BIOLOGIA PLANTARUM 35 (2): 289-292, 1993

BRIEF COMMUNICATION

The growth and nodulation of *Trifolium alexandrinum* as affected by salinity

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Abstract

The growth and nodulation of *Trifolium alexandrinum* were compared at six levels (0 - 1.2 % NaCl) of salinity. Dry mass of shoots and roots, 14 and 20 weeks after the commencement of salinity treatment, increased at low levels of salinity (0.1 - 0.2 % NaCl) but decreased with higher NaCl concentrations (0.4 - 1.2 %). Nodulation occurred at NaCl concentrations up to 0.8 %. Nodule mass decreased with increasing salinity levels. The nodule size remained unaffected at NaCl concentrations up to 0.4 % but was reduced at higher concentrations.

Considering the proportion of soils in the world which are saline, remarkably little effort has been expended on examining the effect of salinity on nitrogen fixation (for review see *e.g.* Sprent 1984). Saline conditions may affect the legume-*Rhizobium* symbiosis by reducing the survival of rhizobia, inhibiting the infection process, affecting nodule function or reducing plant growth (Singleton *et al.* 1982). Bernstein and Ogata (1966) found that salinity affected growth and nodulation of soybean and alfalfa but the two species differed in their response to salinity. Balasubramanian and Sinha (1976) found that NaCl severely reduced nodule initiation in cowpea and mungbean. Yousef and Sprent (1983) grew *Vicia faba* under salt stress and found that the number of nodules per plant was depressed but this was partially compensated by producing larger nodules. This paper investigates the effects of increasing concentrations of NaCl on growth and nodulation of *Trifolium alexandrinum.*

Seeds of *Trifolium alexandrinum* were germinated in Petri dishes containing wet filter paper. One week after germination, seedlings of uniform size were transplanted into pots containing garden soil (sandy clay loam, EC_e = 1.0 dS m^{-1} at 25 °C) with NaCl treatments of 0, 0.1, 0.2, 0.4, 0.8 or 1.2 %.

Received 5 December 1991, *accepted* 21 April 1992.

There were 18 replicates for each NaCl treatment and the experimental design was a randomized complete block. For each NaCl treatment, 9 plants were harvested 14 and 20 weeks after transplantation. At the first harvest electrical conductivity (EC) of soil samples from the root zone was measured by a conductivity meter (*CM-30EF*). The electrical conductivities at 25 °C were 1.0 (0), 1.1 (0.1), 2.4 (0.2), 4.3 (0.4), 8.1 (0.8) and 14.4 (1.2) dS m^{-1} (the figures in parentheses being the equivalent % values of NaCl added to the soil).

The growth response of *Trifolium alexandrinum* to salinity at the two harvests (Table 1) showed an increase in total dry mass at low salinity (0.1 % and 0.2 % NaCl) and then a decrease in growth with increasing salinity levels (0.4 % to 1.2 % NaCl). At the first harvest, the total dry mass of the plants increased by 36 % and 21 % over the control at NaCl levels of 0.1 % and 0.2 %. At second harvest, the increase in total dry mass of plants was 52 % and 10 % over the control at NaCl levels of 0.1 % and 0.2 %, respectively. The next higher concentration of NaCl (0.4 %), however, reduced total dry mass to 71 % and 78 % of the control at first and second harvests, respectively. Further increase in salinity to the highest level (1.2 % NaCl) reduced total dry mass to only 7 % and 31 % of the control at first and second harvest, respectively.

Table 1. Effect of NaCl concentration on shoot and root dry mass of *Trifolium alexandrinum* 14 and 20 weeks after the commencement of salinity treatment (values are means of 9 replicates ± SEM).

NaCl conc. [%]	14 weeks shoot dry mass [g $plant^{-1}$]	root dry mass [g $plant^{-1}$]	20 weeks shoot dry mass [g $plant^{-1}$]	root dry mass [g $plant^{-1}$]
0	0.49 ± 0.13	0.21 ± 0.05	0.57 ± 0.08	0.24 ± 0.06
0.1	0.60 ± 0.17	0.35 ± 0.03 b	0.89 ± 0.23 b	0.34 ± 0.02
0.2	0.63 ± 0.01 b	0.22 ± 0.04	0.63 ± 0.15	0.26 ± 0.04
0.4	0.35 ± 0.12 b	0.15 ± 0.03	0.46 ± 0.13	0.17 ± 0.03 b
0.8	0.17 ± 0.02 a	0.08 ± 0.01 a	0.33 ± 0.13 b	0.09 ± 0.02 a
1.2	0.03 ± 0.01 a	0.02 ± 0.01 a	0.19 ± 0.02 b	0.06 ± 0.01 a

a - significantly different to the control at $P < 0.01$
b - significantly different to the control at $P < 0.05$

Slight plant growth improvements at lower levels of salinity and inhibited growth at higher levels of salinity have also been reported by other workers (*e.g.* Greenway and Munns 1980, Ng 1987, Salim 1988).

Root nodules were formed at all salinity levels except 1.2 % NaCl (Table 2). Nodule fresh mass per plant generally decreased with increasing NaCl concentrations at both first and second harvests. However, at first harvest, the nodule fresh mass was slightly increased at 0.1 % NaCl. At 0.4 % NaCl, nodule fresh mass decreased to 36 % and 48 % of the control at first and second hrvest, respectively. In contrast, salinity levels of up to 0.4 % NaCl apparently had no effect on the mean nodule size.

The higher concentration (0.8 % NaCl), however, significantly reduced the mean nodule size to 48 % and 38 % of the control at first and second harvest, respectively.

Adverse effect of salinity on nodulation has also been reported by other workers (Balasubramanian and Sinha 1976, Lauter *et al.* 1981, Ng 1987, Yousef and Sprent 1983). Present results, however, differ from that of Yousef and Sprent (1983) who observed an increase in the nodule size of *Vicia faba* at low salinity levels. Improved growth of *T. alexandrinum* at low salinity levels was not accompanied by an increase in the nodule mass or nodule size.

Table 2. Effect of NaCl concentration on nodule diameter and nodule fresh mass of *Trifolium alexandrinum* 14 and 20 weeks after the commencement of salinity treatment (values are means of nodules from 9 plants ± SEM).

NaCl conc. [%]	14 weeks nodule size [mm]	nodule fresh mass [g plant^{-1}]	20 weeks nodule size [mm]	nodule fresh mass [g plant^{-1}]
0	2.60 ± 0.21	0.11 ± 0.01	6.60 ± 1.00	0.27 ± 0.01
0.1	2.50 ± 0.40	0.13 ± 0.01	6.00 ± 0.60	0.25 ± 0.06
0.2	2.66 ± 0.62	0.06 ± 0.03 b	6.70 ± 0.90	0.15 ± 0.06 b
0.4	2.50 ± 0.35	0.04 ± 0.02 a	5.00 ± 0.75	0.13 ± 0.05 b
0.8	1.25 ± 0.41	0.03 ± 0.01 a	2.50 ± 0.38 b	0.06 ± 0.01 a
1.2	0	0	0	0

a - significantly different to the control at $P < 0.01$
b - significantly different to the control at $P < 0.05$

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Communicated by J. POSPÍŠILOVÁ