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Performance and persistence of six perennial grasses under different intensities of drought and defoliation

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I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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Suzanne Boschma

To my bearded burbler...

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Abstract

An experiment was conducted under a rain–out shelter at CSIRO's Pastoral Research Laboratory near Armidale, New South Wales, Australia to assess the production and persistence of perennial grasses under different intensities of drought and defoliation stresses. The trial consisted of six perennial grass species; four introduced (tall fescue, cocksfoot, perennial ryegrass and phalaris) and two native (weeping grass and wallaby grass). Two defoliation intensities and three moisture regimes (two droughts and a 'non–stress' control) were applied. The treatments were applied for two six–monthly experimental seasons, Spring–Summer (SS) and Summer–Autumn (SA). Measurements taken included basal area, dry matter yields, green foliage index, nutritive value, carbohydrate reserves, soil water and root distribution.

The aims of this thesis were to quantify the separate and interactive effects of defoliation intensity, drought severity and season of perennial grasses on the measures listed above, and to investigate plant traits which may be important in the persistence of these grasses. With a better understanding of persistence and how pasture grass species respond to drought and defoliation stresses, better management recommendations can be developed.

The severe defoliation treatment stimulated growth, resulting in greater yields than those moderately defoliated. Yields were reduced by both moderate and severe drought, with defoliation intensity generally having no effect during severe drought. During the SS season, drought reduced the phenological plant development (ie. the plants remained vegetative), while during the SA season severe defoliation reduced development. The nutritive quality of the introduced species was similar while the natives tended to respond differently. Wallaby grass tended to have the lowest nutritive value attributes among the species assessed.

Plant basal area increased during summer, however the rate of increase was reduced by severe defoliation and by drought. The green foliage index (foliage percent–green) of the droughted plants fell faster in the SA season than the SS season, possibly due to the higher summer temperatures and evaporation rates. Drought had a greater effect on green index than defoliation intensity. Once the green foliage index had fallen due to drought, there was no effect of defoliation intensity.

In general, defoliation intensity had a substantial effect on plant carbohydrate reserves during the SA season, with severe defoliation inhibiting carbohydrate reserve accumulation. Drought and drought severity had a greater effect on plant carbohydrate reserves in the SS season than the SA season. Reserves accumulated during spring drought. Carbohydrate levels declined during summer when preceded by a spring drought, but rose during summer and autumn when preceded by spring

with favourable rainfall. Fructans appear to have been hydrolysed during the SS season summer drought, while fructan accumulation appeared to have been inhibited by severe defoliation during the SA season.

The effects of the drought and defoliation treatments on soil water were greater during the SS than the SA season, possibly due to high temperatures and high spring growth rates. Defoliation intensity had little effect on soil water content, root mass, root distribution or rooting depth in either experimental season. The rate at which the soil profile dried increased with increasing drought severity, with the differences between the three moisture treatments decreasing with depth. The greatest differences in soil moisture were in the SS season. Root growth occurred below 60 cm during the spring with favourable rainfall, prior to the start of the SA experimental season, however the extra root mass was lost during the SA season. Root weight declined during both experimental seasons, with the greatest reductions occurring in the upper 40 cm of the soil profile. There were no changes below 40 cm in the SS season, while during the SA season there were reductions in root weight at depths below 60 cm in phalaris, perennial ryegrass and wallaby grass. In SS, phalaris, tall fescue and wallaby grass were the deepest rooting species and cocksfoot the shallowest rooting species. Rooting depth was greatest in the 10% drought and shallowest in the 40% drought treatment plots. There were no differences in the SA season. Hydrological models, such as WaterMod, are an effective means of exploring soil water data. WaterMod was effective in graphically showing the movement of water in the soil profile on a daily basis. The model was also effective in showing infiltration following rainfall/irrigation, drainage and the region of maximum root activity.

There were a number of conclusions from the work reported in this thesis. Firstly, the results highlighted that each of the species assessed responded differently to the treatments imposed, suggesting that different management strategies may be needed for individual species. Tall fescue was the best performing species, while the others performed similarly.

Environmental factors (moisture regime) have a greater effect on plant responses during the SS season, while management (defoliation intensity) has a greater effect during SA. The rainfall during spring affects plant carbohydrate reserves during the spring months and the response during the subsequent summer months. Drought during spring results in a decline in carbohydrate reserves during the summer period, while a spring with good rainfall results in an increase in carbohydrate reserves.

Perennial grasses are more likely to die during moderate SS droughts, especially cocksfoot and perennial ryegrass. This reinforces the need for pastures to be moderately grazed during the spring

period to ensure survival over summer. Persistence during drought can be improved by maintaining high plant basal area. It is also important to adopt management strategies that allow plants to accumulate and maintain high levels of plant reserves during spring and summer, and good yields during summer and autumn.

During dry periods or droughts, reducing both grazing intensity and frequency to maintain a pasture with approximately 1500 kg DM/ha biomass will enhance plant survival. Maintaining good herbage biomass throughout a drought will benefit carbohydrate reserve levels, also ensure a high leaf area for photosynthesis, which will assist plant recovery once the drought is relieved. Suggestions are made for future research.

Publications

The following papers are a result of the work (either in part or total) produced during this project:

Scott, J. M., Rapp, G. G. and Boschma, S. P. 1994. Managing the persistence of perennial grasses through drought. *Proceedings of the 9th Annual Conference of the Grassland Society of NSW*. pp. 112. Poster presentation.

Boschma, S. P., Scott, J. M. and Rapp, G. G. 1995. Yield of perennial grasses under different drought and grazing intensities during spring and summer. *Proceedings of the 10th Annual Conference of the Grassland Society of NSW*. pp. 90. Poster presentation.

Boschma, S. P., Hill, M. J., Scott J. M. and Rapp, G. G. 1996. Effect of different intensities of drought and defoliation upon the mortality of perennial grasses. *8th Australian Agronomy Conference, 1996*. pp. 624. Poster presentation.

King, J. R., Boschma, S. P., Scott J. M. and Hill, M. J. 1996. Etiolated regrowth as a measure of potential forage grass recovery following drought stress in New South Wales, Australia. *The Canadian Society of Agronomy, June 1996*. pp. 811. Poster presentation.

Boschma, S. P., Hill, M. J., Scott J. M. and Lutton, J. J. 1997. Carbohydrate reserves of perennial grasses: Effect of drought and defoliation intensity. *XVII International Grassland Congress 1997, Canada*. pp. 22-41–22-42. Poster presentation.

King, J. R., Scott J. M. and Boschma, S. P. 1997. Forage persistence under extremes of cold and drought. *XVII International Grassland Congress 1997, Canada*. In press. Plenary paper presented by J. King.

Scott, J. M., Boschma, S. P. and Rapp, G. G. 1997. How can graziers manage perennial grasses to survive through drought? *Proceedings of the 12th Annual Conference of the Grassland Society, NSW*. pp. 140–142. Poster presentation.

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