Perennial grass survival in drought

Hodgkinson, K.C.

CSIRO Sustainable Ecosystems, GPO Box 284, Canberra, ACT 2601

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Abstract

The survival of perennial grass plants in drought is of scientific and applied interest; scientists want to know why species differ in ability to cope with individual and combined stresses of drought, grazing and fire, and graziers want to maximise survival of desirable forage plants because natural replacement can be very unreliable. Five species taken from Canberra grasslands were glasshouse-grown in large 1 m tall pots for one year and then watering ceased. The rate of passage through early drought stages differed between species. Rewatering plants at various times from onset of full drought was used to determine viability from which survivorship curves were generated. Three native grasses (*Themeda triandra*, *Austrodanthonia auriculata* and *Bothriochloa macra*) and one exotic species (*Phalaris aquatica*) had similar survivorship curves with 50% survival between 60 and 120 days. For the second exotic species, *Eragrostis curvula*, 50% survival was at 260 days. Density of viable tillers generally declined during drought before plant death.

Introduction

The survivorship curves of perennial grasses in arid and semi-arid rangelands eg. Williams (1970) are typically of two types; positively (Deevey Type I) or negatively skewed (Deevey Type III) see (Deevey 1947). At the CSIRO research site at "Lake Mere", in a semi-arid mulga wooded landscape, the survivorship curves for the four dominant perennial grasses conformed to Deevey Type I (Hodgkinson and Muller 2005); risk of death was low between 1986 and 1990 but between 1990 and 1996 there was accelerating risk of death. A grass death model was developed from the data; death begins when 3-month rainfall total declines below a critical threshold of 75 mm and the death rate rises with further low rainfall. Survivorship of several perennial grass species at widely spaced sites in south-eastern Australia provided equivocal support for generality of this grass death model.

Earlier, Harradine and Whalley (1979) had demonstrated that there were differences in the drought tolerance of three perennial grasses from the north-western slopes of NSW. Their glasshouse pot experiment was designed to determine the relative tolerance of the grasses to repeated, increasing levels of water stress in a limited volume of soil. Pots of different but small sizes were used.

In this paper, survival of well established tussock perennial grasses, in long columns of soil to more closely simulate field conditions and the slow extraction of water that takes place, are compared. Typically well-established perennial grasses have rooting depths of one meter or more, provided the soil is deep.

Methods

Intact bases of five grass species (*Ausrodanthonia auriculata* (J.M. Black) H.P. Linder, *Bothriochloa macra* (Steud.) S.T. Blake, *Eragrostis curvula* (Schard.) Nees, *Phalaris aquatica* L. and *Themeda triandra Forsskal*) common to ACT grasslands were cored to a 20cm depth from populations in the suburb of Lawson during September 2000. The cored bases (40 of each species) were laid on top of a commercial soil mix in pots 1 m high by 0.25 m internal diameter and the 200 pots were placed in a semi-controlled glasshouse. Drought and defoliation treatments were imposed until August 2001 and then all pots were rewatered to field capacity and plants grown without any imposed stresses until mid January 2002.

In mid-January the regular watering of pots ceased. Each plant was then checked regularly and assessed for drought status; 1. active leaf growth, 2. leaf wilting, 3. leaf necrosis, 4. all leaves necrotic, some green stem tissue, 5. all leaves and stems dead. After drought status 5 was reached, small sets of randomly selected plants of each species were rewatered to soil field capacity at various times into the drought. About 21 days later each rewatered plant was examined closely for production of new leaves. If no leaves emerged the plant was deemed dead on the day of rewatering. If green leaves were present the plant was deemed alive and the number of tillers counted along with the basal diameter of the plant.

Data in binary form on plant survival after full drought began was used to derive logistic survivorship curves for each species.

Results

Days to drought

The number of days from when the soil columns were at full water capacity to when individual plants had reached full drought status after withholding water, differed widely between species and within species. In order of days to full drought status, the species and the mean days (in bold) and the lowest and highest days (in brackets) are as follows: *P. aquatica* 73 (31 to 130), *B. macra* 135 (121 to 232), *T. triandra* 168 (97 to 377), *E. curvula* 173 (103 to 418) and *A. auriculata* 252 (111 to 561).

Live tillers on rewatering in drought

Fig.1 shows the density of live tillers generally declined for each species as plants remained in drought. This is best seen in *A. auriculata*. Also the death of plants in drought began for all species very soon after the foliage of plants had died. Species differed in the critical threshold for days in drought beyond which all plants of a species died; for *A. auriculata*, *P. aquatica* and *T. triandra* it was about 100 days, for *B. macra* it was about 200 days and for *E. curvula* it was greater than 300 days.

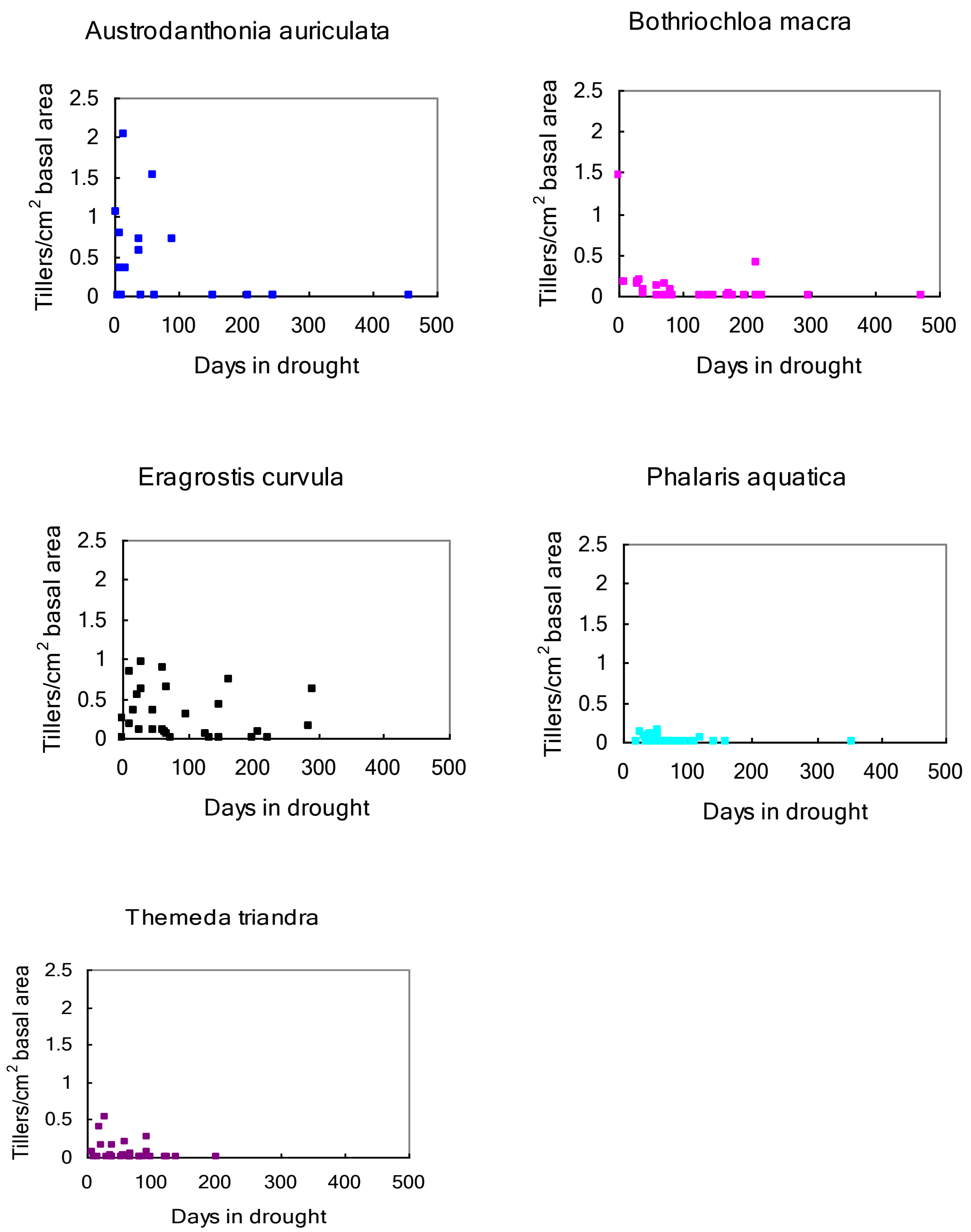

Fig. 1. Tiller density two weeks after rewatering plants at various times in drought. Plants with no live tillers to regrow on rewatering are represented by zero values. Data for each of the five species named are shown.

Survivorship in drought

Fig. 2 shows species varied in survivorship after they had fully entered the drought condition. *E. curvula* survived drought for the longest. The other four species were of similar lower survival ability. The order amongst these four, from least to highest was *P. aquatica*, *T. triandra*, and *A. auriculata*/*B. macra*.

Estimations of the time from onset of full drought to 50% survival was between 60 and 120 days for *A. auriculata*, *B. macra*, *P. aquatica* and *T. triandra*; for *E. curvula* time to 50% survival was 260 days.

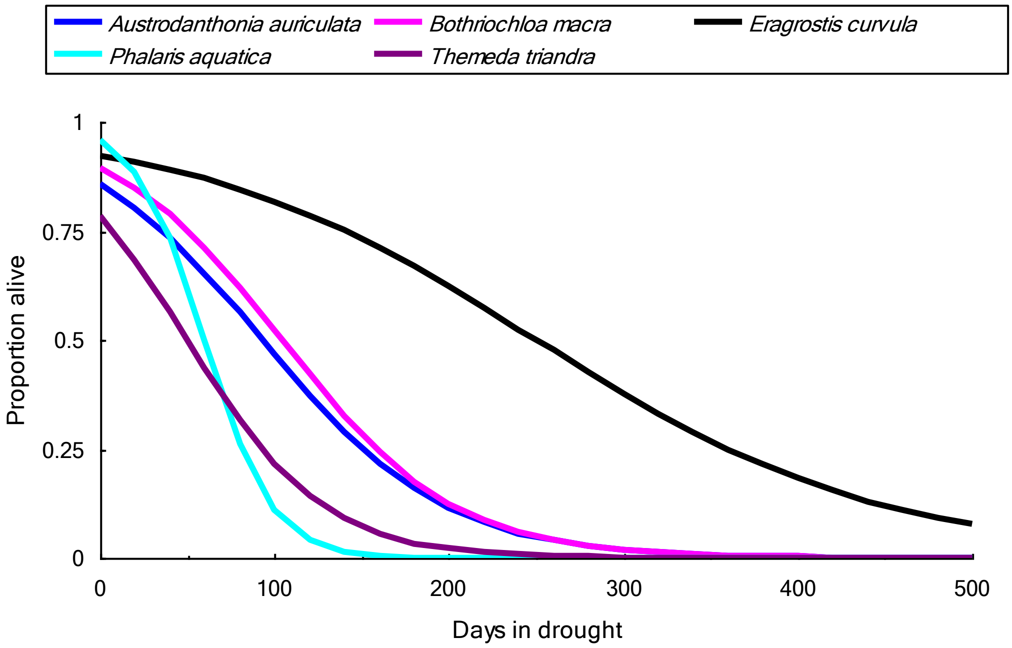

Fig. 2. Survivorship curves for plants in drought.

Discussion

The large and long pots of soil provided slow entry of the individual grass plants into the drought state. In the field, a number of plant community, landscape (Hodgkinson and Muller 2005), soil type and soil depth factors, as well as rainfall amounts and distribution, will modify the rate of entry into and the duration of the drought state for individual grass plants. However the experimental conditions used in this study do allow the growth and survival responses of plant species to be compared.

The observation that tillers viable at the time of entering the full drought condition died in drought, but at different rates for species, may be explained in terms of species differences in water leakage rates from cuticles of the tillers into surrounding air. Cuticle differences, if they exist, would be an evolved trait. The higher survival of *E. curvula* tillers than the other four species may be attributable to longer droughts in southern Africa where it evolved.

Survivorship of the five grasses in drought was reasonably modelled by logistic curves. The shapes of these curves and the species differences in the days to the full drought state, would indicate that the effect of drought on grassland communities is species dependant. Grass plants surviving drought will have an advantage in that they continue to occupy and exploit soil resources previously won and species of lower drought tolerance have to rely on other attributes to win again resource space vacated by drought-killed plants. In this context the higher drought tolerance of *E. curvula* would be an attribute contributing to this species' success in colonising native grasslands and becoming a serious environmental weed in the ACT.

Acknowledgement

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References

Deevey, E. S. (1947). Life tables for natural populations of animals. The Quarterly Review of Biology **22**, 283-314.

Harradine, A. R. and Whalley R. D. B.(1979). Relative drought tolerance of three grass species from the northwestern slopes of New South Wales. The Australian Rangeland Journal **1**, 244-247.

Hodgkinson, K. C. and Muller W. J. (2005). Death model for tussock perennial grasses: a rainfall threshold for survival and evidence for landscape control of death in drought. The Rangeland Journal **27**, 105-116.

Williams, O. B. (1970). Population dynamics of two grasses in Australian semi-arid grassland. Journal of Ecology **58**, 869-875.

Hodgkinson, K.C. (2010) Perennial grass survival in drought. In: *Proceedings of the 16th Biennial Conference of the Australian Rangeland Society*, Bourke (Eds D.J. Eldridge and C. Waters) (Australian Rangeland Society: Perth).