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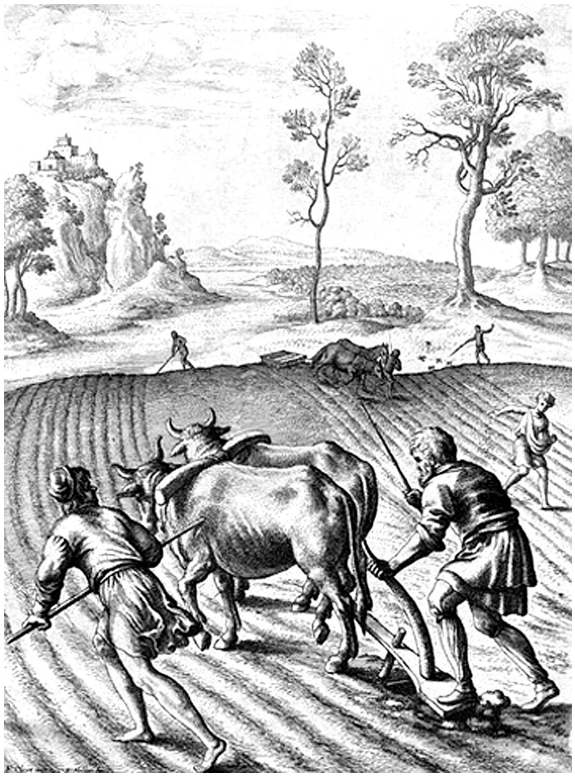

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Response of Six *Medicago sativa* Cultivars to NaCl Concentrations in Irrigation Water

H.M. Saoub
Department of Agricultural Resources and Environment,
Faculty of Agriculture, University of Jordan, Amman 11942 - Jordan

Abstract: Six alfalfa (*Medicago sativa* L.) cultivars were tested for their tolerance to salinity under glasshouse conditions. Six alfalfa cultivars and six NaCl concentrations in irrigation water were used. Soil was placed in 20 cm diameter pots forming an average weight of 2.5 kg. In each pot fifteen seeds were planted and plants were thinned to six plants/pot, five days after emergence. Total dry matter production was significantly reduced with increasing the NaCl concentration in the irrigation water. Maxicrop and diablo verde were the most tolerant cultivars to increasing NaCl concentration in irrigation water, while baladi and hessawi were the most sensitive cultivars. The decrease in herbage yield can be attributed to the decrease in plant height, leaf area and root growth. It can be concluded that increasing NaCl levels up to 6000 ppm in the irrigation water is very risky for the cultivars used in this study.

Key words: Alfalfa, salinity, irrigation water

Introduction

As the need for more crop production increases, the demand on fresh irrigation water is highly emphasized. Therefore, attention towards other possible irrigation sources, like sewage or saline water has grown in the last few decades. The use of saline water for irrigation might help to reduce the use of fresh water and may also contribute in solving the problem of water shortage, especially in arid and semi-arid regions. However, the use of saline water is dependent on the crop ability to tolerate salinity. Saline water may be available as drainage water or brackish ground water and sea water intrusion.

Salt stress reduces plant growth primarily by increasing the energy required to extract water from the soil and also by making biochemical adjustments necessary to survive under stress (Hamdy *et al*., 1993; Taiz and Zeiger, 1991). Hussain *et al*. (1995) reported that alfalfa (*Medicago sativa* L.) can be safely irrigated with water having a total salinity up to 7.8 dsm^{-1} for optimal (11-12-ton/ha/cut) forage production. It was shown that increase of water salinity from 2.1 to 4.6 dsm^{-1} significantly increased the mean green matter yield for the first and second cuttings. They concluded that higher salinity of irrigation water could be a source of plant nutrition as compared to the low salinity irrigation water. Helalia *et al*. (1996) showed that alfalfa produced good growth and dry matter yield when irrigated with water having up to 8.6 dsm^{-1}.

Regarding the specific effects of sodium chloride concentrations in the irrigation water. Ahmed and Mohammed (1994) showed that increasing NaCl concentrations in irrigation water from 1000 to 3000 ppm, resulted in a significant reduction in plant height, average leaf area and dry weight/plant. In the second cut, significant differences were observed between the 13 varieties used in response to salinity levels.

This experiment was designed to evaluate the response of six alfalfa cultivars to NaCl concentration in the irrigation water under glass house conditions.

Materials and Methods

The experiment was conducted in a glasshouse at the University of Jordan on the 21st August, 1999. The soil was collected from a nearby field and sieved using a coarse screen to remove large rocks and dry soil lumps. Soil was placed in 20 cm diameter pots forming an average weight of 2.5 kg. Before planting each pot received 2 g of super phosphate, equivalent to 130 kg ha^{-1} and 2 g of potassium nitrate (30% potassium, 20% N) equivalent to 116 kg ha^{-1} of potassium. In each pot fifteen seeds were planted in the 24th of August, 1999, at a depth of one cm. The plants were thinned to six plants/pot five days after emergence.

The amount of water required was calculated using the Blaney-Criddle method (Cuenca, 1989) as temperature and humidity were the only available parameters. Each pot received a total amount of 6.33 liters of NaCl irrigation water distributed as follows: 2.2 liters of irrigation water were received before the first cut, whereas 1.4 liters were given during the period between the first two cuts and the rest was given until the end of the experiment after the second cut. Hamdy *et al*. (1993) recommended to avoid the use of saline water for irrigation of alfalfa during the early stages of plant growth. This point was taken into consideration in this study. The use of saline water was after the appearance of the second trifoliate leaf for all cultivars.

Six alfalfa cultivars and six irrigation treatments (NaCl concentrations) were placed in a factorial arrangement in a completely randomized design. The alfalfa cultivars are: WL 516, WL 605, maxicrop, diablo verde, baladi (local) and hassawi. Salinity levels in irrigation water were as follows: To: tap water (EC = 0.5 dsm^{-1}); T_1: 1500 ppm NaCl conc. in tap water (EC = 3.5 dsm^{-1}); T_2: 3000 ppm NaCl conc. in tap water (EC = 5.9 dsm^{-1}); T_3: 4500 ppm NaCl conc. in tap water (EC = 8.8 dsm^{-1}); T_4: 6000 ppm NaCl conc. in tap water (EC = 11.0 dsm^{-1}) and T_5: 7000ppm NaCl conc. in tap water (EC = 12.5 dsm^{-1}). EC was measured by EC meter (Ryan *et al*., 1996).

The first cut was taken on the 13th of October 1999, 46 days after planting. After that, two more cuts were taken at 25 days interval between cuts. The plants were cut at 5 cm above the soil surface and placed in paper bags, weighed to obtain fresh weight then dried at 105°C for 24 h and weighed to obtain the dry weight. After the third cut the roots were removed from the pots, washed, dried inside the glasshouse for 24 h to obtain fresh weight. Then the root samples were dried in oven at 105°C for 24 h to obtain dry weight. The following parameters were studied: plant height, average leaf area, accumulative fresh and dry weight of herbage, root fresh and dry weight obtained from the final cut.

Results and Discussion

Total herbage yield: The maximum amount of fresh herbage yield (about 20 g pot^{-1}) was obtained from cultivars WL 516; WL 605 or maxicrop irrigated with water having less than 3000 ppm NaCl. Under high NaCl concentrations (7000 ppm) in the irrigation water, these three cultivars were able to produce herbage yield ranging from about 14 to 17 g pot^{-1} (Table 1). This means that these cultivars have the potential to be grown under irrigation in areas suffering from the water salinity. In general, as the NaCl concentration in irrigation water increases, total fresh herbage yield decreases for all cultivars used in this study. Cultivar Baladi was the most sensitive to salinity stress.

Total dry matter (DM) has a similar trend to the total fresh herbage yield, with a maximum amount of production that reaches about 15 g pot^{-1} for cultivar WL605. Increasing salinity level from control to 7000 ppm NaCl resulted on the decline of DM from 15 to 13 g pot^{-1} (Table 1). Measuring plant height and leaf area in the first two cuts showed that increasing the level of NaCl

Table 1: Total fresh herbage yield and dry matter yield (g/pot) for six alfalfa cultivars grown at different NaCl concentration in irrigation water

NaCl concentration (ppm)	Cultivars					
	WL 516	WL 605	Maxicrop	Diablo verde	Baladi	Hessawi
Fresh herbage yield						
Control	20.348a-c	20.912a	19.705a-d	18.692c-g	16.040j-o	19.322a-e
1500	19.152b-f	19.050b-f	20.460ab	18.222d-h	15.443m-p	19.400a-e
3000	16.475l-m	19.335a-e	19.642a-d	17.895e-l	15.737k-o	17.888e-l
4500	16.473l-m	17.145g-m	18.452d-h	18.520d-g	13.995p	17.500f-j
6000	16.330l-n	17.458f-k	18.260d-h	17.303g-l	11.165q	15.638l-p
7000	14.453op	16.773h-m	17.200g-l	14.668n-p	9.457q	10.495q
Dry matter yield						
Control	14.492ab	14.867a	13.563a-g	13.712a-f	12.883c-h	14.217abc
1500	14.107a-d	14.100a-d	13.678a-f	13.537a-g	12.577d-h	14.108a-d
3000	13.127b-g	14.130a-d	13.392a-g	13.495a-g	12.317e-h	13.737a-f
4500	12.878c-h	13.327a-g	13.800a-e	14.060a-d	11.442h	13.102b-g
6000	12.843c-h	13.332a-g	13.935a-d	13.355a-g	8.935l	12.217fgh
7000	12.21f-h	13.312b-g	13.280b-g	12.075gh	8.363l	8.712i

Table 2: Effect of NaCl concentration (ppm) on plant height and average leaf area for the first and second cuts

NaCl concentration (ppm)	Plant height		Average leaf area	
	First cut	Second cut	First cut	Second cut
0	18.35a	27.48a	1.19a	2.28a
1500	19.84a	25.93a	1.00b	1.05b
3000	19.39a	21.69b	1.07ab	0.72b
4500	18.39a	17.48c	0.76c	0.53b
6000	17.74a	17.42c	0.76c	0.47b
7000	11.90b	8.70d	0.52d	0.40b

Table 3: Root fresh weight and root dry weight (g/pot) for six alfalfa cultivars grown at different NaCl concentration in irrigation water

NaCl concentration (ppm)	Cultivars					
	WL 516	WL 605	Maxicrop	Diablo verde	Baladi	Hessawi
Root fresh weight						
Control	6.130de	16.450a	12.170b	9.720c	12.700b	7.560d
1500	3.510g-j	7.600d	10.040c	9.650c	4.050f-h	6.200de
3000	3.970gh	4.450fg	6.910de	7.150d	1.810k-p	3.000g-k
4500	2.380l-m	2.560h-l	5.595ef	3.650g-l	2.000j-o	1.540k-p
6000	2.730h-l	2.347l-m	2.240l-n	0.785n-p	0.400p	1.650k-p
7000	1.560k-p	0.950m-p	2.250l-n	0.450op	0.300p	1.275l-p
Root dry weight						
Control	2.250e-h	3.230ab	2.065e-l	2.885b-d	3.690a	3.280ab
1500	1.780g-k	2.300e-g	2.615c-e	3.025bc	1.700h-k	1.945f-j
3000	1.420j-m	1.975f-j	2.585c-e	2.235e-h	0.760n-r	1.990f-j
4500	1.550l-l	2.045e-l	2.060e-l	2.385d-f	1.035l-o	1.550l-l
6000	0.796n-r	1.325k-n	1.210k-n	0.925m-p	0.390p-s	1.290k-n
7000	0.320rs	0.540o-s	0.915m-q	0.350q-s	0.185s	0.885m-r

Figures for each parameter followed by the same letters are not significantly different using LSD test ($P \leq 0.05$)

concentration in the irrigation water resulted in decreasing both plant height and average leaf area (Table 2). The decline in plant height and average leaf area means a decline in the vegetative growth of forage crops. This might explain the reduction in total dry matter in response to salinity. Pasternak *et al.* (1993) showed that alfalfa dry matter production was reduced as a result of increasing salinity from 2 to 14 dsm^{-1}. Also, Ahmed and Mohammad (1994) found a significant decline in dry matter as a result of increasing NaCl concentration in irrigation water. They found that the reduction ranged from 19.87 to 36.52% depending on the cultivar. Helalia *et al.* (1996) found that dry matter yield was reduced by about 34% when the crop was irrigated by drainage water (Ec = 6500-10000 ppm). In comparison, the results of the present study showed that the reduction in dry matter production ranged from 12.7 to 45.7%. The difference in results of the present study and the previous studies could be related to the different cultivars used in each study. However, all studies showed the same trend of decline as a result of increasing salt concentration in irrigation water.

Hussain *et al.* (1995) found that dry matter production reach about 38 g pot^{-1} when the crop was irrigated with water having 5000 ppm salts. This was much higher than the values obtained from the present study. The main reason was due to the higher seeding rate used by Hussain *et al.* (1995).

Root fresh and dry weight: Cultivar WL 605 produced the largest root fresh and dry weight when irrigated with tap water (control). However, this declined significantly as the level of NaCl in irrigation water was increased only to 1500 ppm (Table 3). It seems that roots were more sensitive to NaCl concentration than the above ground parts. At the highest level of NaCl, cultivar maxicrop has the largest root fresh and dry weight. Considering the total herbage yield and root weight, it seems that maxicrop have the potential to survive and produce forage under high salinity conditions better than the other cultivars used in this study.

The results of this study showed that the six cultivars can be divided into 3 groups: high tolerance cultivars such as maxicrop and diablo verde, medium tolerance cultivars such as WL 516 and WL 605 while cultivars baladi and hessawi were considered sensitive to NaCl concentration in the irrigation water. Actually, those sensitive cultivars were almost killed and did not survive after the second cut, especially at NaCl concentration above 3000 ppm. In general, increasing NaCl concentration in the irrigation water up to 6000 ppm can be very risky since it caused a significant reduction in herbage yield.

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