The response of lucerne (*Medicago sativa* L.) to the combined effects of NaCl and P

M. E. Rogers[1], C. M. Grieve[2] and M. C. Shannon[2]

Agriculture Victoria, Ferguson Rd. Tatura, Victoria.
[2] George E. Brown Laboratory, USDA/ARS 450 West Big Springs Rd. Riverside, California, USA.

ABSTRACT

The combined effect of NaCl and P on the growth of lucerne was studied in two separate greenhouse experiments. NaCl concentrations were identical in each experiment (0, 50 and 100 mM NaCl) but external P concentrations differed (viz. 0.2, 0.02 and 0.002 mM P in Experiment 1 and 0.5 and 5.0 mM P in Experiment 2). Plants were grown hydroponically and measurements made included root and shoot production, plant tissue ion concentrations and growth solution composition. Low P caused a greater reduction in plant biomass than high NaCl. A significant NaCl*P effect was found only in Experiment 1, where external P concentrations were lower than in Experiment 2. There was no difference in plant production between the two P concentrations of 0.5 and 5.0 mM P under the luxuriant external P conditions in Experiment 2. We conclude that the optimum P level for lucerne grown hydroponically is above 0.02 and below 0.5 mM, and lucerne plants appear to be more affected by low P than by salinity.

KEY WORDS

Alfalfa, P nutrition, salinity, salt tolerance.

INTRODUCTION

Nutrition can significantly influence a plant's response to saline conditions (Grattan and Grieve, 1999). The interaction between salinity and P nutrition is particularly complex and plant responses can vary according to which species or cultivar is being examined, the stage of plant growth as well as the level and form of NaCl and P and the specific conditions of the experiment (Champagnol, 1979). Lucerne (*Medicago sativa* L.) is a species whose tolerance to NaCl alone has been well-studied (e.g. Johnson et al., 1992), however its performance under saline conditions and varying P nutrition is unknown.

The purpose of this study was to investigate the response of lucerne to the combined effects of NaCl and P to determine how these two effects interact to influence salt tolerance and P uptake. This information may be of importance when deciding fertiliser applications in saline areas or in areas where wastewaters (containing high salinity levels and significant concentrations of P) are used for irrigation.

MATERIALS AND METHODS

Experiment 1

Plants were grown hydroponically in a greenhouse at Riverside, California, USA. Seedlings of two cultivars of lucerne (Moapa and Cuf 101), were grown in plastic grids placed on top of ceramic pots (57 litres) containing modified nutrient solution. The P treatments (0.2, 0.02 and 0.002 mM P) were applied immediately and the salinity treatments (0, 50 and 100 mM NaCl) were imposed 12 days later. The solutions were changed at fortnightly intervals and samples of solution were chemically analysed for P, Na, K, Ca and Mg using an Inductively Coupled Plasma Optical Emission Spectrophotometer (ICP) and Cl by silver nitrate titration using an ion selective electrode.

The experiment was a factorial design with three salinity treatments, three P treatments and three replicates placed in a split block structure. Plants were harvested destructively at weekly intervals and there were four harvests in total. At harvest, five plants of each cultivar from each treatment were removed and divided into roots and shoots. Fresh weight and dry weight (dried at 70 ?C for 48 hours) were measured on each sample. Plant material was analysed for Cl, Na, K, Mg, Ca and P.

Experiment 2

The design and procedures for the second experiment were similar to those used in Experiment 1 except only one cultivar of lucerne was grown (Aurora) and the P concentrations were higher (0.5 and 5.0 Mm P). The NaCl concentrations were identical. The plants were grown in polystyrene trays floating in modified nutrient solution in stainless steel tanks in a greenhouse at Tatura, Victoria. Measurements made included nutrient solutions and tissue ion analyses, and shoot and root dry matter production.

The experiment had an unbalanced design, with three NaCl treatments (0, 50 and 100 mM) and two P treatments (0.5 and 5.0 mM) and either three or four replicates.

Statistical analyses

Shoot dry matter growth and tissue ion concentration data were analysed by ANOVA with a randomised block structure (Genstat 5.0, Lawes Agricultural Trust, Rothamsted Experimental Station) for Experiment 1, and by REML (Restricted Maximal Likelihood) for Experiment 2. The data for the two cultivars in Experiment 1 were bulked.

RESULTS AND DISCUSSION

Experiment 1

The level of external P had a significant effect on plant growth at all harvests ($p<0.001$). Plants produced more dry matter at the highest P level (0.2 mM) compared with the lower two P levels regardless of the NaCl concentration ($p<0.001$). Shoot and root growth was severely retarded at the lowest P treatment (0.002 mM). Plants at this P level showed symptoms of P deficiency and were dark green in colour. Level of NaCl had no significant effect on plant dry matter production. The interaction between NaCl and P was significant ($p<0.05$). At the highest P level (0.2 mM), this interaction was negative with plants showing a reduction in growth with increasing NaCl concentrations whereas, at the lower two P levels (0.02 and 0.002 mM) there was no significant reduction in growth at the higher external salinity levels.

Shoot and root concentrations of Na and Cl increased significantly ($p<0.001$) with increasing NaCl concentration. External concentration of NaCl had no significant effect on shoot concentrations of P, however, root P concentrations tended to decrease with increasing NaCl level. There were significant increases ($p<0.001$) in P concentrations in both roots and shoots with increasing external P level.

Experiment 2

Plant biomass production decreased significantly with increasing NaCl concentration ($p<0.001$), but there was no significant difference in dry matter production between the two P treatments nor any NaCl*P effect.

As in Experiment 1, shoot and root concentrations of Na and Cl increased significantly ($p<0.001$) with increasing NaCl concentration. For shoots, there were no significant differences in tissue concentrations of either Na or Cl between the two external P levels, however, there were some differences in root concentrations of these ions at different external P levels. Concentrations of P did not differ according to external NaCl or P conditions in either the shoots or the roots.

Our results emphasise the complex relationship that exists between NaCl and P and confirm the finding that the response will vary according to many genetic, environmental and plant developmental factors (Grattan and Grieve, 1999). Under the experimental conditions described here, a significant NaCl *P effect was found only in Experiment 1, where P concentrations were much lower than in Experiment 2, indicating that, at external P conditions of less than 0.2 mM, lucerne plants are already suffering a significant yield loss and are relatively less sensitive to salinity. Under the luxuriant external conditions in

Experiment 2, there was no difference in plant production between the two P concentrations of 0.5 and 5.0 mM P.

CONCLUSION

Our results suggest that high or non-limiting concentrations of P (0.2 to 5.0 mM) do not appear to affect lucerne's response to NaCl. This information may be useful when 1) refining management strategies for the disposal of nutrient-rich saline wastewater, 2) calculating suitable P fertiliser rates for lucerne growing in saline soils and 3) determining the threshold concentration for saline irrigation water which can safely be applied to a lucerne crop that is growing in soil at a particular concentration of P.

REFERENCES

1. Champagnol, F. 1979. *Phosphorus Agri.* **76,** 3-43.

2. Grattan, S. R. and Grieve, C. M. 1999. *Sci. Hort.* **78,** 127-157.

3. Johnson, D.W., Smith, S. E. and Dobrenz, A. K 1992. Theor. Appl. Gen. **83,** 833-838.