BIOLOGIA PLANTARUM 43 (3): 455-457, 2000

BRIEF COMMUNICATION

Response of alfalfa genotypes to saline water irrigation

A. ANAND, M.J. BAIG and P.K. MANDAL

Division of Crop Improvement, Indian Grassland and Fodder Research Institute, Jhansi-284003, India

Abstract

The influence of saline water (4, 8, 12 dS m^{-1}) irrigation on gas exchange and growth response of alfalfa genotypes Anand-2, T-9 and IL-112 was studied. T-9 and IL-112 showed a significant increase in net photosynthetic rate (P_N) at low salinity (4 dS m^{-1}) compared to the control whereas Anand-2 maintained an unaltered P_N. Reduction in P_N at higher salinities was primarily due to reduction of stomatal conductance. There was a greater reduction in transpiration rate as compared to P_N rate, which resulted in an increase in water use efficiency (WUE). High WUE may serve as one of the strategies of the plant to withstand saline environment. However, the slight increase in WUE in Anand-2 could not help in maintaining its growth. Increase in Na^+ concentration in comparison to K^+ concentration may also contribute to the inhibition in growth.

Additional key words: *Medicago sativa*, photosynthetic rate, salinity, stomatal conductance, transpiration rate, water use efficiency.

Soil salinity is widely reported to be major problem particularly in irrigated agriculture. The reduction in growth due to salinity may result from several physiological responses like changes in water status, modification of the ion balance, stomatal behaviour, mineral nutrition, photosynthetic efficiency, carbon allocation and utilisation (Munns and Termatt 1986). The objective of this study was to determine the photosynthetic responses of the alfalfa genotypes to increasing salinity and relate them to growth responses.

Alfalfa (*Medicago sativa* L.) seeds cv. T-9, Anand-2 and IL-112 were sown in pots filled with 18 kg of 3:1 sandy loam soil to farm yard manure mixture. A basal dose corresponding to 20 kg/ha N and 80 kg/ha P_2O_5 was applied to the pots in the form of urea and single superphosphate, respectively. The pots were irrigated with saline water prepared by adding equivalent amounts of NaCl, $MgCl_2$, $CaCl_2$ and Na_2SO_4 to tap water (electrical conductivity, EC, 0.8 dS m^{-1}) so as to achieve an EC of 4, 8 and 12 dS m^{-1} for different treatments. Plants irrigated with tap water were taken as control. There were five pots per treatment and three plants per pot.

The measurements of gas exchange (rates of photosynthesis and transpiration, stomatal conductance, and internal CO_2 concentration) were made by portable photosynthetic system with infrared gas analyser (*LICOR 6200*, Lincoln, USA) on fully expanded leaves at 15 d after the first cut. First cut was taken at 75 d after sowing. Three plants were harvested per treatment and their fresh mass was recorded. Water use efficiency was calculated as the ratio of leaf net photosynthetic rate to transpiration rate. The data were statistically analysed according to Gomez and Gomez (1984).

The photosynthetic rate (P_N) was stimulated at 4 dS m^{-1} in T-9 and IL-112 followed by a decline at higher salinities. Anand-2, however, maintained unaltered P_N (Table 1). The stimulation of P_N at low salinity may bethe result of inability of plants under controlled condition to reach their full assimilatory potential. It can also be

---

Received 13 September 1999, *accepted* 7 February 2000.

Abbreviations: c_i - internal CO_2 concentration; DAS - days after sowing; E - transpiration rate; EC - electrical conductivity, g_s - stomatal conductance, P_N - net photosynthetic rate, WUE- water use efficiency,

Acknowledgements: The authors thank the Head of the Division and Director of the Institute for providing the facilities during the study.

Fax: 91 0517 440833, e-mail: anjali@igfri.up.nic.in

explained as the increased photosynthate demand by the plant to meet out the additional energy expenditure imposed by adjustment to increased salinity. This is in accordance with the reports by Herold 1980) and von Caemmerer and Farquhar (1984) that an increase of P_N occurs in response to the increased photosynthate demand.

Reduction in stomatal conductance (g_s) could reduce P_N by lowering internal CO_2 concentration (c_i) (*e.g.* Downtown *et al.* 1985, Long and Baker 1986). A strong correlation was found between g_s and P_N ($r = 0.931$), and also between g_s and c_i ($r = 0.746$), and c_i and P_N ($r = 0.530$). It seems that the reduction in g_s primarily limits photosynthesis.

On the other hand, despite a marked reduction of g_s the c_i in IL-112 increased at 12 dS m^{-1} (Table 1). This suggests that high salinity affects photosynthesis not ohly due to its effect on stomatal closure but also due to non stomatal factors. Ultrastructural damage and decrease in chlorophyll content was observed, *e.g.*, by Melesse and Caesar (1992) and Bethke and Drew (1992).

Table 1. Effect of saline water irrigation on photosynthetic rate, stomatal conductance, intercellular CO_2 concentration, and transpiration rate of alfalfa genotypes T-9, Anand-2, and IL-112.

Salinity [dS m$_{-1}$]	P_N [µmol(CO_2) m^{-2} s^{-1}]			g_s [mmol m^{-2} s^{-1}]			c_i [µmol mol^{-1}]			E [mmol(H_2O) m^{-2} s^{-1}]		
	T-9	Anand-2	IL-112	T-9	Anand-2	IL-112	T-9	Anand-2	IL-112	T-9	Anand-2	IL-112
0.8	13.6	18.6	9.5	134.9	235.3	95.3	170.1	184.3	172.6	4.7	5.5	3.0
4.0	24.5	20.3	21.4	326.6	248.7	245.9	211.2	194.9	202.3	8.2	6.0	6.4
8.0	18.5	20.6	21.4	247.6	232.9	212.1	187.8	183.9	197.4	5.2	5.4	5.9
12.0	18.1	21.0	15.4	212.7	276.8	243.4	202.0	222.0	221.6	4.2	5.1	3.3
LSD$_{0.05}$		3.6			30.8			21.2			1.1	

Table 2. Influence of saline water irrigation on water use efficiency, fresh mass, and potassium and sodium concentrations of alfalfa genotypes T-9, Anand-2, and IL-112.

Salinity [dS m$_{-1}$]	WUE [mmol mol^{-1}]			Fresh mass [g plant^{-1}]			K^+ concentration [mg g^{-1}(d.m.)]			Na^+ concentration [mg g^{-1}(d.m.)]		
	T-9	Anand-2	IL-112	T-9	Anand-2	IL-112	T-9	Anand-2	IL-112	T-9	Anand-2	IL-112
0.8	2.9	3.5	3.2	18.2	25.0	19.0	23.9	25.8	24.1	3.0	2.2	1.4
4.0	3.0	3.4	3.4	21.3	16.5	17.2	23.0	24.8	22.3	2.6	2.6	3.5
8.0	3.6	3.8	3.7	15.0	11.5	15.5	20.0	22.3	20.9	4.0	2.6	3.8
12.0	4.4	4.1	4.7	14.5	12.8	15.7	20.5	24.6	26.4	2.9	4.9	2.1
LSD$_{0.05}$		0.6			4.9			2.5			1.0	

The decreasing rate of transpiration (E) in response to salinity is one of the mechanisms to improve water relations (Munns and Termatt 1986). In this investigation (Table 1), there was a greater reduction in E as compared to P_N thereby increasing the water use efficiency (Table 1). This could be one of the strategies of the plant to withstand the saline environment. On the contrary, Khan *et al.* (1994) observed that increased salinity decreased not only P_N, g_s but also WUE in *Medicago sativa.*

Plant growth in terms of the fresh mass of the plant declined by 48.6 % in Anand-2 at 12 dS m^{-1} compared to its control. Growth in IL-112 and T-9 was not significantly affected (Table 2). As no consistent relationship between plant growth and P_N was observed, it is unlikely that the effect of salinity on growth was mediated mainly through its effects on leaf P_N. Plant growth at high salinity may be affected by the low availability of water due to high salt concentration in the soil solution or by accumulation of specific ions (*e.g.* Munns *et al.* 1995).

In T-9 K^+ concentration declined whereas Anand-2 showed an accumulation of Na^+ at 12 dS m^{-1}. In IL-112 no consistent changes in Na^+ and K^+ concentration were found (Table 2). We suggest that the growth differences may be explained by differences in WUE. In T-9 and IL-112 WUE increased significantly under salinity and growth was maintained. Anand-2 showed no marked change in WUE in various treatments and its biomass decreased.

References

Bethke, P.C., Drew, M.C.: Stomatal and non stomatal components to inhibition of photosynthesis in leaves of *Capsicum annuum* during progressive exposure to NaCl salinity. - Plant Physiol. **99**: 219-226, 1992.

Downtown, W.J.S., Grant, W.J.R., Robinson, S.P.: Photosynthetic and stomatal responses of spinach leaves to salt stress. - Plant Physiol. **78**: 85-88, 1985.

Gomez, K.A., Gomez, A.A.: Statistical Procedures for Agricultural Research. - J. Wiley and Sons, New York 1984.

Herold, A.: Regulation of photosynthesis by sink activity - the missing link. - New Phytol. **86**: 131-144, 1980.

Khan, M.G., Silberush, M., Lips, S.H.: Physiological studies on salinity and nitrogen interaction in alfalfa. II. Photosynthesis and transpiration. - J. Plant Nutr. **17**: 669-682, 1994.

Long, S.P., Baker, N.R.: Saline terrestrial environments. - In: Baker, N.R., Long, S.P. (ed.): Photosynthesis in Contrasting Environments. Pp. 63-102. Elsevier, Amsterdam - New York - Oxford 1986.

Melesse, T., Caesar, K.: Stomatal and non stomatal effects of salinity on photosynthesis in faba beans (*Vicia faba* L.). - J. Agron. Crop Sci. **168**: 345-353,1992.

Munns, R., Termatt, A.: Whole plant responses to salinity. - Aust. J. Plant Physiol. **13**: 143-160, 1986.

Munns, R., Schachtman, D.P., Condon, A.G.: The significance of a two-phase growth response to salinity in wheat and barley. - Aust. J. Plant Physiol. **22**: 561-569, 1995.

von Caemmerer, S., Farquhar, G.D.: Effects of partial defoliation, changes of irradiance during growth, short term water stress and growth at enhanced p(CO_2) on the photosynthetic capacity of leaves of *Phaseolus vulgaris* L. - Planta **160**: 320-329, 1984.