Developing grazing tolerant lucerne

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Abstract

A major restriction to the broad adoption of lucerne in southern Australian farming systems is its inability to withstand persistent grazing pressure. A dryland grazing trial was sown at Roseworthy, South Australia, in September 1998 with continuous sheep grazing imposed from September 1999. This trial is investigating the grazing tolerance of a broad range of lucernes including existing cultivars, breeders lines generated from historic grazing trials, and 'wild type' lucernes introduced from overseas.The trial was completed in September 2000, with population densities ranging from 5-75% after 12 months of continuous grazing. A large amount of variation for persistence under continuous grazing pressure was shown to exist across all dormancy levels. Seed harvested from surviving plants in 2001 will be used to form new breeders lines in the development of grazing tolerant lucernes.

Key words

Lucerne, grazing tolerance, cropping rotation, water-use.

Introduction

With increasing interest being shown in lucerne for phase rotations in broad-acre cropping systems, the issue of grazing tolerance is once again being addressed. Cereal farmers will require a grazing tolerant lucerne because of limited fencing and little control over grazing pressure. Although current Australian lucerne cultivars have been developed for the animal industries, they are still incapable of persisting under continuous grazing.

The concept of grazing tolerance relates to maintaining high rates of plant recovery and growth during the removal of plant tissue usually by animals (7). Grazing tolerance has been linked to decumbency or prostrateness (7), a deep-set crown (6), subsurface budding (5), broad crowns (8), creeping roots (7), prolific and nonsynchronous budding (2), extended periods of budding (4), high stem number (7), maintenance of leaf area under grazing (3), and maintenance of root carbohydrates (3,8).

The importance of direct use of animals for screening grazing tolerance has been demonstrated by Smith *et al.* (9).Continuous grazing combines the stressful effects of trampling, tugging, waste excretion, and almost daily defoliation (8).

A standard test to characterise lucerne cultivars for grazing tolerance has been developed by the North American Alfalfa Improvement Conference organisation (NAAIC) (1). In this test, the plants are allowed to reach an early flowering stage before continuous intensive grazing begins. The paddock is then grazed with cattle for the entire grazing season, but supplemented with hay when forage supply becomes insufficient to maintain animal health (1). The initial establishment and final stand density are used to interpret the results. Surviving plants of each entry screened are used as parents to advance to the next cycle of selection or as parents for a synthetic cultivar (9).

This grazing trial seeks to determine the grazing tolerance of a range of lucernes under dryland Australian conditions using the more intensive selection pressure of sheep.

Methods

The design and management of the trial used the NAAIC protocol with a few major exceptions. Sheep were used to graze the trial to provide more intensive grazing than cattle and the trial was lengthened to a year in place of a single growing season.

The paddock was designed with a large border area to allow provisions for the sheep (water and shade) to be kept away from the trial area. The trial was sown early in September 1998 using a self-propelled plot seeder with 25cm row spacings. Each plot has 5 rows, m in width and 5m in length and is replicated three times. There were 120 entries sown representing a broad cross-section of Australian and introduced cultivars, breeders lines with previous grazing tolerant selection and 'wild type' lucernes with international origins. The plots were allowed to establish using conventional grazing management for the first year (1 week of grazing followed by 4-6 weeks rest). Winter vigour was measured visually using height as an index on the 27th August, 1999. The initial establishment density was measured on the 10th August 1999 using a 1m^2 wire grid placed in the middle of each plot. The wire grid has 50 cells, measuring 10x20cm. A score of 1 is given for each cell that contains at least one lucerne crown. The density score (number of plants in cells out of a possible 50) is approximately the number of plants/m^2. The score was doubled to give percentage density. Plant density was measured a further 4 times throughout the duration of the trial to follow the decline in plant population density.

Results

The intensive selection pressure imposed by a year of continuous sheep grazing was successful at dramatically reducing the population density of most lucerne entries. Final plant densities ranged from 2-100% of their original population or between 5-75% density (2-40 plants/m^2). The decline in density for a representative selection of entries over the one year period is illustrated in figure 1. The decline in density was fairly gradual for most of the cultivars until the trial reached the winter months, with the exception of Rippa. This cultivar had the greatest winter activity in the trial, and the least grazing tolerance.

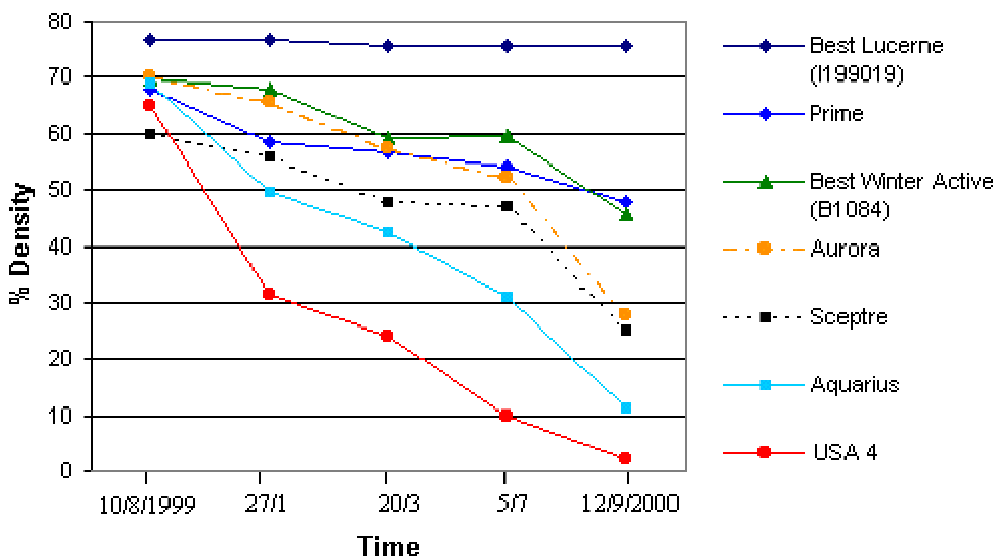

Figure 1. Lucerne density decline under continuous grazing.

The average 5% LSD for each date is 14.11, 15.6, 16.17,15.9, 12.81 respectively.

Although there is a general relationship between grazing tolerance and winter vigour, Figure 2 illustrates that it is not highly significant (r^2= 0.58). The red circles indicate lucerne breeders lines that have had parents with previous selection for grazing tolerance. In most cases this has been successful at increasing the grazing tolerance at each winter activity level. The entry with the highest grazing tolerance, 'I199019', is a low yielding wild type introduction with natural grazing tolerance. This introduction has several key characteristics that contribute to its grazing tolerance including deep set, broad crown, prostrate habit and a high stem number. Its plant density did not reduce during the duration of the trial (Figure 1).

The grazing tolerance of commercial cultivars entered into the trial is listed in Table 1. There are significant differences between the winter active (dormancy 6-8) and highly winter active (dormancy 8-9) cultivars. 'Sceptre' is notable for its comparatively high grazing tolerance relative to its winter activity. The American bred highly winter-active cultivars (USA1-4) have significantly less grazing tolerance than those developed in Australia, with the exception of 'Aquarius' and 'Falkiner'.

In the winter dormant class, Prime has significantly greater grazing tolerance than 'P545' and 'WL320'.

Figure 2: Winter activity and grazing tolerance.

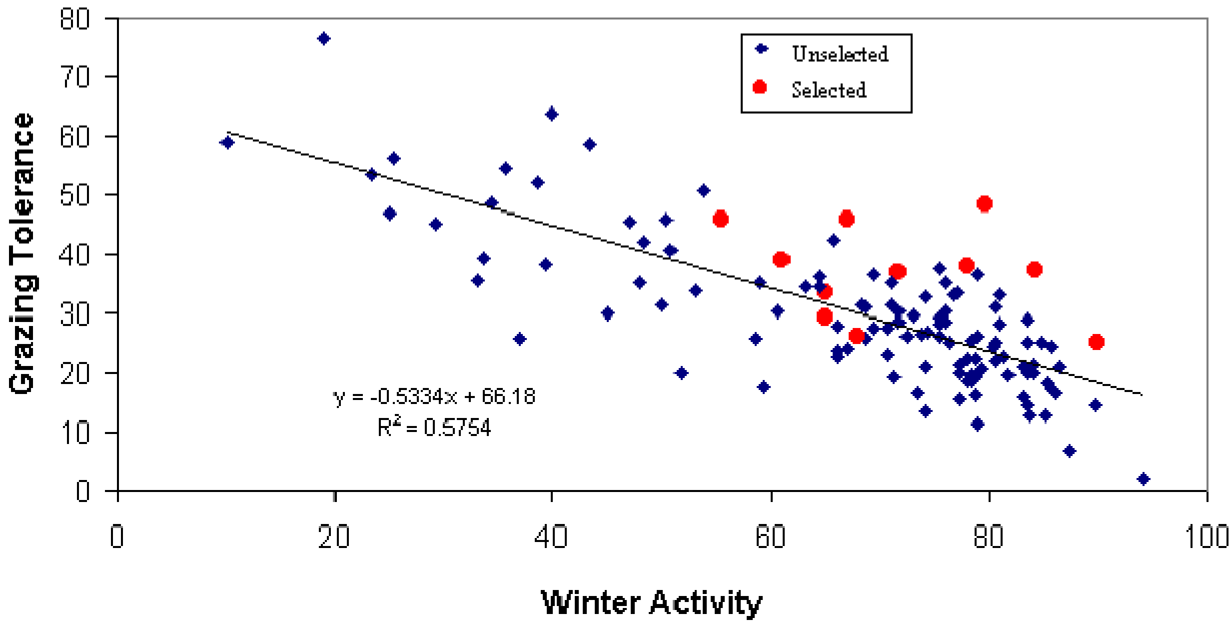

Table 1. Grazing tolerance of lucerne cultivars.

Entry	Winter vigour	Grazing tolerance	Entry	Winter Vigour	Grazing tolerance
I199019	1.9	99.99	Aurora	7.1	39.53
Jindera	1.0	94.99	WLS/S	5.9	38.29
B1084	6.5	79.38	Genesis	7.5	37.98
B1093	7.2	70.59	Hunter River	6.6	37.39
Prime	3.9	56.37	WL 320	4.2	35.27

C537	8.1	53.51	Eureka	8.1	35.26
Sheffield	6.6	50.00	Hallmark	8.4	27.20
Trifecta	7.4	44.17	Falkiner	7.4	17.02
Quadrella	7.2	43.80	Aquarius	7.9	16.37
Hunterfield	7.5	42.48	USA1	8.2	13.45
Flairdale	7.5	43.08	USA2	8.5	10.21
Sceptre	8.6	41.90	USA3	9.1	6.46
P545	3.3	41.85	USA4	9.8	3.28

'Grazing tolerance' refers to (final density)/(initial establishment)*100
Average 5% LSD =13.5 for grazing tolerance

Discussion

The domesticated winter active lucernes in this trial were unable to withstand continuous grazing for one year. However, the winter active Australian bred cultivars performed much better than expected, with most having a grazing tolerance of 37-50% (approximately 12-15 plants/m^2). The results probably reflect the passive selection pressure that has developed from using sheep grazing on Australian lucerne breeding field trials. The two winter active class (6 and 7) breeders lines 'B1084 and B1093' reflect the potential grazing tolerance that can be achieved with recurrent selection.

The American bred highly winter active lucerne cultivars (dormancy 8-9) performed poorly in this grazing trial relative to the Australian cultivars 'Sceptre', 'Eureka' and 'Hallmark'. They are often selected and bred for haymaking or 'cut and carry' green forage and not for utilisation by sheep grazing. This management can reduce their tolerance to trampling, urine burn and other effects of grazing animals.

The decline of the super winter active cultivar 'USA4', is an indication of the low grazing tolerance in all current highly winter active lucernes. The new super winter active lucernes (winter activity rating 9.5-10) have been marketed by seed companies for short phase rotations. Improvements in grazing tolerance of highly winter active lines will be important where the lucerne in a phase is not being cut for hay. Developing a very winter active lucerne with grazing tolerance is clearly a very challenging task, since narrow, high crowns are characteristic of these plants. SARDI's conventional breeding trials are showing that many current highly winter active lucernes struggle to persist for 3 years, even under rotational grazing.

The decumbent growth habit and high winter dormancy of extremely grazing tolerant lucerne make this material poorly suited as a monoculture pasture species in areas of southern Australia where cold conditions represent a significant part of the growing season. However, this material may be useful for intercropping, where winter growth is associated with competition against the annual crop and is not desired.

There may also be a role for prostrate, dormant grazing tolerant material in a pasture mixture where the lucerne extends the growing season of a pasture that predominantly contains annuals. The results of this trial have shown that extremely grazing tolerant lucernes can survive at least one year of continuous grazing pressure in a situation where no other feed was available. In a pasture mixture the grazing pressure will be less persistent on the lucerne because the annual plants would provide most of the production during winter months, with the shorter dormant lucerne avoiding grazing. The performance of this lucerne in a pasture mixture needs to be confirmed over a time period of more than one year.

A diverse group of lucerne germplasm was tested for grazing tolerance by the Department of Agriculture, South Australia, in the early to late 1970s. Tolerant lines were detected, but further breeding has been neglected due to the need to develop lines with aphid and disease resistance. Although parent plants were not directly compared with the selected generation, the results in figure 2 suggest that a gain in grazing tolerance has been made in previous grazing tolerance selections. A further study using selected and unselected populations will be completed to test the heritability of the trait and quantify the genetic gain made in grazing tolerance. Individual survivors from the best entries have been dug up and transferred to the Waite Institute where they will be crossed with other grazing tolerant and disease resistant material to form new breeders lines and potentially new cultivars.

Conclusion

The results of this sheep grazing trial have shown that there is further potential to increase the grazing tolerance of lucerne in all winter activity classes. Australian bred lucerne cultivars in general already exhibit a moderate level of tolerance, but require rotational grazing to maintain a high population density.

Grazing tolerance across a wide range of winter dormancy classes will extend existing applications, including lucerne for cropping systems and permanent pastures.

Acknowledgments

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References

1. Bouton, J. H. and Smith, S.R. 1996. In: Standard Tests to Characterize Alfalfa Cultivars. 8th Ed. (*North American Alfalfa Improvement Conference*)

2. Brummer, E. C. and Bouton, J.H. 1991. *Agron. J.* **83,** 996-1000.

3. Brummer, E. C. and Bouton, J.H. 1992. *Agron. J.* **84,** 138-143.

4. Leach, G. J. 1979. *Aust. J. Exp. Agric. Anim. Husb*.**19,** 208-215.

5. Lorenz, R. J., Buchholz, D.D., Rausch, D.L. and Coutts, J.H. 1986. In: Alfalfa for Dryland Grazing. (USDA-ARS: Washingon DC)

6. Piskovatski, J. M. and Stepanova, G.V. 1981. *Report of the 27th Alfalfa Improvement Conference*, Madison, p70-73.

7. Small, E. 1996. *Can. J. Bot*. **74,** 807-822.

8. Smith, S. R. and Bouton, J.H. 1993. *Crop Sci*. **33,** 1321-1328.

9. Smith, S. R., Bouton, J.H. and Hoveland, C.S. 1989. *Agron. J.* **81,** 960-965.