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Effect of Salinity on some Growth Parameters of Cultivated Sunflower under Saline Conditions

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ABSTRACT

Analysis on some growth parameters experiments were conducted on two sunflower (*Helianthus annuus* L.) cultivars FH-1 and FH-6, grown in pots lined with polyethylene bags. Twenty days after germination, salinity levels were created by the addition of NaCl of EC_e 3.0, 4.5 and 6.0 dS m^{-1}. Growth parameters such as relative growth rate, relative increase in leaf area and relative increase in plant height were suppressed at all salinity levels.

Key Words: Sunflower; Salinity; Growth analysis

INTRODUCTION

Salinity has seriously limited crop production on about 20 million hectares of the world's cultivated land (EL-Ashry *et al.*, 1985). In Pakistan, salinization started at the end of 19th century and is responsible for seriously affecting the economy by limiting crop productivity to a large extent over vast irrigated areas of Pakistan.

Saline soils contain sufficient salts to impair the growth of the crop plants. Changes in the plant behavior induced by salinity have been found in water up take and water balance, gas exchange, transpiration, photosynthesis and respiration, optical properties of leaves, ion uptake, metabolic pathways, growth morphology and anatomy of the plant and balance of hormones (Poljakoff-Mayber & Gale, 1975).

Sunflower possesses some genetic potential to grow in low to moderately salt affected areas with a threshold level of EC_e 2.5 dS m^{-1} (Fenster *et al.*, 1976; Heikal *et al.*, 1980). Seed yield has been found to start decreasing beyond EC_e 2.5 dS m^{-1} and reach to 30% losses at EC_e 11.3 dS m^{-1}, but 49.21% seed yield losses at EC 10 dS m^{-1} have also been reported (Hussain & Rehman, 1992).

Salinity caused reduction in oil content (Muhammad & Makhdum, 1973), plant dry matter, achene and oil yield (Cheng, 1984), leaf area expansion (Rawson & Munns, 1984), plant height, leaf area and number (Rehman & Hussain, 1998). Quereghi *et al.* (1991) reported greater reduction in shoot length and biomass as compared to not parameters, while Hussain and Ismail 1994) reported reduction in relative growth rate in to parent NaCl solution.

Growth analysis involves the quantitative studies of the performance of plants or plant components, integrated both throughout the system and across ecologically and agronomically at meaningful intervals of time. Growth analysis is a useful tool for elucidating the response of the plant to various cultural, fertilizer and environmental conditions in which the plant grows. The present research was planned to furnish knowledge about the effect of salinity on some growth parameters of sunflower under saline condition and deals with plant height, leaf area and dry matter production per unit time under varying salinity environments.

MATERIALS AND METHODS

The experiment was conducted in the wire house of Botanical Garden, University of Agriculture, Faisalabad in spring 1998. Experiment was carried out in pots lined with polythene bags. Field soil was mixed with sand, homogenized and then air-dried. Seed of sunflower cultivars FH-1 and FH-6 were obtained from Ayub Agricultural Research Institute, Faisalabad.

Sowing was done on February 28, 1998. Eighty pots lined with polythene bags were filled with 10 kg soil. Five seeds were sown in each pot. Tap water was used for normal irrigation. Seed germination started on 12th March, 1998. After two weeks of germination three plants were kept in each pot for further observations. Pots were arranged in a Completely Randomized Design. The experiment comprised of four treatments and ten replications.

Preparation of saline solution. Four salinity levels were developed after 20 days of seed germination (four leaf stage). Salinity at EC levels of 3.0, 4.5 and 6.0 dS m^{-1} were developed by using NaCl solution. Normal soil having EC 1.5 dS m^{-1} without addition of salt was taken as control.

Growth studies. These studies were started on the completion of development of salinity levels. Four harvests were taken at an interval of 10 days each. Three

plants from each treatment were randomly taken from each variety. Plants were removed washed and brought to laboratory for the study of following parameters.

Relative increase in plant height/day. Plant height was measured in centimeters from soil surface (stem base) to the base of capitulum (tip of plant) with a meter stick for each plant in each harvest and means were calculated. Total plant height as well as relative increase in plant height/day were recorded.

From the values of above mentioned parameters the following calculations were made using formula proposed by Radford (1967).

$$\frac{\text{Log}_e L_1 - \log_e L_2}{T_2 - T_1} \text{ cm/day}$$

Where

L_1 = Initial of preceding plant

L_2 = Plant height of following harvest

Statistical analysis were conducted for analysis of variance technique (Steel & Torrie, 1980) and various treatments were compared by applying Duncan's new Multiple range test.

Relative increase in leaf area/day. For the estimation of leaf area, the product of maximum length and maximum width was multiplied with constant factor K (0.75).

$$\text{Total leaf area} = \text{Maximum length} \times \text{maxium width} \times 0.75$$

The leaf area of all the leaves of a plant was calculated and then mean per plant was calculated. Total leaf area as well as relative increase in leaf area per day were recorded.

Relative increase in leaf area was calculated by the formula.

$$\text{RLA} = \frac{\text{Log}_e A_2 - \log_e A_1}{T_2 - T_1} \text{ cm}^2\text{/day}$$

Where

A_1 = Initial leaf area (cm^2)

A_2 = Leaf area after `t' days

Relative growth rate. Fresh plants were kept in kraft paper bag and dried in an oven at 70°C for 48 hours. Then oven dry weight of plants was recorded in grams by using analytical balance. Dry weight of the plants as well as relative growth rate was recorded for dry weight of each harvest.

$$\text{RGR} = \frac{\text{Log}_e W_2 - \log_e W_1}{T_2 - T_1} \text{ g/day}$$

Where

W_1 = Initial dry weight (g)

W_2 = Dry weight after `t' days (time interval between two harvest)

T_1 = Days of preceding harvest

T_2 = Days of following harvest

RESULTS AND DISCUSSION

Relative increase in plant height per day. Data about relative increase in plant height (cm) are presented in Table I. Both varieties i.e. FH-1 and FH-6 did not show large variation between themselves. Plant height increased across the harvest from Ist harvest to 4th harvest, but plant height decreased in each harvest as salinity levels increased.

In Ist harvest both the varieties indicated almost same trend towards salinity stress. The maximum increase in plant height per day in V_1 (FH-1) was 0.044 cm while minimum plant height was 0.011. At 6 dS m^{-1} with 75% decrease over control due to the highest application of salts. A decrease of 18.18% was noted at 4.5 dS m^{-1}, while at 3.0 dS m^{-1} the relative increase was same as that of control. In V_2 (FH-6) the results were same as that of V_1 (FH-1). In 2nd harvest large differences were observed between two varieties. The

Table I. Relative increase/decrease in plant height (cm)

V_1				V_2			
T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
1.5 dS m^{-1}	3.0 dS m^{-1}	4.5 dS m^{-1}	6.0 dS m^{-1}	1.5 dS m^{-1}	3.0 dS m^{-1}	4.5 dS m^{-1}	6.0 dS m^{-1}
2nd - Ist Harvest							
0.044	0.044	0.036	0.011	0.044	0.036	0.034	0.002
%decrease over control	0.00	18.18	75	-	18.18	22.72	95.45
3rd - 2st Harvest							
.067	0.021	0.016	0.013	0.015	0.013	0.006	0.005
%decrease over control	68.65	76.11	80.59	-	13.33	60.00	66.66
4th - 3rd Harvest							
0.091	0.089	0.085	0.081	0.089	0.088	0.082	0.056
%decrease over control	2.19	6.59	10.98	-	1.12	7.86	37.07

maximum increase in plant height was noted in V_1 (FH-1) than V_2 (FH-6). Maximum plant height (0.067) was observed at 1.5 dS m^{-1} while minimum (0.013) was noted at 6 dS m^{-1} with 80.59% decrease over control. Plant height at 3 dS m^{-1} and 4.5 dS m^{-1} showed 68.65 and 76.11% decrease over control.

In 3rd harvest both varieties showed an increase in plant height as compared to 2nd harvest but both the varieties showed same results with minor differences. Maximum plant height was 0.091 and 0.089 cm, respectively in V_1 (FH-1) and V_2 (FH-1) at 1.5 dS m^{-1} (control). Maximum decrease of 10.98 and 37.07% in plant height over control was noted at 6 dS m^{-1} in both varieties, respectively due to high salt stress.

Relative increase in leaf area per day. Relative increase in leaf area per day is presented in Table II. Maximum increase in leaf area was found during harvest interval 2-1 than gradually decreased up to harvest intrerval 4-3, suggesting that plants shifted their activity towards reproductive growth. A trend of gradual decrease in leaf area with increasing salinity levels was observed in each harvest.

During harvest interval 2-1 in V_1 (FH-1) maximum value (0.105 cm^2) was noted in T_0 (control) and minimum value (0.019 cm^2) was found in T_3 (6 dS m^{-1}) with 81.90% decrease over control. Leaf area under T_1 (3 dS m^{-1}) and T_2 (4.5 dS m^{-1}) showed 60.00% and 71.42% reduction, respectively indicating a gradual decrease from control. In case of V_2 (FH-6) similar trend was observed with a maximum value of 0.092 cm^2 in T_0 (1.5 dS m^{-1}). In T_3 (6 dS m^{-1}) leaf area decreased by 14.13%. The area under T_1 (3 dS m^{-1}) had not shown any difference with respect to control showing non-significant effect of salinity, but T_2 showed 2.17% decrease over control.

In time interval of harvest 3-2, V_1 (FH-1) showed its maximum value (0.073 cm^2) under T_1 (3 dS m^{-1}) showing 35% increase were control and minimum value of 0.055 cm^2 under 6 dS m^{-1} with 19.11% decrease compared to control (0.068 cm^2). In V_2 (FH-2) maximum leaf area (0.072 cm^2) was observed under T_0 with 38.88% decrease over control in T_3 (6.0 dS m^{-1}). T_1 and T_2 showed 12.5 and 31.94% decrease respectively over control.

In V_1 maximum value (0.029cm^2) was observed in 4-3 harvest was under T_0 (1.5 dS m^{-1}). The treatments, T_1, T_2 and T_3 had 6.89, 24.13 and 89.65%, decrease, respectively over control showing that as the salinity

Table II. Relative increase/decrease in leaf area (cm^2)

V_1				V_2			
T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
1.5 dS m^{-1}	3.0 dS m^{-1}	4.5 dS m^{-1}	6.0 dS m^{-1}	1.5 dS m^{-1}	3.0 dS m^{-1}	4.5 dS m^{-1}	6.0 dS m^{-1}
2nd - Ist Harvest							
0.105	0.042	0.030	0.019	0.092	0.092	0.090	0.079
% decrease over control	60.00	71.42	81.90	-	0.00	2.17	14.13
3rd - 2st Harvest							
0.068	0.073	0.063	0.055	0.072	0.063	0.049	0.044
% increase over control	+7.35	7.35	19.11	-	12.5	31.94	38.88
4th - 3rd Harvest							
0.029	.027	0.022	0.003	0.051	0.041	0.027	0.009
% decrease over control	6.89	24.13	89.65	-	19.60	47.05	82.35

Table III. Relative growth rate

V_1				V_2			
T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
1.5 dS m^{-1}	3.0 dS m^{-1}	4.5 dS m^{-1}	6.0 dS m^{-1}	1.5 dS m^{-1}	3.0 dS m^{-1}	4.5 dS m^{-1}	6.0 dS m^{-1}
2nd - Ist Harvest							
0.062	0.054	0.050	0.039	0.082	0.057	0.054	0.051
% decrease over control	12.90	19.35	37.09		30.48	34.14	37.80
3rd - 2st Harvest							
0.106	0.097	0.069	0.055	0.092	0.080	0.065	0.065
% decrease over control	8.49	34.90	48.11		13.04	29.34	29.34
4th - 3rd Harvest							
0.143	0.137	0.115	0.120	0.143	.112	0.120	0.088
% decrease over control	4.19	19.58	16.08		21.67	16.08	38.46

increased, the leaf area decreased. Same trend was found in V_2 with maximum value of 0.051 at 1.5 dS m^{-1}. The treatments had T_1, T_2 and T_3 19.60, 47.05 and 82.35% decrease respectively over control showing that increased salinity levels had decreasing effect on the leaf area.

Relative growth rate. The values of relative growth rate are given in Table III. The highest growth rate was observed at harvest interval 4-3. A decreasing trend in growth rate in various harvest intervals was noted from T_0 - T_3 and it was due to increasing salinity levels.

In harvest interval 2-1 maximum value (0.062 g) was recorded in T_0 of V_1 (FH-1) where as minimum (0.039 g) was noted in T_3, T_1 and T_2 showed 12.90 and 19.35% decrease over control. A regular decrease of 0.057, 0.054 and 0.051 g was observed under T_1, T_2 and T_3, respectively with 30.48, 34.14 and 37.80% decrease respectively over control.

During harvest interval of 3-2 maximum value (0.106 g) observed in T_0 of V_1 while minimum value (0.055 g) in T_3, while T_1 and T_2 have 8.49 and 34.90 percent, decrease, respectively over control. In V_2, maximum value (0.092 g) was observed under control, whereas, all other treatments caused a decrease in relative growth rate.

Between the time interval of 3rd and 4th harvest V_1 showed a maximum value (0.143 g) in T_0 and a minimum value (0.120 g) in T_3, T_1 and T_2 exhibited less values 0.13 and 0.115 g, respectively. In V_2 the maximum value (0.143 g) was in T_0, while minimum value (0.688 g) was in T_3 with 38.46 percent decrease over control. T_1 and T_2 showed 21.67 and 16.08%, decrease, respectively over control.

CONCLUSION

Plant height increased across the harvests from Ist harvest to 4th harvest but decreased in each harvest as salinity levels increased. A trend of gradual decrease in leaf area with increasing salinity levels was observed n each harvest. Maximum increase in leaf area was found during harvest interval 2-1 than gradually decreased upto harvest interval 4-3. Similarly, a decrease in relative growth rate in various harvests was recorded for dry matter production.

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