Drought resistance of perennial grasses

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Abstract
An experiment was conducted to determine the responses of 7 native and 3 introduced perennial grass species to continuous drought. Leaf survival during severe drought varied among the species nearly four-fold, from 11 to 40 days. Some native species had the longest and some the shortest leaf survival times, with the introduced species ranking intermediate. The value of deep roots was not tested in these experiments, but some species exhibited various morphological traits which contributed to survival during severe drought, such as leaf folding or rolling, leaf shedding and leaf wax coatings.

Key words
Available soil water, dehydration tolerance, leaf survival, relative water content.

Introduction
Native grasses are generally regarded as being deeper-rooted and more drought tolerant than introduced grass species, but there is little reliable information to support these claims. Losses of perennial grasses can occur during drought periods, so their ability to survive drought may be as important as their productivity. We report on an experiment where 10 grass species were subjected to drought. A number of physiological traits were measured that compare their abilities to avoid or tolerate dehydration, contributing to their overall 'strategy' of drought resistance (Ludlow 1989).

Methods
Ten perennial grass species, including 7 native Australian species (*Austrodanthonia caespitosa*, *A. duttoniana*, *A. racemosa*, *A. richardsonii* cv. Taranna, *Microlaena stipoides*, *Bothriochloa macra* and *Themeda australis*) and 3 introduced species (*Phalaris aquatica* cv. Landmaster, *Dactylis glomerata* cv. Currie and *Eragrostis curvula* cv. Consol) were studied. Single plants of each species in pots (15 cm diameter and 40 cm depth) in a growth chamber were watered daily to 45% of field capacity for 6 to 8 weeks to allow roots to reach the bottom of the pots. At this point, the drought treatment commenced, and no more water was applied. Various physiological measurements were taken to determine how plants used or conserved water as the soil dried out.

Results and discussion
All of the perennial grass species exhibited the three stages of plant response to soil drying and dehydration defined by Sinclair and Ludlow (1986). There were few differences between species in Stages I and II, but leaf survival during Stage III ranged nearly four-fold, from 11 days for *Microlaena* and *Bothriochloa* to 40 days for *A. caespitosa*. Using principal components analysis, 3 species groups were identified with similar 'strategies' of response to water deficits (Figure 1). *T. australis* did not fit into any group.

Group 1. The 4 *Austrodanthonia* species and *Eragrostis* all had good dehydration tolerance and also good dehydration avoidance traits. They exhibited a conservative response of transpiration to declining soil water, and they had a larger supply of water to use during Stage III as leaf death approached.

Group 2. *Dactylis* and *Phalaris* had lower values of available soil water (ASW) in stage III and, accordingly, a shorter leaf survival time. *Dactylis* and *Phalaris* differed from the other 8 species in having lower dehydration tolerance, as indicated by higher values of relative water content at which leaf death occurred. These were above the threshold used by Ludlow (1989) to classify species as having a dehydration tolerance strategy to water stress.

Group 3. *Bothriochloa* and *Microlaena* had good dehydration tolerance, but poor dehydration

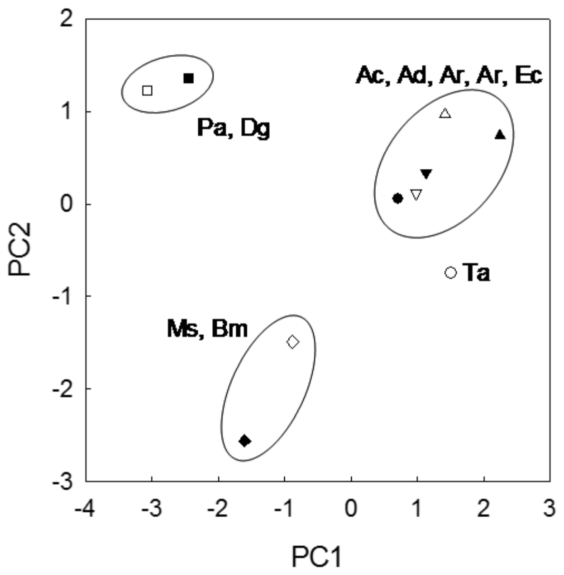

Figure 1. Grouping of 10 perennial grass species by principal components analysis for traits relating to drought resistance. Species are indicated by the first letters of their genus and species names, as given in the Methods.

avoidance during Stage II, indicated by lower water content values in Stage III than the other species, resulting in the shortest leaf survival times.

Leaf survival depends upon the rate of water loss from the leaf and the difference in relative water content (ΔRWC) at which transpiration becomes minimal and leaves die. Thus, leaf survival, as a measure of drought resistance, results from a combination of drought avoidance and drought tolerance traits (Ludlow 1989). We found that the best predictors for leaf survival among these perennial grasses were ΔRWC, a plant water trait, and ASW in Stage III, a soil water trait. These traits are both measures of the amount of water available to the plant during Stage III.

We found that species exhibited differences in leaf morphological traits which, although more qualitative than quantitative, may well have contributed to dehydration avoidance. For example, *Dactylis* and *Themeda* folded their leaves, while *A. caespitosa* and *Eragrostis* tightly rolled their leaves at the beginning of Stage III. These contribute to dehydration avoidance by minimising effective leaf area and, therefore, water loss (Ludlow 1989). In contrast, *Bothriochloa* and *Phalaris* rapidly shed most of their leaves at the beginning of Stage III, a 'plastic' response reducing leaf area and water loss, thus contributing to dehydration avoidance. *Austrodanthonia* species had a range of traits such as large amounts of cuticular wax on leaves, hairy leaves or most stomates on the upper surface of leaves (protected when rolled). All these features may have aided in reducing water loss.

It should be noted that the results presented here only show differences between plants in their internal physiology, as the depth of the pots in this experiment prevented the expression of any drought resistance due to species greater rooting depth. Deep roots, by increasing the supply of water to the plant, are an important trait for dehydration avoidance which may contribute significantly to the drought resistance of deep-rooted species (Ludlow 1989). For example, although *Dactylis* and *Phalaris* showed similar characteristics for leaf survival and other traits (Figure 1), *Phalaris* is consistently reported to be deeper-rooted (McWilliam and Kramer 1968), and anecdotal evidence suggests it is more drought resistant than *Dactylis*. A deep-rooted nature to compensate for poor dehydration avoidance during Stage III drought is therefore an additional benefit.

References

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