Salt tolerant lentils – a possibility for the future?

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Abstract

309 accessions of lentil (*Lens culinaris* Medik.) were screened for tolerance to high levels of salinity (6 dS/m NaCl). Three attributes were used to determine tolerance; namely shoot dry weight, plant height, and visual symptoms of salinity toxicity. The visual symptom score indicated that 237 of the 309 screened accessions were significantly affected by 6 dS/m NaCl. Australian cultivars generally had low tolerance to NaCl, especially 'Nugget', which performed poorly in all three attributes. One accession that performed well in all three attributes was LG128 (ILL3534) from India.

Key Words

salinity, *Lens culinaris*, sodium chloride, pulses

Introduction

Poor growth of pulses in the southern Mallee of Victoria has been partly attributed to the hostile nature of the subsoils in this region. High pH, toxic boron levels, high salinity and sodicity are all contributing factors (P Rengasamy, personal communication), making these soils problematic to pulse growers, particularly in years with low rainfall. The nature of the environment excludes amelioration to alleviate the problem, and thus other alternatives, such as tolerant cultivars must be found to improve the reliability, productivity and profitability of pulses in this region. Genetic variation in tolerance to these factors must be identified before breeding can be initiated. Pulses are reputed to be salt sensitive (1). A reliable screening method for salinity tolerance and the identification of tolerance to salt in lentil is the first step toward gaining an understanding of the response of lentil to salinity, of the mechanisms that confer tolerance, and eventually to the breeding of salt-tolerant lentil cultivars suited to Australian conditions.

Methods

309 accessions of lentil were selected from landraces, VIDA breeding lines, the Australian Temperate Field Crops Collection (ATFCC), literature references and Australian cultivars for study. Six seeds of each accession were sown in pots containing 1:1 sand:humus (pasteurised Attunga? humus plus organic compost) mixture, and were watered daily with reverse osmosis water and a dilute commercial nutrient solution (either 'Aquasol'? + $Ca(NO_3)_2.H_2O$ + $MgSO_4.3H_2O$, or 'Nitrosol'? + $Ca(NO_3)_2.H_2O$ at 20% of the recommended concentrations for hydroponic solutions). Salinity treatments (?) were applied 10 days after the average date of plant emergence. Sodium chloride was added to the solution incrementally at 2 dS/m per day, until the concentration of NaCl in the solution was 6 dS/m. Control plants of each accession were watered with dilute nutrient solution only. Plants were watered with 150mL solution (? salt) daily for four weeks. Glasshouse day temperatures were 24?C? 4?C and 17?C? 2?C at night. Two replicates were evaluated over different periods in the same glasshouse unit. The control and salt-treated pots were randomised, and a repeated check accession was included to assess variation spatially within the glasshouse and temporally between replicates.

Plants were harvested 28 days after salt addition. Tolerance was assessed using three attributes: average shoot dry weight, average plant height and visual salinity symptoms. The selection of these attributes was based on the typical symptoms of salinity; namely stunting, reduction in plant biomass, an overall yellowing of the plant and in severe cases plant death. Visual symptoms were scored on a 1-10 scale where 1 = plant unaffected, and 10 = all plants dead.

The three measured attributes were analysed separately using the method of residual maximum likelihood (REML) (2). The significance of the main effects of accession and salt, and their interaction was assessed with Wald Tests, and pairwise t-tests were used to check for significance ($P \leq 0.05$) between the control and salt means for each accession.

Results

A subset of 20 accessions representing the full range of tolerance to salinity is reported in this paper.

Visual salinity symptoms did not appear until at least one week after the addition of the salt, and in some accessions salinity symptoms were not noticeable until 20 days after the salt treatment had been imposed.

Only within accession comparisons (i.e. between the control and salt treatment of the same accession) are reported in this paper.

The method of residual maximum likelihood indicated that the interactions between accession and salt for both dry weight and visual rating were highly significant ($P<0.001$), while the interaction for height was not significant ($P=0.966$). Within the data set there were, however, accessions that displayed significantly different ($P \leq 0.05$) heights between the salt and control treatments.

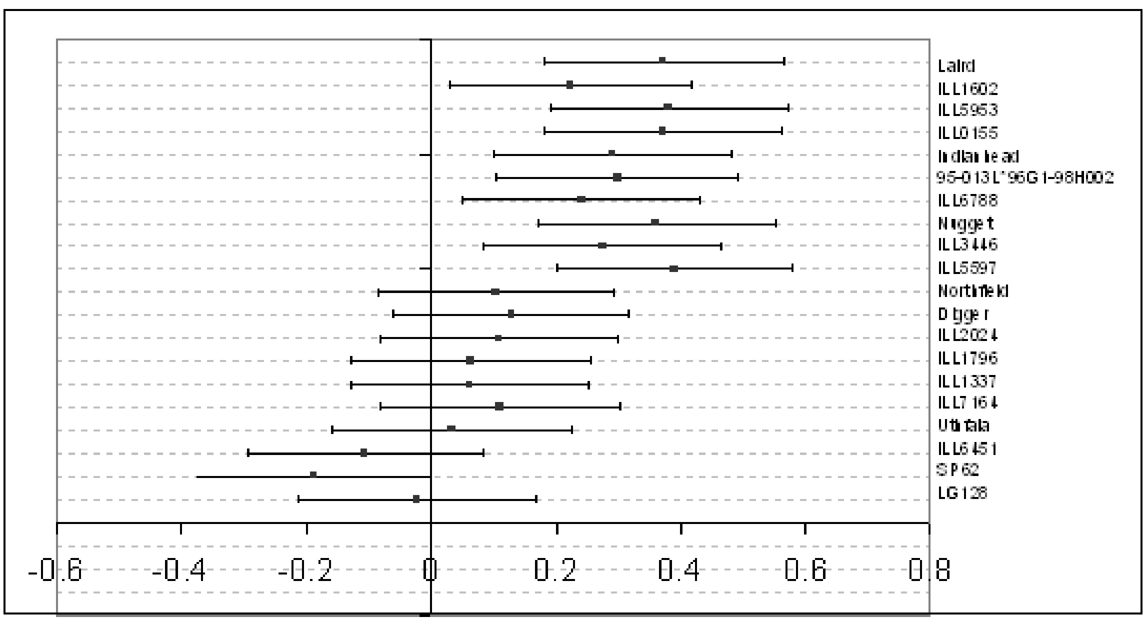

Figure 1. Confidence intervals for the difference in shoot dry weight between the control and salt treatments for the 20 selected accessions*.

* The horizontal lines correspond to 95% confidence intervals for the difference between the control and salt treatments of each accession. Accordingly, horizontal lines that do not overlap the zero vertical line indicate accessions for which the difference (control – salt) is significantly different from zero ($P \leq 0.05$).

Of the 309 accessions evaluated, 122 showed a significant decrease in plant dry weight under the high salinity ($6 dSm^{-1}$) regime used.

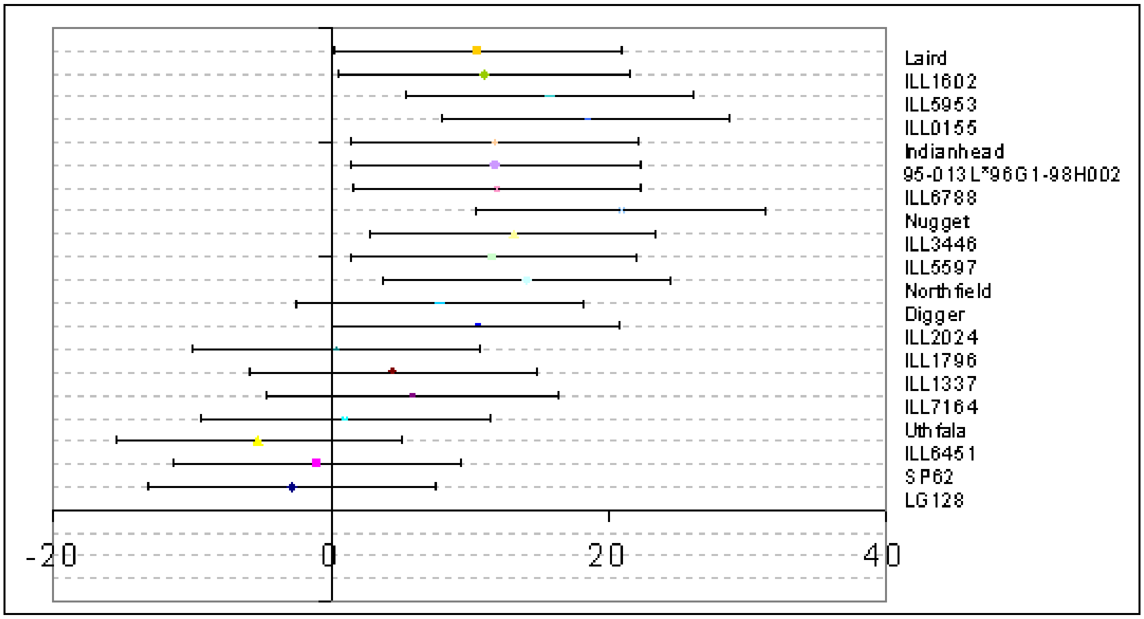

Figure 2. Confidence intervals for the difference in plant height between the control and salt treatments for the 20 selected accessions*.

* The horizontal lines correspond to 95% confidence intervals for the difference between the control and the salt treatments of each accession. Accordingly, horizontal lines that do not overlap the zero vertical line indicate accessions for which the difference (control – salt) is significantly different from zero ($P \leq 0.05$).

Of the 309 accessions evaluated, 165 showed a significant decrease in plant height in response to salinity. However plant height may not be an appropriate attribute to base salt tolerance on, as overall the interaction between salt and accession for plant height was not significant ($P=0.966$).

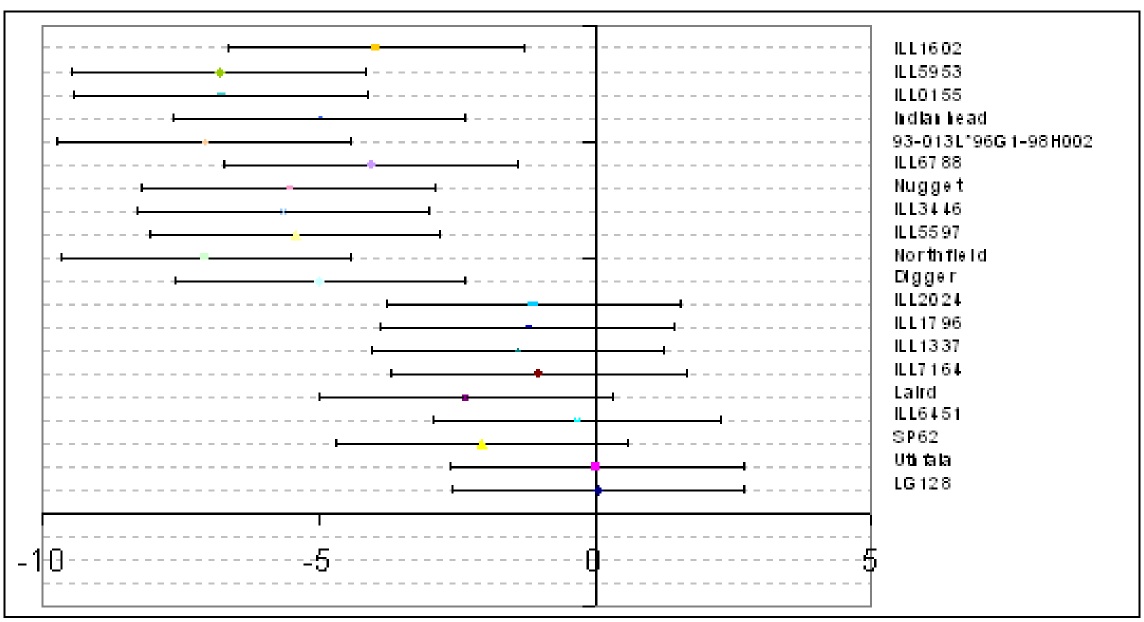

Figure 3. Confidence intervals for the difference in visual symptoms between control and salt treatments for the 20 selected accessions*.

* The horizontal lines correspond to 95% confidence intervals for the difference between the control and the salt for treatments of each accession. Accordingly, horizontal lines that do not overlap the zero vertical line indicate accessions for which the difference (control – salt) is significantly different from zero ($P \leq 0.05$).

Of the three attributes measured, the visual symptom scores placed more of the accessions into the ‘intolerant category’ than any other attribute. Of the 309 accessions tested, 237 showed a significant increase in visual symptoms compared with their control.

None of the 309 screened accessions produced significantly more growth in the salt treatment relative to the control, although some plants did show an increase in dry weight and height. Increased plant fresh weight has been found previously at low concentrations of salinity in *Sesbania grandiflora* (3). A number of accessions were consistently worse than their control in all three attributes, including Indianhead, Laird and Nugget. Australian cultivars generally performed poorly, with ‘Nugget’ the worst. ILL6788 has previously been identified as salt tolerant (4) but it consistently performed poorly ($P \leq 0.05$) in all attributes in our study. Accessions that performed better than ILL6788 in all attributes were identified, and their incorporation into a breeding program is warranted. LG128 (also known as ILL3534) from India was not significantly affected by salinity in all three attributes. SP62 from Chile and ILL 6451 (a breeding line from ICARDA, previously identified as salt tolerant (4)) were also relatively unaffected at the high salinity concentration tested. Accessions showing relatively strong growth and few symptoms under this level of salinity have already been incorporated into the lentil breeding program at VIDA.

The current screening method has its limitations. Screening is at an early seedling stage whereas in the southern Mallee salinity toxicity is more likely to occur later in the season. The correlation between salt tolerance at the early seedling stage and at later growth stages in lentil is unclear although some research indicates a positive relationship (5). Experiments are in progress to compare the response of lentils in the seedling stage with later growth stages, and assess whether the attributes measured correlate with seed yield.

Conclusion

The identification of lentil accessions with tolerance to high levels of salinity is the first step towards breeding a salt tolerant lentil cultivar for Australian conditions. Understanding the mechanisms that confer tolerance and its effects on plant water relations will help identify improved tolerance and cultural practices that will eventually lead to a more reliable lentil production system in the southern Mallee.

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