Drought resistance of native and introduced perennial grass species

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ABSTRACT

We studied the responses of a range of native and introduced perennial grass species to drought. All species showed good drought resistance, and the varied responses were interpreted in the context of the dominant strategy utilised by each species: tissue dehydration avoidance or dehydration tolerance. We conclude that species with the dehydration tolerance strategy such as *Eragrostis curvula, Themeda australis* and *Austrodanthonia racemosa* will be the most drought resistant.

Key words

Avoidance, dehydration, drought, perennial grass, resistance, strategy, tolerance.

INTRODUCTION

Perennial grasses are the key to the economic and environmental sustainability of pastures for livestock grazing on the New South Wales tablelands. Catastrophic losses of perennial grasses can occur during drought periods and there is anecdotal evidence of differences in drought resistance among species, but information on the basic ecophysiological responses of these species to water stress is lacking. Perennial plant characteristics and responses to water stress seem to coincide so as to comprise alternative strategies of avoidance or tolerance of tissue water deficits (Ludlow 1989). Our aim was to determine the responses of 8 perennial grass species to drought in terms of their strategy as avoiders or tolerators of water deficits.

METHODS

The eight species studied are listed in Table 1. The first 3 species listed are introduced, and the following 5 are native to Australia. The experiment was conducted in a growth cabinet controlled to 24 ?C light/ 18 ?C dark, and a 16 h photoperiod of 600 ?mol m-2s-1 photo synthetically active radiation. Plants were grown in pots containing 6.5 kg of a silty loam topsoil from Sutton, NSW. Pots were rewatered daily to 60% of field capacity for 6-8 weeks of plant growth until the drought treatment commenced and no more water was applied. Pots were weighed daily to determine their water use and soil water content, expressed as a percentage of the available soil water (ASW) between the field capacity (35.5% gravimetric soil water) and the final soil water (FSW) content reached by each species (Table 1). Leaf relative water content (RWC) was measured at the end of the dark period, daily for about the first 10 days of drought and then every 2-3 days until all leaves had died, and the RWC of the last surviving leaf (RWC_L) was used to determine the lethal value (Ludlow 1989).

Table 1. Lethal relative water content (RWC_L), leaf survival period, final soil water content (FSW) and available soil water threshold for transpiration decline (ASW_T) in 8 perennial grass species.

Species	RWC_L (%)	Leaf Survival (days)	FSW (%)	ASW_T (%)
Phalaris aquatica	31.4	23	9.40	25.3

Dactylis glomerata	30.9	33	7.99	23.9
Eragrostis curvula	23.2	37	7.11	30.9
Themeda australis	22.7	32	8.39	32.9
Bothriochloa macra	27.7	21	9.02	24.4
Microlaena stipoides	23.7	21	7.62	26.0
Austrodanthonia racemosa	24.5	38	6.76	31.3
Austrodanthonia caespitosa	28.0	40	7.51	28.5

RESULTS AND DISCUSSION

Leaf RWC remained high with soil drying in all species until a threshold at 20-15% ASW, after which RWC declined with ASW to the RWC_L (Fig. 1). In the continuum of responses between extreme avoidance and extreme tolerance, the single most important determinant of strategy is the tissue dehydration tolerance of the species, as assessed by the RWC_L (Ludlow 1989). All 8 species would be considered dehydration tolerant when compared to other species (Ludlow 1989), with 4 species considered as having a tolerance strategy (RWC_L<25%), and the other 4 species considered as having a strategy intermediate between tolerance and avoidance (RWC_L>50%) of dehydration (Table 1).

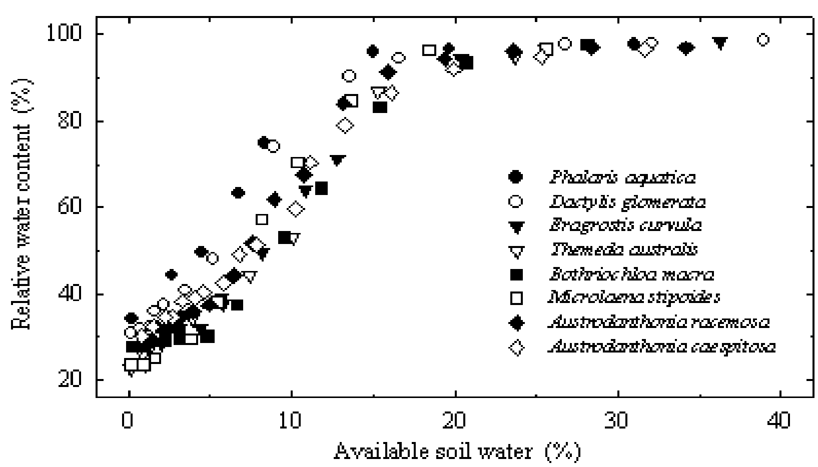

Figure 1. Changes in leaf relative water content with available soil water for 8 perennial grass species.

In the tolerance strategy, *E. curvula, T. australis* and *A. racemosa* seem to have a conservative response: to minimise water loss and conserve green leaf area (at the cost of fixing carbon), waiting for the drought to end. Their daily transpiration began to decline linearly with declining ASW at threshold values (ASW_T) higher than the other species (Table 1). The slow rate of water loss (aided by leaf rolling or folding) combined with their dehydration tolerance resulted a long period of leaf survival in these species. In contrast, *M. stipoides* had good dehydration tolerance but was less conservative in reducing water losses, resulting in a short period of leaf survival. Perhaps the response of M. stipoides is to opportunistically fix carbon (and thereby lose water) in the face of drought.

P. aquatica and *B. macra* are classified as dehydration avoiders/tolerators, however they did not appear to be very good at avoiding dehydration as indicated by low ASW_T values and short leaf survival periods, resulting in high FSW values (Table 1). Field measurements (data not presented) indicate that these species have deep roots, so their dehydration avoidance may arise more from maximising water uptake than from traits associated with minimising water loss. However, *P. aquatica* and *B. macra* also showed pronounced leaf wilting at ASW_T followed by senescence of older leaves, a plastic response to minimise water loss. *D. glomerata* and *A. caespitosa* seem better adapted to avoiding dehydration by minimising water loss, as indicated by a long period of leaf survival and low FSW values (Table 1). *D. glomerata* folded and *A. caespitosa* rolled its leaves in elastic responses to water deficits. *A. caespitosa* may also avoid dehydration by maximising water uptake with deep roots as indicated by field measurements (data not presented).

CONCLUSION

The concept of strategies is a useful framework for interpreting the multiple responses of plants to drought. Good drought resistance can be achieved with either the dehydration avoidance or tolerance strategy, as we have seen here, but ultimately species of the tolerance strategy such as *E. curvula, T. australis* and *A. racemosa* will be the most drought resistant.

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