INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2004/06–1–149–152
http://www.ijab.org

Effect of Salinity on Seedling Emergence and Growth of Sunflower (*Helianthus annuus* L.) Cultivars

HAKAN TURHAN AND CAVIT AYAZ†
Field Crops Department, Agricultural Faculty, Canakkale Onsekiz Mart University, 17020, Canakkale, Turkey
†*Department of Horticulture, Agricultural Faculty, Canakkale Onsekiz Mart University, 17020, Canakkale, Turkey*
Corresponding author's E-mail: hturhan@comu.edu.tr

ABSTRACT

In this study, response of three sunflower cultivars (Dolunay, Edirne-87 and Turkuaz) to seven NaCl concentrations (0, 0.25, 0.50, 0.75 1.00, 1.25 ve 1.50%) was investigated. The study was evaluated in two steps, seedling emergence and growth. The results showed that salinity caused a delay in both seed germination and emergence. At higher NaCl concentrations, no seed emergence was observed. In the second step, after thinning seedlings and leaving one plant in each pot, the plants were kept for three weeks. The results indicated that growth of all the cultivars was decreased with increasing NaCl concentrations. At 0.50% NaCl and higher concentrations, reduction in plant growth was more dramatic. In conclusion, this method can be a practical salinity screening approach for reducing plant material prior to field experiments.

Key Words: Salt Stress; Sunflower; Germination; Seedling Growth; Screening

INTRODUCTION

Soil salinity is one of the most severe environmental stresses and affects crop production in arid and semi-arid lands. The salinity problem in arid and semi-arid regions is more serious than that in other areas. An increasing proportion of the world's food supply is produced in semi-arid regions with irrigation (Shannon *et al*., 1994) and the reductions in production of agricultural crops in these areas sometimes reach up to 50% because of salinity problems (McWilliams, 1986; Evengelou, 1994).

One of the commercially important agricultural crops is sunflower which is grown in irrigated and non-irrigated semi-arid regions in Turkey and most of the world. About 60% vegetable oil consumption of Turkey is met from sunflower; the rest is obtained from olive, cottonseed, and soybean, and sesame seed. Thus, sunflower has a significant importance in agriculture of Turkey. However, in some areas, sunflower production faces salinity problem, especially in basins.

Many investigations for screening aspects on a range of crops' development under *in vitro* and *in vivo* conditions have been carried out to determine the responses to salinity or drought stress (Lynch & Tai, 1989; Haverkkort *et al*., 1990; Levy, 1992). Screening of sunflower or other crops plays a crucial role in breeding programmes for inducing salinity tolerance. According to a classification based on water stress day index, sunflower was determined as a moderately sensitive crop to salinity (Katarji *et al*., 2003). There has been variation in response of sunflower genotypes to salinity (Ashraf & Tufail, 1995; Muralidharudu *et al*., 1999). For economical production in saline soils, it is important that many commercially released sunflower cultivars require to be tested for salinity using a rapid reliable screening method. As a result, in terms of either development of salt tolerant plants or determination of suitable salt tolerant crops for a region, selection and evaluation of salt tolerance of plants has a preliminary importance. Therefore, the aim of this study was to evaluate effect of different NaCl levels on seed germination and emergence, and to develop a rapid and easy salt screening method for sunflower prior to field trials.

MATERIALS AND METHODS

The study was carried out using three hybrid sunflower (*Helianthus annuus* L.) cultivars, Turkuaz, Dolunay and Edirne-87 which are widely grown in Canakkale Region, Turkey. Monthly average temperature during growing period in 2001 was 14.0, 16.6 and 20.9 ºC for April, May and June, respectively. In addition, monthly average relative humidity was 84.8, 77.2 and 72.2% for April, May and June, respectively.

The pot size was 6˝ deep and they were filled in with 2.2 kg soil which consisted of a mixture of sand, peat compost and field soil in 1:1:1 ratio. Prior to the experiment, the amount of water held by soils was calculated from the difference between dry and wet soil weight. After determination of field capacity, the salt treatments (0, 0.25, 0.50, 0.75, 1.00, 1.25 and 1.50% NaCl) were determined by using amount of water held by soils (Naik & Widholm, 1993). Salt solutions at different NaCl concentrations were prepared by dissolving NaCl in deionised water that was also used during whole experimental period.

After adjusting all pots to field capacity, 10 seeds per pot with a tray beneath were sown in April, which was the sunflower planting time of the region. Although the experiment was conducted in open field, while it was raining, the pots were covered with a transparent plastic shed (not touching the plants). In the rest of time, they were kept open in order to minimize the shedding effect.

The seedlings were counted every day during 10 days for determination of seedling emergence percentage after a week from sowing. The plants were then thinned and one healthy plant left for each pot. All the treatments were subsequently supplied with deionised water to keep the moisture of soil at about field capacity.

After four weeks from sowing date, plant height (cm), number of leaves per plant, leaf fresh weight, stem fresh weight, shoot fresh weight, root fresh weight, leaf dry weight, stem dry weight, shoot dry weight and root dry weight were determined. For root fresh weight, after removing soil from roots in water, they were kept for an hour between paper towels to remove excess water and then weighed. For dry weights, these were kept at 90 ºC for 48 h in an oven and immediately weighed.

The experimental design was randomized block factorial design with four replications. Treatments were not fed with any nutrient solutions in order to alleviate nutrient stress arising from salinity. The statistical analyses were carried out by using the SAS computer package (SAS Institute Inc., 1985, Cary, North Caroline, USA). For treatment comparison, Least Significant Difference (LSD) test was applied at 0.05 significance level. Apart from absolute salinity tolerance, relative tolerance was used and calculated for each cultivar and different salinity levels by using the following formula:

$$\text{Relative tolerance}(\%) = \frac{(\text{Absolute value} \times 100)}{(\text{Value at } 0.00\% \text{ NaCl level})}$$

RESULTS AND DISCUSSION

The three hybrid sunflower cultivars were tested for evaluation of their responses to seven levels of NaCl salinity at both the seed emergence and seedling stages. Seedling emergence decreased with increasing NaCl levels (Table I). Cultivar Edirne-87 seemed better than the others for seedling emergence.

Increasing salinity levels caused delay in seedling emergence as a result of reducing cell division and plant growth metabolism (Maas & Nieman, 1978). At the highest NaCl concentration, seedling emergence was inhibited and some of seeds did not emerge at all.

After determination of seedling emergence, one plant per pot was allowed to grow to assess the effect of salinity on seedling growth. Variance analyses of the data indicated inhibitory effect of NaCl on plant growth (Table II). The effect of salinity on all the measured characters was highly significant ($P > 0.001$). Many investigations on several plant species have been carried out to determine the response of plants to salt stress (Bilski *et al*., 1988; Efron & Levy, 1988; Levy *et al*., 1988; Turhan, 1999). According to Asraf *et al*. (2003), NaCl has an inhibitory effect on sunflower seed germination and its effect on germination showed time-course dependence for absorption of Na and Cl by the hypocotyls. Similarly, Delgado and Sanchez (1999) also found that sunflower seedling growth was affected from NaCl treatments. The results of these previous studies are in line with results of our present study.

The results (Table II) indicate that the differences between cultivars for all the characters, except number of leaves, were not significant. Mean values of cultivars for each of NaCl concentration are given in Table III. After 0.50% NaCl concentration, the effect of salinity on plant growth was more obvious and dramatic (Fig. 1).

Table I. Daily seedling emergence (%) of sunflower cultivars starting from 8th day of sowing

		Observation date (May 2001)									
NaCl (%)	**Cultivar**	**8th**	**9th**	**10th**	**11th**	**12th**	**13th**	**14th**	**15th**	**16th**	**17th**
0	Edirne-87	22	22	34	44	53	63	78	81	81	81
0	Turkuaz	9	9	22	28	34	47	53	53	53	53
0	Dolunay	19	22	25	28	31	41	56	59	59	59
0.25	Edirne-87	-	-	3	13	19	38	69	72	72	72
0.25	Turkuaz	3	3	3	9	22	41	59	72	72	75
0.25	Dolunay	25	25	44	44	47	56	56	59	59	59
0.50	Edirne-87	-	-	6	9	13	28	34	50	44	44
0.50	Turkuaz	-	-	-	-	3	16	28	28	34	41
0.50	Dolunay	-	-	9	19	25	31	38	47	47	47
0.75	Edirne-87	-	-	3	6	13	13	31	44	44	41
0.75	Turkuaz	-	-	-	3	6	13	34	41	44	44
0.75	Dolunay	-	-	6	6	9	22	34	44	56	56
1.00	Edirne-87	-	-	-	6	9	19	28	31	31	31
1.00	Turkuaz	-	-	3	3	6	19	38	41	41	47
1.00	Dolunay	-	-	-	-	6	13	28	31	34	44
1.25	Edirne-87	-	-	-	-	-	-	13	16	16	16
1.25	Turkuaz	-	-	-	-	-	13	25	31	38	38
1.25	Dolunay	-	-	-	-	-	3	9	9	13	13
1.50	Edirne-87	-		-	-	6	22	31	38	41	44
1.50	Turkuaz	-	-	-	-	-	13	13	22	28	31
1.50	Dolunay	-	-	-	-	6	13	25	31	44	47

The differences between cultivars for number of leaves were significant as this character shows genotypic dependence. For the rest of characters, there was no significant difference between cultivars. However LSD test, sometimes, would not reflect actual performance of a cultivar in cultivar comparisons (Turhan, 1997). Therefore, in Table II, relative tolerance values (in brackets) were used instead of absolute values. For example, cultivar Edirne-87 did not show a better performance than other cultivars whereas its performance at higher NaCl levels was better than others. Similar but inverse performance was observed in cultivar Dolunay. Thus, absolute mean value based comparison would not be sufficient in comparison of cultivars for environmental stresses.

Table II. Variance analyses of characters measured from hybrid sunflower cultivars grown under salt stress

Character	Source				
	NaCl sd: 6	Cultivar sd: 2	NaCl*Cul. sd: 12	Rep. sd: 3	Error sd: 60
Plant height	217.34***	1.33	6.37	3.37	7.55
Number of leaves	62.93***	8.14*	1.73	2.23	2.18
Leaf fresh weight	71.09***	1.54	2.30	2.12	2.87
Stem fresh weight	33.50***	1.21	1.22	0.30	1.22
Shoot fresh weight	205.21***	4.42	6.27	3.96	7.34
Root fresh weight	60.12***	7.20	8.91	9.66	4.81
Leaf dry weight	2.00***	0.09	0.08	0.08	0.10
Stem dry weight	1.11***	0.03	0.12**	0.01	0.03
Shoot dry weight	5.45***	0.66	0.34	0.07	0.22
Root dry weight	1.03***	0.06	0.08	0.10	0.06

***, ** and *: significant at 0.001, 0.01 and 0.05 significance level, respectively; sd: standard deviation

CONCLUSION

The results of this two-stage experiment showed that salinity delayed the germination and inhibited plant growth above 0.50% NaCl. There were some differences between cultivars in terms of germination and seedling emergence. At seedling growth stage, using relative tolerance in comparison of genotypes for salinity gives more reliable results than using absolute values. Therefore, according to relative tolerance, Cultivar Edirne-87 among the cultivars showed the highest performance at higher NaCl concentrations whereas Dolunay showed the lowest performance. As a result, this study indicates that the method used could be useful in screening and selection for the determination of responses to salinity in sunflower before a field trial.

Table III. Effect of Salinity on all measured characters in three sunflower cultivars

	NaCl levels (%)							
Cultivar	**0.00**	**0.25**	**0.50**	**0.75**	**1.00**	**1.25**	**1.50**	**Mean**
Plant height (cm) (LSD $_{0.05}$: NaCl = 2.244)								
Dolunay	16.48	15.75 (96)[1]	15.25 (93)	11.50 (70)	10.83 (63)	4.25 (26)	3.75 (23)	11.05
Edirne-87	17.83	13.80 (77)	13.50 (76)	10.50 (59)	9.25 (52)	6.63 (37)	6.87 (39)	11.20
Turkuaz	14.50	13.88 (96)	13.75 (95)	10.63 (73)	6.38 (44)	6.38 (44)	5.88 (41)	10.77
Mean	16.27a*	14.48 (89)a	14.70 (90)a	10.88 (67)b	10.00 (35)b	5.75 (35)c	5.50 (33)c	
Number of leaves (LSD $_{0.05}$: NaCl = 1.207, Cultivar= 0.790)								
Dolunay	8.50	7.50 (88)	6.00 (71)	5.50 (65)	6.25 (74)	2.00 (24)	1.50 (18)	5.32c
Edirne-87	10.00	8.00 (80)	7.00 (70)	6.25 (63)	5.50 (55)	4.00 (40)	4.00 (40)	6.39a
Turkuaz	8.00	7.25 (91)	7.25 (91)	5.25 (66)	6.00 (75)	3.25 (41)	2.50 (31)	5.75ab
Mean	8.83a	7.83 (89)ab	6.75 (76)bc	5.67 (64)c	5.92 (67)b	3.08 (35)d	2.67 (30)d	
Shoot fresh weight (g) (LSD $_{0.05}$: NaCl= 2.213)								
Dolunay	13.05	10.93 (84)	10.15 (78)	6.50 (50)	6.45 (49)	1.70 (13)	1.70 (13)	7.21
Edirne-87	15.75	8.48 (54)	9.50 (60)	6.13 (40)	4.53 (29)	2.90 (20)	4.00 (31)	7.33
Turkuaz	13.20	11.48 (87)	9.83 (74)	7.28 (55)	7.63 (59)	3.98 (30)	2.28 (23)	7.95
Mean	13.99a	10.29 (74)b	9.83 (70)b	6.63 (70)c	6.20 (44)b	2.86 (21)d	2.68 (23)d	
Root fresh weight (g) (LSD $_{0.05}$: NaCl = 1.791)								
Dolunay	6.55	6.1 (93)	5.70 (87)	3.28 (50)	3.90 (59)	0.58 (9)	0.38 (6)	3.78
Edirne-87	11.20	8.48 (50)	5.55 (50)	3.50 (31)	2.10 (19)	1.90 (17)	3.17 (28)	4.72
Turkuaz	5.08	5.78 (114)	4.43 (87)	4.90 (96)	3.78 (74)	1.98 (39)	1.45 (29)	3.91
Mean	7.61a	5.83 (77)ab	5.23 (69)bc	3.89 (51)cd	3.26 (43)de	1.48 (19)e	1.67 (22)e	
Shoot dry weight (g) (LSD $_{0.05}$: NaCl = 0.382)								
Dolunay	2.13	1.68 (79)	0.55 (26)	0.98 (46)	0.95 (45)	0.23 (11)	0.23 (11)	0.96
Edirne-87	2.73	1.25 (46)	1.45 (53)	0.98 (36)	0.58 (21)	0.45 (16)	0.63 (23)	1.15
Turkuaz	2.18	1.75 (80)	1.50 (69)	1.20 (55)	1.28 (59)	0.58 (27)	0.38 (17)	1.26
Mean	2.34a	1.56 (67)b	1.17 (50)c	1.05 (45)c	0.93 (40)c	0.42 (42)d	0.41 (18)d	
Root dry weight (g) (LSD $_{0.05}$: NaCl = 0.205)								
Dolunay	0.78	0.68 (87)	0.63 (80)	0.30 (38)	0.43 (55)	0.08 (10)	0.05 (6)	0.96
Edirne-87	1.33	0.60 (45)	0.63 (47)	0.40 (30)	0.23 (17)	0.13 (10)	0.25 (19)	1.15
Turkuaz	0.85	0.58 (68)	0.48 (56)	0.45 (53)	0.40 (47)	0.25 (29)	0.18 (21)	1.26
Mean	0.98a	0.62 (63)b	0.58 (59)bc	0.38 (39)cd	0.35 (40)de	0.15 (15)e	0.16 (16)e	

* Means with the same letter are not significantly different at p=0.05; [1] The values in brackets are relative tolerance (%) of the cultivars in each drought level

Fig. 1. Seedling growth of three sunflower cultivars under different NaCl concentrations

REFERENCES

Asraf, M., R. Zafar and M.Y. Asraf, 2003. Time–course changes in the inorganic and organic components of germinating sunflower achenes under salt (NaCl) stress. *Flora*, 198: 26–36

Ashraf, M. and M. Tufail, 1995. Variation in salinity tolerance in sunflower (*Helianthus annuus* L.). *J. Agron. Crop Sci.*, 174: 351–62

Bilski, J.J., D.C. Nelson and R.T. Conlon, 1988. Response of six wild potato species to chloride and sulphate salinity. *American Potato J.*, 65: 605–12

Delgado, I.C. and A.J. Sanchez-Raya, 1999. Initial shoot development of sunflower under special saline conditions. *Phyton–Int. J. Expt. Bot.,* 65: 1–5

Efron, H. and D. Levy, 1988. Response of potatoes to brackish water. *Water and Irrigation Rev.*, 8: 4–6

Evangelou, V.P., 1994. Influence of sodium and soils of humid regions. *In:* M. Pessarakli (ed.), *Handbook of Plant and Crop Stress*, pp: 31–62. Marcel Dekker Inc. New York

Haverkkort, A.J., M.V.D. Waart and K.B.A. Bodlaender, 1990. The effect of early drought stress on number of tubers and stolons of potato in controlled and field conditions. *Potato Res.*, 33: 89–96

Katarji, N., J.W. Van Hoorn, A. Hamdy and M. Mastrorilli, 2003. Salinity effect on crop development and yield, analysis of salt tolerance according to several classification methods. *Agric. Water Manag.*, 62: 37–66

Levy, D., E. Fogelman and Y. Ytzhak, 1988. The Effect Of Water Salinity On Potatoes (*Solanum tuberosum* L.) Physiological Indexes and Yielding Capacity. *Potato Res.*, 31: 601–10

Levy, D., 1992. The response of potatoes (*Solanum tuberosum* L.) to salinity: plant growth and tuber yields in the arid desert of Isreal. *Ann. Appl. Biol.*, 120: 547–55

Lynch, D.R. and G.C.C. Tai, 1989. Yield and yield components response of eight potato genotypes to water stress. *Crop Sci.*, 29: 1207–11

Maas, E.V. and R.H. Neiman, 1978. Physiology of plant tolerance to salinity. *In:* E.V. Maas and R.H. Neiman (eds.), *Crop Tolerance to Suboptimal Land Conditions,* pp: 277–99

McWilliam, J.R., 1986. The national and international importance of drought and salinity effects on Agricultural production. *Australian J. Physiol.*, 13: 1–13

Muralidharudu, Y., G. Ravishankar, M. Hebbara and S.G. Patil, 1999. Genotypic variation in sunflower (*Helianthus annuus*) for salt tolerance. *Indian J. Agric. Sci.*, 69: 362–5

Naik, P.S. and J.M. Widholm, 1993. Comparison of tissue culture and whole plant responses to salinity. *Plant Cell, Tissue and Organ Culture*, 33: 273–80

SAS Institute, 1985. *Statistical Analysis System User's Guide: Statistics.* SAS Inst., Cary. N.C.

Shannon, M.C., C.M. Grieve and L.E. Francois, 1994. Whole–plant response to salinity. *In:* Wilkinson, R.E. (ed.), *Plant–Environment Interaction,* pp: 199–244. New York, USA

Turhan, H., 1997. Salinity studies in potato (*Solanum tuberosum* L.). *PhD. Thesis*, p. 255. The University of Reading, Reading, UK

Turhan H., 1999. Comparison of Effect of NaCl on Potato (*Solanum tuberosum* L.) cultivars under *in vitro* and *in vivo* conditions, *Proceedings of III. Field Crops Cong.*, Adana, Turkey, 2: 65–70

(Received 20 November 2003; Accepted 02 December 2003)