be doubled by 2020 (Qureshi & Barrett-Lennard, 1998). Increase in the human population of the world demands an increase in food production where as land deterioration is causing a significant amount of decrease in yield. Irrigated agriculture contributes significantly toward meeting world food and fiber needs but at the same time faces problem of limited water supplies. Saline water irrigation can often be used successfully without hazardous effects to crop or soils under adoption of new crop and water management strategies. Use of saline water for irrigation provides compromising solution in conventional irrigation with good economic feasibility (Ahmad *et al*., 1986).

The production of edible oil in Pakistan is much below our domestic requirements and this shortage is a constant drain on our resources. Rape and mustard occupies the maximum area among oil seed crops grown in Pakistan (Beg, Naazar 1982). During 1994-95 total area occupied by rapeseed and mustard in Pakistan was 0.3 million hectares

with a total production of 0.2294 million tons. Canola especially has been developed for oil by Canadian scientists. They have tried to reduce the amount of erucic acid in this newly bred variety. This crop is considered to be capable of growing under relatively harsh conditions. Its cultivation lately encouraged by the Pakistan Government is now cultivated on an area of 8 Lac acres. This crop grows successfully on rain and canal irrigated areas.

Environmental factors greatly affect plant growth and yield. Sowing date is an important determinant of crop yield. Sowing date depends on the onset of significant rainfall, temperature and humidity of a region. Decreasing crop yield in delayed sowing date has been reported by many workers (Kohn & Storrier, 1970, Doly & Marcellos, 1974; Degenhardt & Kondra, 1981; McDonald *et al*., 1983). Experiments were carried out to study the effect f different sowing dates on the vegetative and reproductive growth of canola (*Brassica napus* L.) cultivars viz., Oscar and Rainbow under different salinity levels.

Materials and Methods

Clay pots containing approximately 3 Kg soil each were lined inside with plastic sheets and having a basal outlet for drainage. Two cvs., of Canola viz., Oscar and Rainbow were used in this experiment. Five sets of 30 pots each, comprising of three treatments and divided into 10 pots for each treatment were used for each cultivar. Seeds were sown on the following dates:
1st set on15th September 2001 (D1).
2nd set on 29th September 2001 (D2).
3rd set on13th October 2001 (D3).
4th set on 27th October 2001 (D4).
5th set on10th November 2001 (D5).

Three seeds of each cultivar were sown in clay pots filled with non-saline soil and irrigated with tap water. Seedlings were thinned to one per pot after 20 days prior to starting saline water irrigation. Out of 30 pots kept for each set, 10 replicates were maintained per treatment, 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. Concentration of sea salt was gradually increased in irrigation water till it reached to the desired salinity of each treatment. Each pot was irrigated with 1.5L of tap water / salt solution twice a week.

Mean temperature and humidity during September, October and November 2001 were as follows:

Months	Max. Temp	Min. Temp.	Humidity
September	33°C	26°C	60%
October	36°C	24°C	46%
November	33°C	19°C	31%

Plant height was recorded fortnightly, whereas leaf area, fresh and dry biomass were recorded in harvested plants. Number of flowers and siliquae were recorded weekly. Seed number and weight per plant were recorded at the termination of the experiment. Total flower 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 computer program Costat 3.03. Mean separation of data was carried out using Duncan Multiple Range test (Duncan, 1955).

Results and Discussion

Vegetative growth: Growth is an end result between anabolic and catabolic reactions. The growth of plant was ulimately reduced by salinity, although plant species vary in salt concentration they can tolerate before growth is impaired (Greenway & Munns, 1980; Munns, 1993; Iyengar & Reddy, 1994, 1997; Shannon & Nobel, 1995). Fortnightly measurements of growth in terms of height in Oscar and Rainbow sown at different time periods and irrigated with different levels of sea salt solution exhibited significant reduction ($p<0.001$) in all sets sown at different dates in both cultivars as compared to their respective control (Figs. 1 & 2). These findings established that salinity causes stunted growth in glycophytes (Robinson *et al*., 1983; Seemann & Chritchley, 1985). Cvs. Oscar and Rainbow sown at 27th October 2000 showed maximum height in comparison with other dates of sowing under control as well as high salinity level. It appears that prevailing maximum temperature 36^{o}C and minimum temperature 24^{o}C with 46% R.H is most suitable for providing growth stimulus. Improvement in growth even under saline conditions was also evident in seeds sown at above-mentioned dates.

Biomass production is a measure of net photosynthesis and factors limiting plant growth that limits net photosynthesis (Reddy *et al*., 1997). Growth of plants sown at different time periods and irrigated with different salinity levels in terms of shoot biomass exhibited significant ($p<0.001$) reduction in fresh and dry shoot biomass as compared to control in all sowing dates in both cultivars (Fig. 3). Cvs. Oscar and Rainbow sown on 27th October 2000 produced maximum fresh and dry shoot biomass under non-saline water irrigation but when subjected to saline water irrigation it exhibited reduction in fresh weight by 58 and 47% and dry weight by 57 and 49%. Dry matter production which is considered an index of photosynthetic activity (Danks *et al*., 1983; Lawlor, 1987) was reduced.

Leaf area is a good indicator of water and salinity stress, since leaf expansion generally requires a high turgor pressure for cell enlargement (Krieg, 1983). Total area of leaves produced per plant sown at different time periods and irrigated with different salinity levels exhibited significant ($p<0.001$) reduction in leaf area as compared to non-saline control in all plants (Fig. 4). Plants of cv. Oscar sown on 13th October 2000 and Rainbow sown on 27th October 2000 gave better growth performance in terms of leaf area. It is now well accepted that osmotic adjustment plays a crucial role in plant adaptation to drought (Turner & Jones, 1980; Quisenberry, 1982). Salinity induced osmotic stress is considered responsible for the reduced leaf area in Canola and wild mustard (Huang & Redmann, 1995).

Reproductive growth: Reduction in reproductive growth could be cumulative effect of various factors such as decline in number of flowers (Bishnoi *et al*., 1990; Sharma, 1992). Faulty development of pollen grain and ovules is a result of improper fertilization and denature embryo, reduction in number of pods per plant and seeds per pod, production of shrived seeds etc., (Kumar *et al*., 1980).

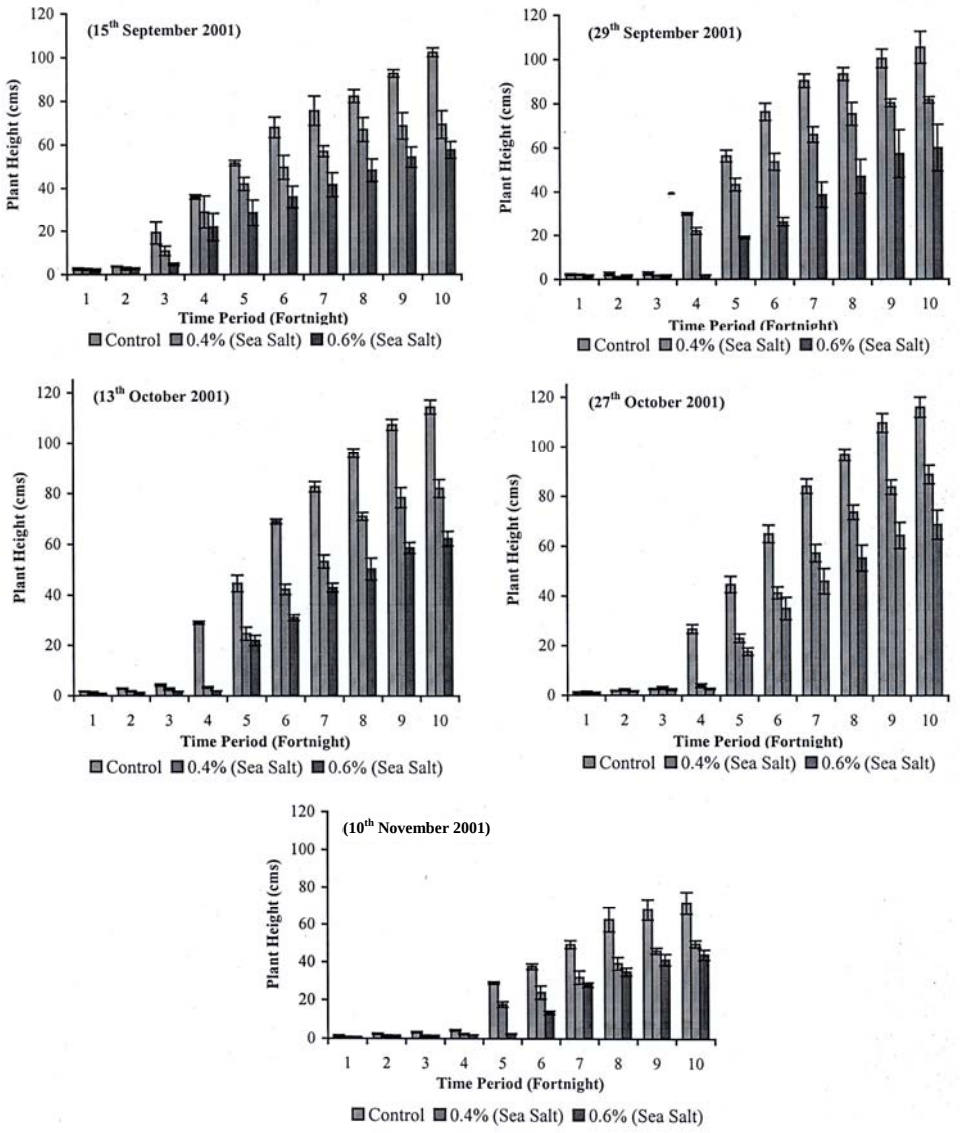

Fig. 1. Effect of irrigation water of different salinity levels on plant height in Canola cv. Oscar sown at difeerent dates.

Weekly study of number of flowers and siliquae in plants sown at different time periods and irrigated with different salinity levels exhibited significant ($p<0.001$) reduction in flower and siliquae production as compared to control at all sowing dates in both cultivars (Table 1). Francois (1994) found pod reduction in Canola grown under saline condition. Shereen *et al*., (2002) also observed reduction in fertility and yield in rice (*Oryza sativa* L.) under salinity, which correspond with the findings of others (Khatun & Flowers, 1995; Khatun *et al*., 1995; Mohiuddin *et al*., 1998).

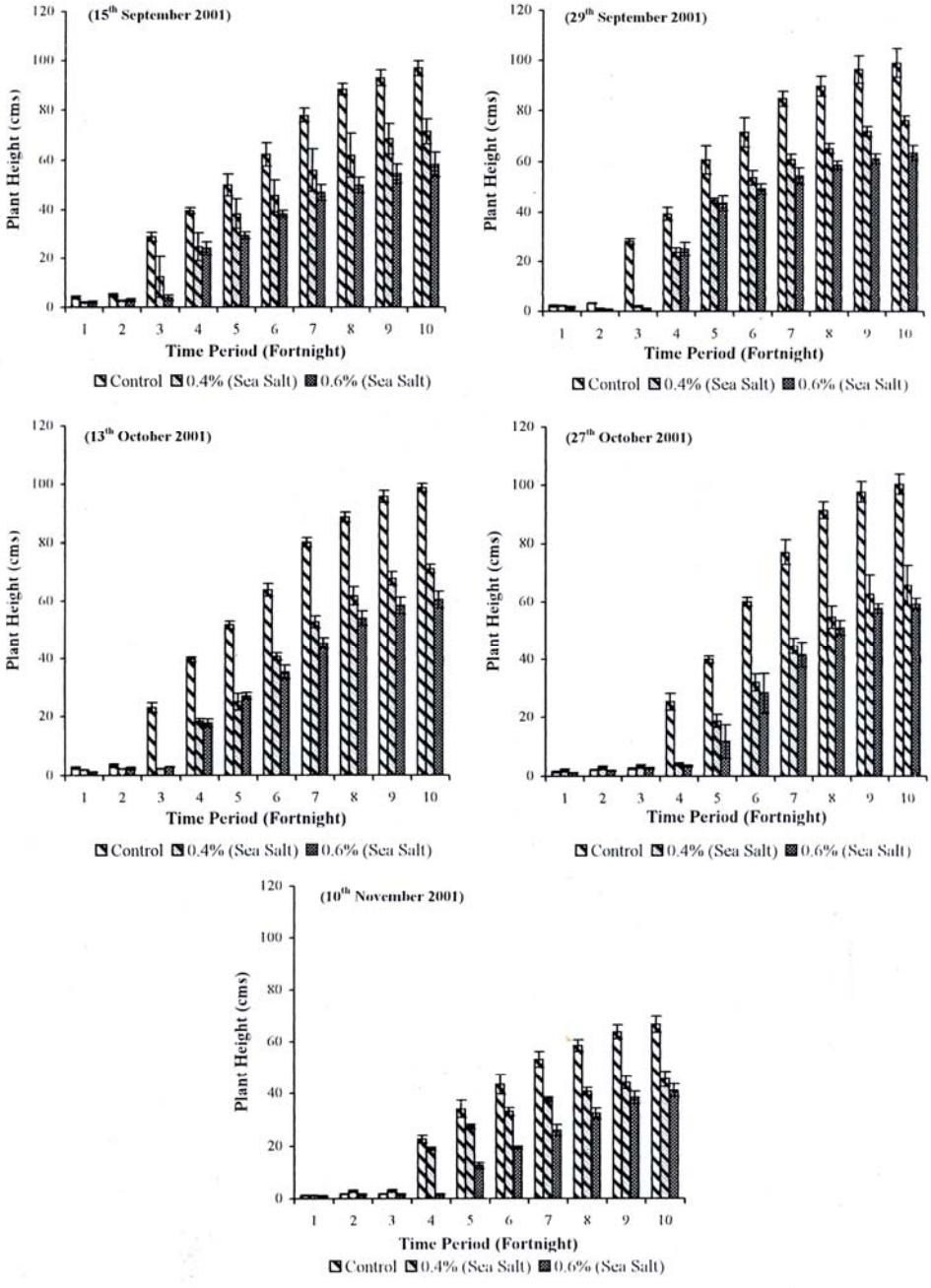

Fig. 2. Effect of irrigation water of different salinity levels on plant height in Canola cv. Rainbow sown at difeerent dates.

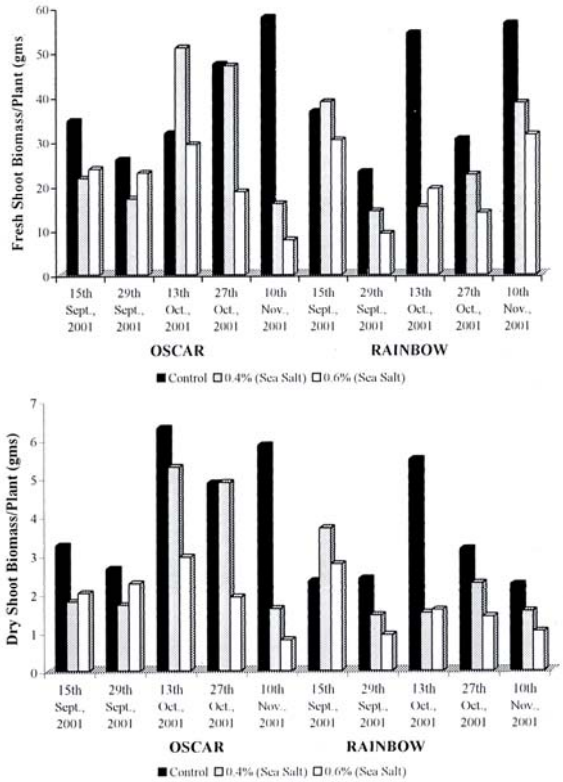

Fig. 3. Effect of irrigation water of different salinity levels on shoot biomass per plant (fresh and dry) in Canola cvs. Oscar and Rainbow sown at different dates.
Set-1: 15th Sept. 2001, **Set-2**: 29th Sept. 2001, **Set-3**: 13th Oct. 2001, **Set-4**: 27th Oct. 2001, **Set-5**: 10th Nov. 2001.
H1: First Harvest **H2**: Second Harvest

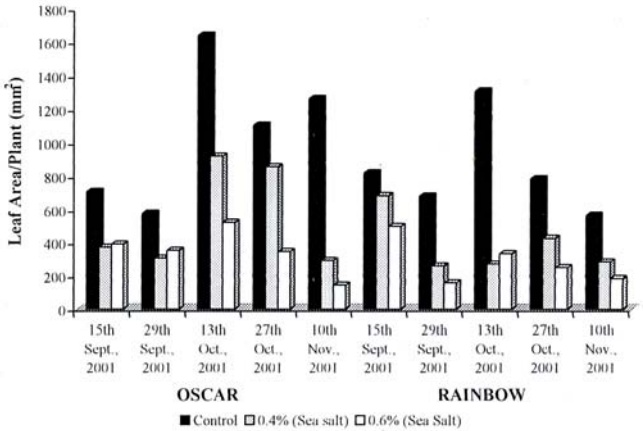

Fig. 4. Effect of irrigation water of different salinity levels on total leaf area per plant in Canola cvs. Oscar and Rainbow sown at different dates.
Set-1: 15th Sept. 2001, **Set-2**: 29th Sept. 2001, **Set-3**: 13th Oct. 2001, **Set-4**: 27th Oct. 2001, **Set-5**: 10th Nov. 2001.
H1: First Harvest **H2**: Second Harvest

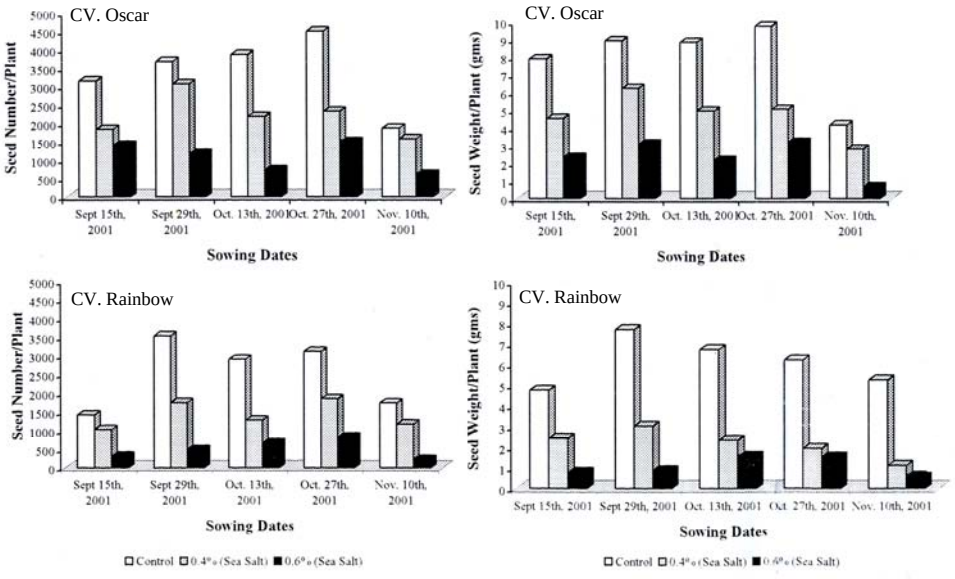

Fig. 5. Effect of irrigation water of different salinity levels on seed number and weight per plant in Canola cvs. Oscar and Rainbow sown at different dates.

Total flowers shed in plants sown at different time periods and irrigated with different levels of salinity showed highly significant ($p<0.05$) values in salinity treated plants as compared to their respective control in all sowing dates of both cultivars (Table 1). Increased production of flowers alone does not help in achieving high yield both in terms of number of fruits or seeds (Dhingra & Varghese, 1997). A good early vegetative growth carry plants earlier to reproductive phase and provides sufficient photosynthate for developing fruits. Some time flower formed towards fag end of season do not set fruit as early formed fruits exercise inhibitory effects on late formed flowers (Huff & Dybing, 1980).

Study of the seed number and weight per plant in plants sown at different time periods and irrigated with different salinity levels exhibited significant ($p<0.001$) reduction in saline treated plants as compared to their respective control in all sowing dates in both the canola cultivars (Fig. 5). Comparing the different treatments of different sowing dates in both cultivars exhibited maximum seed number and weight per plant in cv. Oscar sown on 27th October in control as well as high salinity level. In cv. Rainbow plants sown on 29th September in control while in high salinity sown on 27th October exhibited maximum yield in terms of seed number and weight per plant. There were non-significant differences between the reproductive yield of cv. Oscar sown in the months of September and October whereas that of November was considerably reduced. This could be due to change in climate towards colder side and reduction in relative humidity. Low yield in canola under delay in sowing in the present study was positively correlated with the results of other workers (Taylor *et al*., 1991). Growth and yield of different crops is adversely affected by high levels of salinity e.g., cotton (Ahmad *et al*., 1995; Ahmad *et al*., 2002) and wheat (Akhtar *et al*., 1994).

Table 1. Effect of irrigation water of different salinity levels on total flowers, siliquae and flowers shed per plant in canola cvs. Oscar and Rainbow sown at different dates.

Treatment	Oscar				Rainbow			
	Total flowers per plant	Total pods per plant	Total flowers shed per plant	Flower shedding (%)	Total flowers per plant	Total pods per plant	Total flowers shed per plant	Flower shedding (%)
15th September 2001 (Set-1)								
Control	370.000 a ±8.504	204.333 a ±2.036	165.667 a ±8.002	45 b	344.000 a ±9.134	162.667 a ±3.686	181.333 a ±5.59	53 b
0.2% (S.S)								
EC_{iw} (2.5dS/m)	287.667 b ±6.677 (-22.251)	148.000 b ±2.962 (-27.558)	139.667 a ±4.598 (-15.633)	48 b	210.667 b ±6.379 (-38.758)	80.667 b ±1.71 (-50.408)	130.000 b ±8.082 (-28.337)	61 ab
0.4% (S.S)								
EC_{iw} (4.5 dS/m)	209.000 c ±2.185 (-43.513)	90.333 c ±1.895 (-55.732)	118.667 a ±3.656 (-28.351)	57 a	149.667 c ±5.965 (-56.431)	52.667 c ±1.018 (-67.621)	97.000 b ±5.859 (-46.506)	64 a
$LSD_{0.05}$	**38.175**	**14.064**	**663.182**	**6.387**	**43.736**	**14.499**	**39.595**	**8.759**
29th September 2001 (Set-2)								
Control	412.000 a ±15.62	230.667 a ±5.679	181.333 a ±11.057	44 a	366.333 a ±5.315	198.667 a ±2.219	167.667 a ±4.167	46 b
0.2% (S.S)								
EC_{iw} (2.5 dS/m)	338.333 b ±5.21 (-17.831)	184.333 b ±4.167 (-20.039)	154.000 a ±1.154 (-15.071)	46 a	218.667 b ±4.822 (-40.307)	97.667 b ±2.036 (-50.838)	121.000 b ±2.905 (-27.834)	55 a
0.4% (S.S)								
EC_{iw} (4.5 dS/m)	215.333 c ±8.63 (-47.735)	109.000 c ±3 (-52.746)	106.333 b ±6.669 (-41.351)	49 a	166.000 c ±6.691 (-54.635)	68.333 c ±3.716 (-65.606)	97.667 c ±3.656 (-41.748)	59 a
$LSD_{0.05}$	**64.333**	**26.496**	**44.862**	**6.456**	**33.957**	**16.555**	**16.555**	**4.565**
13th October 2001 (Set-3)								
Control	409.667 a ±0.838	250.667 a ±3.469	159.000 a ±3.464	39 c	370.333 a ±4.764	204.333 a ±2.673	166.000 a ±2.309	45 b
0.2% (S.S)								
EC_{iw} (2.5 dS/m)	309.000 b ±1.763 (-24.273)	168.333 b ±1.018 (-32.847)	140.667 a ±2.775 (-11.538)	46 b	215.667 b ±9.008 (-41.752)	102.333 b ±2.364 (-49.919)	113.333 b ±7.026 (-31.738)	52 a
0.4% (S.S)								
EC_{iw} (4.5 dS/m)	199.667 c ±5.738 (-51.250)	89.000 c ±2.848 (-64.435)	110.667 b ±3.288 (-30.336)	55 a	167.667 c ±1.071 (-54.734)	77.667 c ±0.838 (-61.937)	90.000 b ±1.527 (-45.733)	54 a
$LSD_{0.05}$	**20.975**	**15.927**	**19.116**	**4.264**	**35.943**	**12.688**	**26.134**	**4.848**

Table 1. (Cont'd.).

Treatment	Oscar				Rainbow			
	Total flowers per plant	Total pods per plant	Total flowers shed per plant	Flower shedding (%)	Total flowers per plant	Total pods per plant	Total flowers shed per plant	Flower shedding (%)
27th October 2001 (Set-4)								
Control	444.333 a ±1.644	265.333 a ±3.338	179.000 a ±3.785	40 b	349.000 a ±2.962	206.000 a ±4.582	143.000 a ±2.603	41 b
0.2% (S.S)								
EC_{iw} (2.5 dS/m)	301.000 b ±6.359 (-32.257)	179.333 b ±2.036 (-32.412)	121.667 b ±4.438 (-32.037)	40 b	254.000 b ±6.429 (-27.230)	122.333 b ±3.006 (-40.616)	131.667 a ±3.906 (-36.032)	52 a
0.4% (S.S)								
EC_{iw} (4.5 dS/m)	231.333 c ±6.938 (-47.937)	123.000 c ±4.176 (-53.534)	108.333 b ±2.987 (-39.430)	47 a	194.333 c ±5.834 (-44.318)	91.667 c ±1.018 (-55.500)	102.667 b ±6.834 (-28.302)	52 a
$LSD_{0.05}$	**33.064**	**19.8**	**22.681**	**4.565**	**31.743**	**19.29**	**28.69**	**8.019**
10th November 2001 (Set-5)								
Control	340.000 a ±3.785	174.000 a ±2.645	166.000 a ±2.516	49 b	290.333 a ±7.632	140.000 a ±2.333	150.333 a ±6.167	52 b
0.2% (S.S)								
EC_{iw} (2.5 dS/m)	261.667 b ±4.22 (-23.038)	130.000 b ±3.179 (-25.237)	131.667 b ±1.539 (-20.630)	50 b	167.000 b ±6.429 (-42.479)	64.000 b ±2.403 (-54.235)	103.000 b ±7.055 (-31.434)	61 a
0.4% (S.S)								
EC_{iw} (4.5 dS/m)	184.667 c ±3.532 (-45.635)	69.333 c ±2.714 (-60.155)	115.333 c ±1.835 (-30.534)	63 a	123.000 c ±2.666 (-57.634)	45.667 c ±2.457 (-67.378)	77.333 b ±0.838 (-48.559)	63 a
$LSD_{0.05}$	**23.117**	**17.121**	**12.024**	**4.315**	**35.745**	**14.376**	**32.557**	**8.58**

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

Table 2. Electrical conductivity and pH values of soil as a result of salt accumulation during saline water irrigation of different salinity levels in canola cvs. Oscar and Rainbow.

Treatment	Oscar		Rainbow	
	EC (dS/m)	pH	EC (dS/m)	pH
Control	1.233 c ±0.145	7.300 a ±0.029	0.967 c ±0.088	7.050 a ±0.05
0.40%	4.100 b ±0.208	7.567 a ±0.109	4.833 b ±0.549	7.367 a ±0.192
0.60%	7.333 a ±0.219	7.550 a ±0.104	7.667 a ±0.273	7.117 a ±0.06
$LSD_{0.05}$	**0.669**	**0.309**	**1.236**	**0.414**

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

Changes in soil characteristics: Changes in electrical conductivity and pH of soil at different stages of growth being irrigated with different salinity levels are presented in Table 2. Electrical conductivity of the soil increased with the increase in salinity levels of irrigation water in all sowing dates of both cultivars. 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 affects the plant growth and productivity (El-Saidi, 1997). There appears to be some increase in ECe value due to irrigation with saline water upto grand period of growth (about 3 months duration) which has been brought down during subsequent irrigation. The pH of the soil exhibited slight difference in all salinity levels at all sowing dates of both cultivars.

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