Lucerne varieties differ in their response to liming on an acid soil.

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ABSTRACT

An on-farm experiment was commenced in May 1999 to determine cultivar variation in lucerne with respect to soil acidity and response to applied lime. Ten lucernes were tested at two levels of lime (0 and 2 t/ha). Lucerne growth responded significantly to lime application. There was greater response to liming in the second and subsequent cuttings compared to the first cutting. Lime application also gave a significant improvement in nodulation and leaf to stem ratio of lucerne. Leaf drop was significantly reduced by lime application. Varieties had differential response to lime application. Response to lime application was greater in Aurora and Y8804 lucerne where yield increased by 32%, while Hunter River yield increased by only 12%. Hunterfield and PL55 performed well even without liming. Results suggest that lucerne cultivars differ in their ability to tolerate soil acidity. Liming and the growing of suitable cultivars may help to improve lucerne production on acid soils.

Key words

Acid soil, lucerne, nodulation, Varietal efficiency, varieties.

INTRODUCTION

Soil acidity is one of the factors limiting plant growth in many parts of the world (4, 5). This includes Australia where soil acidity is a major threat to the production and long term sustainability of pastures and other crops.

Lucerne is a deeply rooted perennial legume and is grown as a high quality animal feed on a wide range of soils, including acid soils. Lucerne, with its high nitrogen fixation capacity, is also grown in Australia in rotation with wheat to improve the yield and protein content of wheat grain. Among the pasture species, lucerne is considered to be sensitive to acid soils. Despite this farmers continue to grow lucerne because it is the most productive legume in northern NSW and is well adapted to the summer rainfall environment.

Amelioration of acid soils by surface application of lime and other materials is the main commercially available option (4, 7). Lime application on surface soil generally does not have a rapid effect in reducing the subsoil acidity (5, 2). Furthermore, mixing lime with the subsoil is generally not economically feasible (4). Therefore, selecting and growing acid-tolerant cultivars may be a sustainable approach for the better growth and productivity of pastures and crops on acid soils. There is very limited information regarding variation in lucerne cultivars for tolerance to acid soils. Lucerne grows well in a pH range of 6.5 to 7.5. However, with acidification brought on by usual crop production practices, it is important to find lucerne cultivars which extend this pH range. The present study was therefore designed to determine the variation in acidity tolerance of lucerne cultivars under field conditions, and to investigate the response of these cultivars to liming. This study has enabled us to determine the acid tolerance efficiency of these lucerne cultivars. Acid tolerance varietal efficiency indicates the ability of a cultivar/line to grow and yield better on acid soils than other cultivars.

MATERIALS AND METHODS

This experiment was commenced on 20th May 1999 as an on-farm trial at David Bowman's property near Dunedoo in NSW. The soil was a brown sandy clay loam having a soil pH of 4.8 (1:5 $CaCl_2$). Aluminium saturation % of soil was 0.8. The soil was high in manganese (DTPA extractable Mn 50 mg/kg) and iron (DTPA extractable Fe 53 mg/kg). The experiment was set up in a split-plot design with 10 lucerne cultivars in main plots and two lime levels in sub plots. There were three replications. The ten lucernes tested were Hunter River, Hunterfield, Sceptre, Aurora, Genesis, Aquarius, Y8804, Venus (Y8622), PL90 and PL55. Lime levels were nil and 2 tonne lime/ha. Each sub-plot was 7 ? 3.5 m. All data were subjected to an analysis of variance, including separation of main effects of cultivars and lime supply, and their interaction effects. Least Significant Difference (LSD at $P = 0.05$) was used to assess the differences among pairs of treatment means where the F values of the ANOVA indicated significance.

Lime was broadcasted and mixed in the top 3-5 cm layer three weeks before lucerne sowing. The seed was inoculated with commercial peat-based alfalfa inoculum *(Rhizobium meliloti*) before sowing. Seed was mixed in sand to facilitate the uniform spread and distribution in each plot. Seed was broadcasted at 6 kg ha^{-1} followed by raking.

Ten plants in each plot were randomly selected and carefully removed, 80 days after sowing, to record the number and dry weight of nodules per plant. Soil was washed off the roots under deionised water followed by a brief dip in double deionised water. Nodules were separated very carefully from the roots of each plant and counted. These nodules and roots were dried in an oven at 65 C for 48 h, and weighed.

Leaves were separated from stems of these plants, and dried in an oven at 65 C for 48 h, and weighed, to determine leaf to stem ratio.

Number of total leaflets and leaflets drop were also counted from the 20 stems taken at 120 days after sowing from each plot and referred to here as leaf drop (% of total leaves).

Herbage (above ground biomass) was harvested on 28 October 99, 21 December 99, 5 February, 19 April and 6 June 2000. At each harvest, herbage was dried in a dehydrator, and then the dry matter yields were determined. Total herbage dry weight yields are presented in the results and discussion section.

Acid tolerance efficiency (ratio of herbage yield in no lime treatment to herbage yield in +lime treatment and expressed as percentage) was calculated for each cultivar to determine the relative impact of lime application.

RESULTS AND DISCUSSION

Results indicate that lucerne responded significantly to lime application (Figure 1). There was greater response to liming in the second and subsequent cuttings compared with the first cutting. Lucernes differed markedly in response to lime application. Clearly the response to lime application was greater in Aurora and Y8804, while response was comparatively less in Hunter River. Acid tolerance efficiency was 68% in Aurora and Y8804 indicating 32% reduction in herbage yield when lime was not applied to these cultivars. Herbage yield of Aurora increased from 4.07 t/ha without lime application to 6.03 t/ha in +lime treatment. Similarly, yield of Y8804 increased from 5.35 t/ha without lime application to 7.89 t/ha in +lime treatment. There was only a 12% increase in yield of Hunter River with lime application. Ranking of lucerne cultivars/lines based on dry matter yields without lime treatment is in order of: PL55 > Hunterfield > Sceptre> PL90 > Venus > Y8804 > Genesis > Aquarius > Hunter River > Aurora (Figure 1).

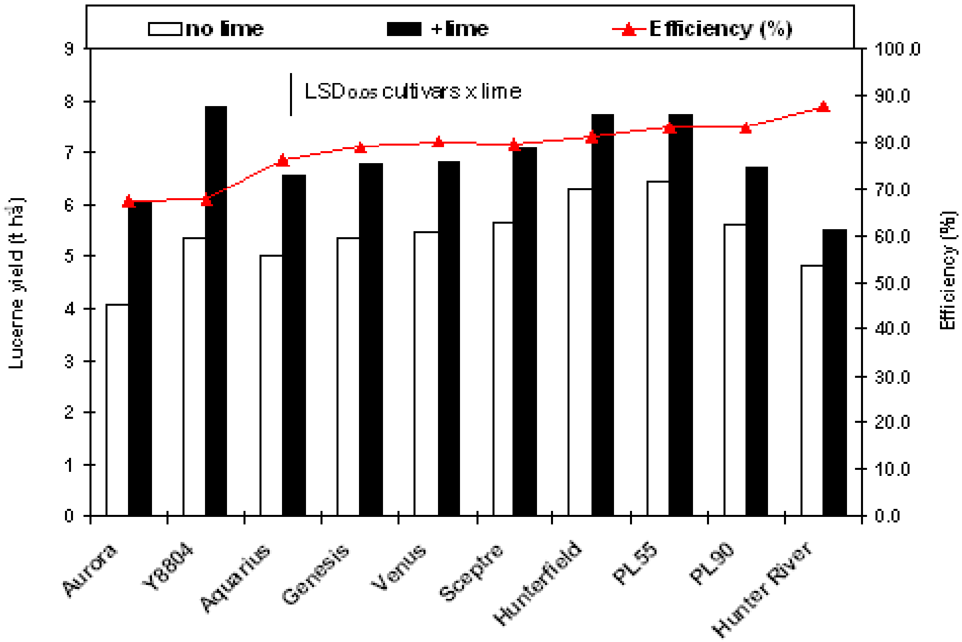

Figure 1. Response of lucerne cultivars to liming on an acid soil

Lime application produced a significant improvement in nodulation of lucerne (both number and dry weight of nodules per plant) (data not given). Cultivars differed significantly in number and dry weight of nodules. In the no lime treatment, PL55 had the highest dry weight of nodules followed by Hunterfield, Sceptre, PL90, Venus, Hunter River, Y8804, Aquarius, Genesis, and Aurora.

Leaf to stem ratio was improved significantly by lime application (data not given). PL55 had the highest leaf to stem ratio followed by Hunter River, Venus, Hunterfield, Sceptre, Genesis, Aurora, Aquarius, PL90 and Y8804. Leaves have much better quality than stems, so it is important to have leafy varieties to provide high quality lucerne.

Leaf drop was significantly reduced by lime application (Figure 2). Cultivars differed significantly in response to leaf drop. The ranking of lucernes according to leaf drop in the no lime treatment is PL55 < Hunter River < Hunterfield < Venus < Sceptre < PL 90 < Aurora < Aquarius < Genesis < Y8804.

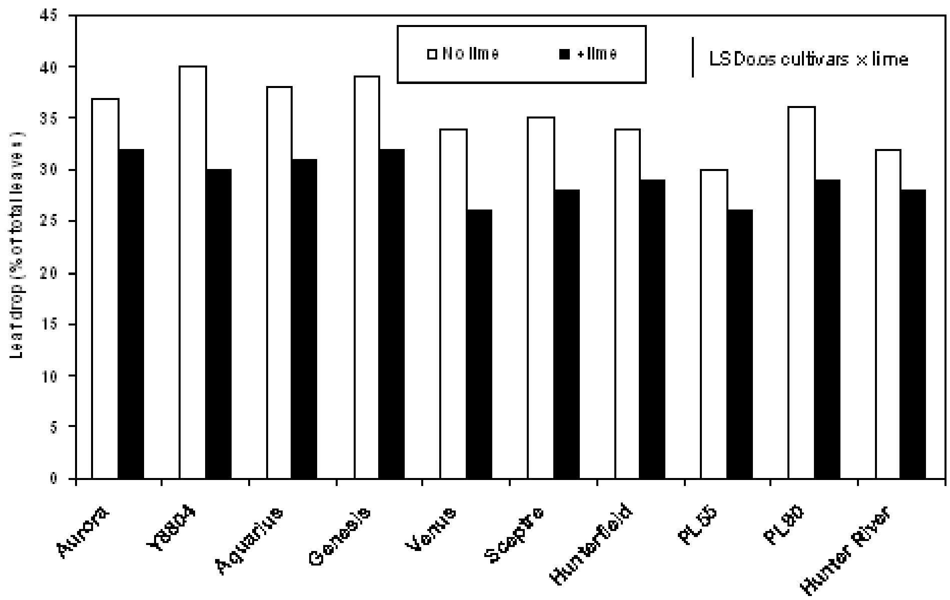

Figure 2. Effect of liming on leaf drop in lucerne cultivars on an acid soil

Genotypic differences for tolerance to soil acidity have been reported in maize (1, 6,). The results of our present study on lucerne similarly demonstrate variation in lucerne cultivars for tolerance to soil acidity. Differences in herbage yield, nodulation and leaf retention in lucerne cultivars on acid soil may be related to root development (elongation and absorption), translocation and utilisation of nutrients (1, 3). Cultivars with a high nutrient efficiency ratio (mg dry shoot weight/ mg of element in shoot), when grown under acid soil stress, may have an advantage in adapting to mineral-stressed acid soils. Cultivars/lines that are efficient nutrient utilisers might be useful in breeding for more efficient cultivars for mineral-stressed-acid soils.

CONCLUSIONS

Results suggest that growing adapted cultivars and liming on acid soil, not only increases herbage yield, but also improves leaf to stem ratio, leaf retention and nodulation in lucerne. These associations may have widespread implications in managing the growth potential and nitrogen contribution of lucerne on acid soils. It is concluded that selection and further breeding of acid-soil tolerant cultivars is feasible.

ACKNOWLEDGMENTS

The authors wish to thank Mr David Bowman (farmer) and Technical Officers, Bill Davidson, Jason Hughes and John Paul for their help with this trial. This research was partly supported by Grains Research and Development Corporation of Australia (GRDC Project DAN337).

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