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# Water use efficiency of three native mulga grasses and one exotic grass

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## Summary

The water use efficiency (WUE) of one exotic grass (*Anthephora pubescens*) and three grasses native to the mulga (*Acacia aneura*) lands of south western Queensland (*Aristida jerichoensis*, *Digitaria ammophila* and *Thyridolepis mitchelliana*) was evaluated in a pot trial. The WUE of the exotic was greater than that of the native species, though when additional phosphorus was supplied to the pots there was no difference between the WUE of *Anthephora* and *Digitaria*. Additional phosphorus increased the WUE of all species, but only in *Digitaria* was the response significant.

The study indicates that more effort could be directed towards evaluating and improving the WUE of exotic and native pasture species for rangeland Australia.

## 1. INTRODUCTION

Most of Australia lies within the semi-arid and arid zones so the main factor limiting pasture and crop production is water. In these areas rainfall is low and variable and water for irrigation is not generally available, so the ability of a plant to survive extended droughts and the capacity to grow rapidly when water is available are highly desirable attributes. Water use efficiency (WUE) is also an important consideration when selecting pasture species for Australian rangelands (Daines and Robinson 1973). Indeed, Hurd (1974) claims that increasing the efficiency of water use of plants should receive a high priority in agricultural research.

There are no data on the water use of native pasture species of the mulga (*Acacia aneura*) rangelands of south western Queensland. We also lack knowledge about the water use of one of the more promising exotic species for the area (*Anthephora pubescens*). A glasshouse trial was therefore designed to evaluate the WUE of this exotic grass and three native species. The effect of improved plant nutrition on WUE was also assessed.

## 2. MATERIALS AND METHODS

A randomized block design of 4 species $\times$ 2 fertilizer levels $\times$ 5 replications was used. Forty-five pots each 20 cm in diameter and 20 cm high and lined with a plastic bag were filled with 6 kg of oven-dry mulga soil (pH, 4.6; $(NO_3)$ N, 3 ppm; available P, 15 ppm; replaceable K, 0.4%). The equivalent of 55 kg ha$^{-1}$ phosphorus as $NaH_2PO_4.2H_2O$ was applied in solution to 20 pots. All pots were then watered to 'field capacity'. An additional five unsown and unfertilized pots were used to measure evaporation from the soil surface. The trial was conducted in an open sided plant house at the laboratory between the months January and July. Mean daily temperatures decreased from 24°C in January to 16°C in June.

A number of seeds of one species was sown in each pot such that, in each replication, there were two pots of each species, one fertilized and one unfertilized. The species were *Aristida jerichoensis*, *Digitaria ammophila*, *Thyridolepis mitchelliana* (native grasses) and *Anthephora pubescens* (introduced grass). *T. mitchelliana* is a $C_3$ grass (Christie 1978) whereas the others are probably $C_4$ grasses (Downton 1971). On germination, seedlings were thinned to one per pot.

When each plant was in full flower, the top growth was removed 1 cm above ground level (Harvest 1, H1), oven dried at 80°C for 36 h, and weighed. After harvest, the pots were weighed to an accuracy of $\pm 1$ g each day and watered to maintain soil moisture at field capacity. The quantity of water added per day was recorded. Thirty-two days after the first harvest the number of leaves and tillers was recorded and the plants in each pot again harvested (H2). The plant material was oven dried at 80°C for 36 h before weighing. Roots were washed over a 1.2 mm sieve, soaked in a 2% detergent solution for 24 h, rewashed and oven dried at 80°C for 36 h. The dry weights were recorded.

The water use efficiency was calculated as the ratio of plant dry weight (H2) (tops and roots) to water used during the period between harvests.

All data were subjected to analysis of variance.

## 3. RESULTS

*Thyridolepis*, *Digitaria* and *Anthephora* produced many leaves in contrast to *Aristida* which produced relatively few (Figure 1). Further, *Aristida* produced only one half to one third the number of tillers of the other three species (Figure 1). There was no significant effect ($P \leqslant 0.05$) of additional phosphorus on either leaf or tiller numbers. Nor was the species $\times$ phosphorus interaction significant.

Top weights of *Anthephora* and *Digitaria* were higher than those of the other species at the first harvest, but only the addition of phosphorus allowed them to maintain this dominance at the second harvest (Figure 2). On the other hand, there was no significant difference in the dry weight at either harvest of *Aristida* and *Thyridolepis*.

Root weights of *Aristida* and *Thyridolepis* were similar, but much lower than those of *Anthephora* and *Digitaria* (Figure 2). Root/shoot ratios, however, were similar for all species except *Thyridolepis* which was considerably lower (Figure 2).

WUE of *Anthephora* and *Digitaria*, and *Aristida* and *Thyridolepis*, were not significantly different but the WUE of *Anthephora* and *Digitaria* was higher ($P \leqslant 0.05$) than *Aristida* and *Thyridolepis*. The simple covariance analysis between fertilizer treatments showed that WUE was significantly ($P \leqslant 0.05$) increased by the addition of phosphorus. WUE of *Anthephora* at both phosphorus levels, and WUE of *Digitaria* at the higher phosphorus level, were significantly greater ($P \leqslant 0.05$) than those of *Aristida* and *Thyridolepis* at either level of phosphorus, and *Digitaria* at the lower phosphorus level.

## 4. DISCUSSION

Extrapolation of pot trial results to the field is fraught with errors, particularly when nutrient stress is involved. Field trials are necessary to either confirm the results of pot trials, or to show that in the field roots explore a sufficiently large volume of soil to supply the plant with adequate water and nutrients.

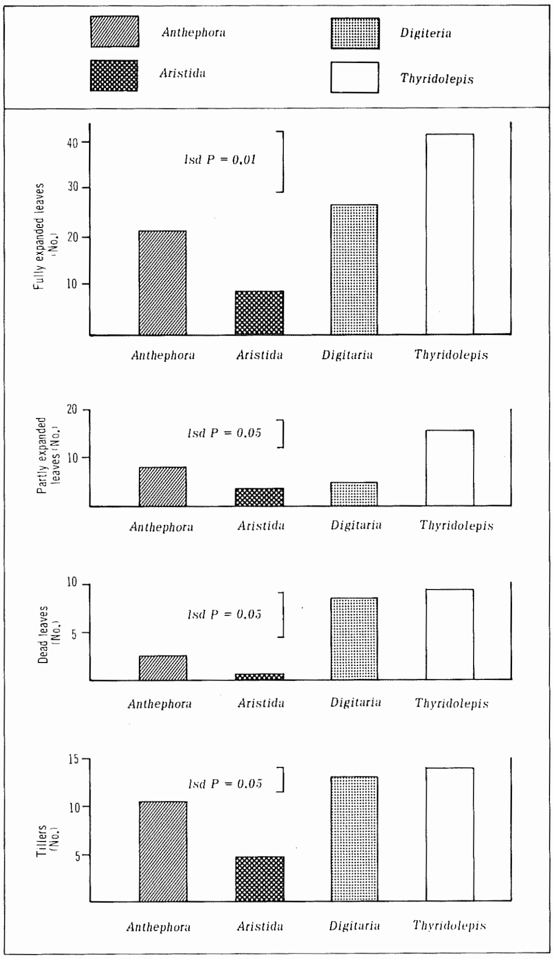


Figure 1. Leaf and tiller numbers at the second harvest. (Unsheathed or unrolled leaves were considered to be fully expanded; sheathed or rolled leaves were classed as partially expanded. Leaves without photosynthetic potential — totally or almost chlorosed or brown — were classed as dead.)

In spite of these limitations, these data, together with figures quoted by O'Donnell, O'Farrell and Hyde (1973), show that *Anthephora pubescens* uses water more efficiently and produces more dry matter than the native grasses. This concurs with the suggestion of Morley (1966) that introduced pasture species are more efficient users of water than native species. *Digitaria ammophila* exhibited the highest WUE of the three native species at both phosphorus levels, though the differences between *Digitaria* at the lower phosphorus level and *Aristida* and *Thyridolepis* were not significant (Figure 2). This suggests that, although the latter two species have a lower water use efficiency, they are more able to withstand the low phosphorus soils characteristic of the mulga regions. *Aristida* in particular is well adapted to the environment and its frequency of occurrence (Roberts 1972) reflects this. On the other hand, *Thyridolepis*, which has a low root/shoot ratio, may be suited to more favourable habitats where increased water availability would enable it to grow well even though its root distribution might be poor. Improved soil phosphorus levels do not appear to benefit *Thyridolepis*. Similar results were obtained by Silcock (1974) for *Monachather paradoxa*, another native of the mulga lands.

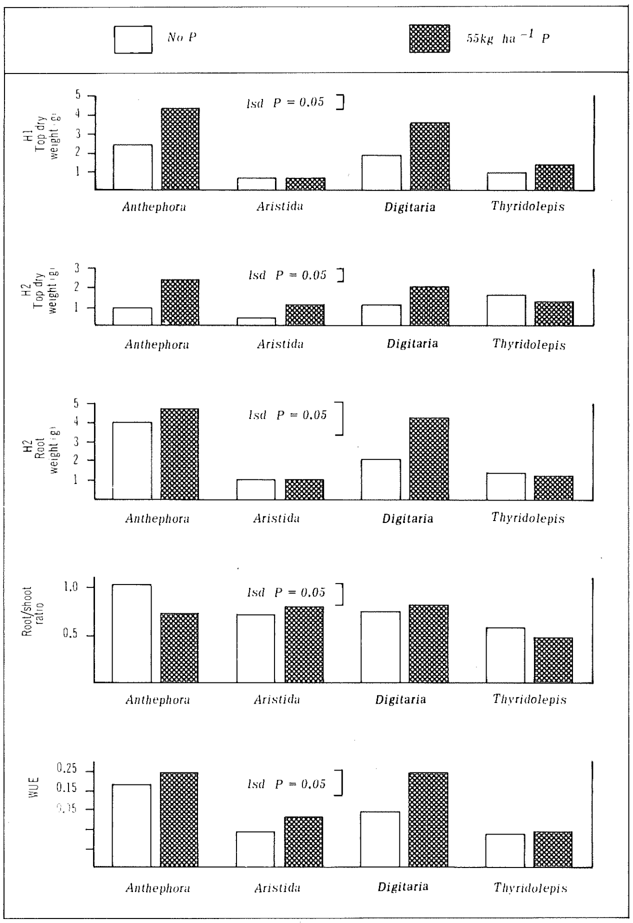


Figure 2. Top weights at both the first ($H_1$) and second ($H_2$) harvests, and root weights, root/shoot ratios and water use efficiency (WUE) at the second harvest of plants grown under two soil phosphorus levels.

An additional factor to be considered in the interpretation of these results is the photosynthetic pathway used by *Thyridolepis* ($C_3$) compared with the other grasses ($C_4$). $C_3$ plants usually have considerably lower WUE values than $C_4$ plants (Black 1971); WUE of *Thyridolepis* was less than about half that of *Anthephora* and *Digitaria*, but was similar to that of *Aristida*. The latter species does not appear to correspond to Black's statement. This may be due to measuring the WUE after defoliation, so the regrowth ability of each species may have influenced WUE.

High WUE does not necessarily lead to satisfactory plant development in an arid zone: survival under low soil moisture tension, the ability to respond quickly to removal of stress and the potential for subsequent high rates of production are all equally important. Nonetheless, the results of this study support the conclusions of Daines and Robinson (1973) and Hurd (1974), and indicate that more work is necessary in evaluating the WUE of native and exotic pasture species under Australian rangeland conditions.

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