The influence of grazing interval and perennial grass species on soil moisture.

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Abstract

To examine interactions between perennial grass species and grazing management, phalaris, cocksfoot, tall fescue and wallaby grass were grazed by sheep at intervals of 2, 5 or 8 weeks over the spring-autumn periods of 1994/5 and 1995/6. For simplicity sake, only the two most widely differing species, phalaris and wallaby grass, are presented. Soil moisture was monitored to 150 cm using a neutron moisture meter. The results depended on the season, 1994/5 being much drier than 1995/6. In 1994/5 there was a significant grazing by species interaction with wallaby grass more effective at drying the profile than phalaris when grazed every 2 and 5 weeks and phalaris more effective than wallaby grass when grazed every 8 weeks. This was mainly due to changes in the profile over 0-90 cm depth, below this there was only a minor but significant effect of species. Overall, there was no interaction between grazing interval and species. In the wetter 1995/6 season, total soil moisture was significantly lower under the 5 and 8 week grazing regimes compared to the 2 week grazing interval. This result largely reflected that for the 0-90 cm section of the profile. In the 90-153 cm section of the profile there was also a significant grazing by species interaction evident. By May 1996, soil under plots that had been grazed every 5 or 8 weeks was at least 22 mm drier compared to those grazed every 2 weeks. By implication, the magnitude of the advantage of perennial species over annual species in drying soil profiles will depend in part on the grazing management of the pasture.

Key Words

Phalaris, wallaby grass, water use, grazing management

Introduction

The necessity of perennial species in pastures to efficiently utilise soil water is now generally accepted in the higher rainfall, permanent pasture, regions of eastern Australia. In these landscapes, the most commonly sown perennial species are phalaris (*Phalaris aquatica*), cocksfoot (*Dactylis glomerata*), tall fescue (*Festuca arundinacea*) and perennial ryegrass (*Lolium perenne*). Of these, phalaris has been demonstrated in some situations to be useful in generating a soil moisture buffer and/or reducing deep drainage. Ridley *et al*. (1997), based on field measurements, estimated that deep drainage was 20 mm per annum less under phalaris than cocksfoot. Sandral *et al*. (2006), at their higher rainfall site, drew a similar conclusion and found that phalaris was superior to wallaby grass at extracting sub soil moisture. However, both studies were carried out under grazing or defoliation regimes different to those typically applied to grazed pastures on-farm. In the case of the former, the swards were mechanically defoliated infrequently (3-6 times per annum), whereas in the latter, the plots were crash grazed by sheep at least every 6 weeks. Considering the disparity between experimental and on-farm grazing management the question arises as to how grazing management may influence the ability of different pasture species to utilise soil water.

Modelling the effects of rotational and continuos grazing on soil moisture, Murphy et al. (2004) concluded that transpiration increased as a proportion of evapotranspiration under rotational grazing. This has implications for soil moisture storage and thereby deep drainage. Phalaris-based pastures under continuous grazing maintained higher soil moisture levels (at 120 cm depth) than when rotationally grazed (Schroder *et al.*1998). In contrast, Chapman *et al*. (2003) also working in southern Victoria found maximum soil water deficit (20-140 cm) occurred under well fertilised set-stocked pastures compared to a range of other grazing (including rotational) and fertiliser management combinations. Likewise, Bird *et al*. (2004) were unable to demonstrate any major effects of pasture management (again including rotational grazing) on soil water use in perennial ryegrass pasture. They suggested that had the amount of perennial ryegrass in the pasture had been maintained at higher levels, greater water use may have occurred. Grazing management not only affects the temporal pattern of leaf area accumulation but also alters botanical composition. In turn, both of these can drive changes in water use and it is difficult to determine the extent to which either is the major source of influence. These difficulties aside, it is important that the water use of various perennial grass species be examined under grazing management conditions relevant to those used on-farm.

To examine interactions between species and grazing management, 4 species (phalaris, cocksfoot, tall fescue and wallaby grass) were grazed at intervals of 2, 5 and 8 weeks over the spring-autumn periods of 1994/5 and 1995/6. Measurements of soil water were taken to assess what impacts these treatments had on soil moisture.

Methods

The experiment has been described in full by Virgona and Bowcher (2000) and only the relevant details are presented here. The experiment was located at, Wagga Wagga in southern New South Wales on a yellow sodosol. The experimental design was a split-plot with 3 grazing treatments (main plots) and 4 perennial grass species (sub-plots each 10.8 x 6 m).. The species investigated were phalaris (cv. Sirolan), cocksfoot (cv. Porto), tall fescue (cv. Demeter) and wallaby grass (cv. Taranna). Laneways containing one plot of each species, which had been established in spring 1993, were fenced with electrified wire and grazed in common to leave approximately 500 kg/ha of dry matter at intervals of 2, 5 and 8 weeks with cross-bred wethers from spring until autumn. The grazing treatments were imposed from October to March in 1994/5 and September to May in 1995/6.

Basal cover was measured at the beginning and at the end of the experimental period in each year. Soil moisture levels were measured using a neutron moisture meter that had been calibrated at the site when the soil was either very wet or very dry. One access tube (to a depth of 160 cm) was located in each plot and measurements were taken at depths of 15, 30, 45, 60, 75, 90, 115 and 145 cm. Bulk density was measured to depth using intact cores in order to calculate volumetric water content. Soil moisture was monitored from just before the experimental period to just after. The frequency of soil water measurements was deliberately varied to increase around rainfall events and decrease at other times (4 - 19 days in 1994/5 and 4 - 16 days in 1995/6). The soil profile was analysed as a whole (to 153 cm) and in two sections, above 90 cm and below 90cm. The data was analysed using linear mixed modelling following Orchard *et al*. (2000). Specifically, cubic splines were included in the model to account for species, grazing and species x gazing effects through time Where present, differences between predictions are regarded as significant when greater than twice the standard error.

Results

Seasonal conditions were much drier in 1994/5 (September-April rainfall of 297 mm) than in 1995/6 (September-April rainfall 456 mm). Grazing treatments ceased earlier in 1995 than 1996 because it was feared that the swards would become damaged in the dry conditions. Basal cover of phalaris decreased over the 1994/5 period (Table 1) but was still acceptable and no other species were present. In 1995/6 basal frequency did not substantially change throughout the experimental period (Table 1).

Table 1. Mean basal cover for all phalaris and wallaby grass under each grazing treatment at the start and end of the experimental period in both years.

		Phalaris			Wallaby grass		
		2 wk	5 wk	8 wk	2 wk	5 wk	8 wk
1994/5	Oct.	17.5	13.0	13.4	8.8	8.6	7.7
	May	9.4	7.5	12.2	11.6	10.0	10.0
1995/6	Sept.	17.4	19.5	19.0	14.8	16.6	16.9
	May	14.6	18.4	14.8	15.9	19.2	14.2

For total soil water stored (0-153 cm), there was a significant grazing x species x spline (days) interaction in 1994/5. Predicted values for each of the measurement dates are shown in Figure 1 for phalaris and wallaby grass only (results for tall fescue and cocksfoot were intermediate). While there were times at which there were significant differences between phalaris and wallaby grass, for the most part these were small and were not sustained over the spring-autumn period. However, it does appear that wallaby grass was more effective than phalaris at drying the profile when grazed every 2 or 5 weeks and that phalaris (at least in the spring-early summer period) was more effective than wallaby grass when grazed every 8 weeks.. The results were similar when the above 90 cm section of the profile was analysed alone. However, under 90 cm there was a significant species x spline(days) interaction only but the difference between the two species were minor (data not sown).

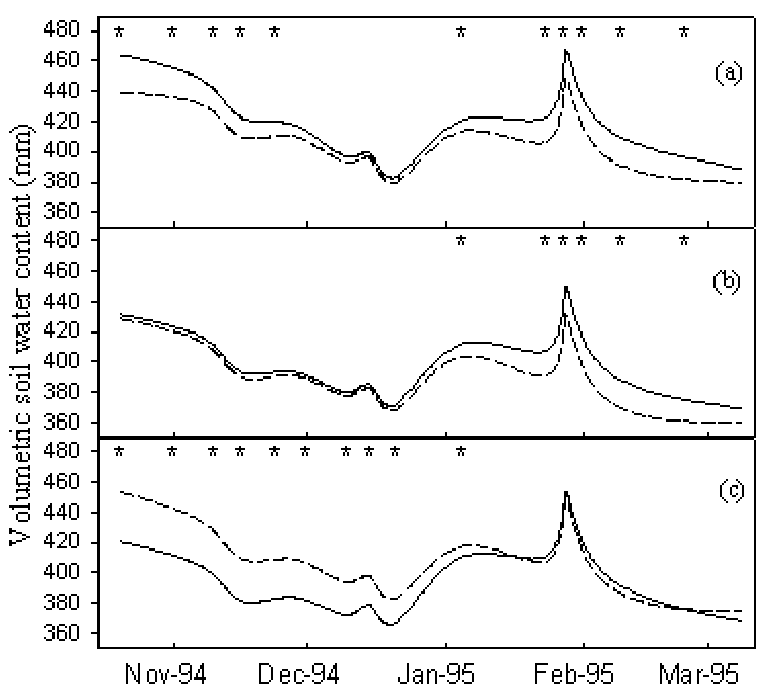

Figure 1. Volumetric soil water content (0-153 cm) under phalaris (solid line) and wallaby grass (dashed line) grazed at 2 (a), 5 (b) and 8 (c) weekly intervals throughout the summer of 1994/1995. Stars indicate the presence of significant differences(calculated as greater than twice the predicted standard error) between the grass species.

Considering total soil water in the 1995/6 (wetter) spring-autumn period, there was a significant grazing x spline(days) interaction (Fig. 2). Grazing intervals of 5 and 8 weeks left the soil profile drier by 21 and 22 mm, respectively, compared to the 2 week treatment by May 1. Results were similar in magnitude and significance for the above 90 cm section of the profile.

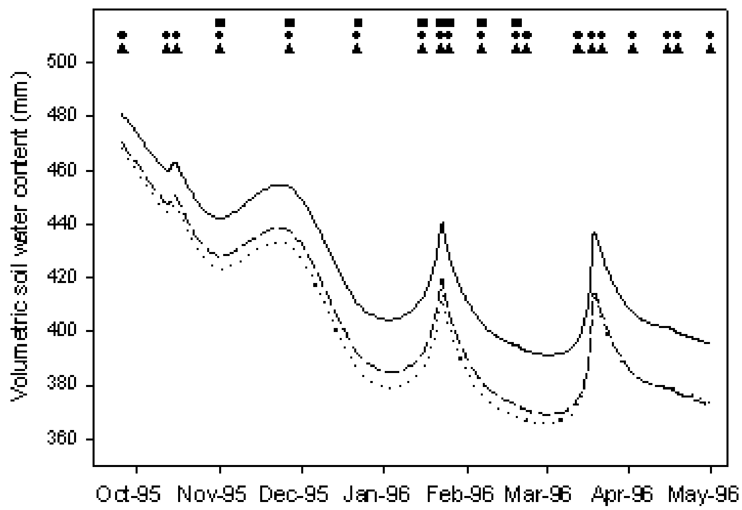

Figure 2. Volumetric soil water content (0-153 cm) in 1995/1996 for the grazing intervals of 2 weeks (solid line), 5 weeks (dashed line) and 8 weeks (dotted line) across all four species. Symbols indicate the presence of significant differences (calculated as greater than twice the predicted standard error) between the 2 and 8 week (p), 2 and 5 week (˜), and 5 and 8 week (?) grazing treatments.

In the 90-153 cm section of the profile, there was a significant grazing x species x spline(days) interaction which showed the largest differences between phalaris and wallaby grass occurring under the 8 week grazing interval (Fig. 3). By the conclusion of the experiment the phalaris left the below 90 cm section of the profile drier than wallaby grass by 14, 6 or 28 mm in the 2, 5 and 8 week treatments, respectively

Discussion

In both years, grazing interval had significant effects on total soil moisture storage, this occurred despite only small changes in basal cover, particularly in 1995/6 when the largest grazing effects were measured. Interestingly, for that year, there was no grazing x species level interaction but considering the species alone, the results are consistent (for phalaris) with those found by Schroder *et al*. (1997). Overall differences between the years were probably the result of the contrasting rainfall conditions.

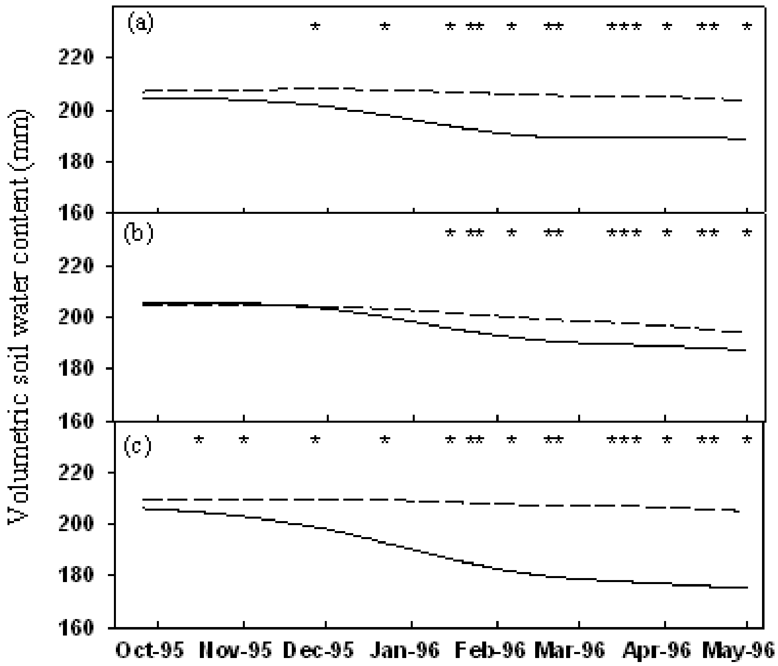

Figure 3. Volumetric soil water content below 90 cm under phalaris (solid line) and wallaby grass (dashed line) grazed at 2 (a), 5 (b) and 8 (c) week intervals throughout 1995/1996 period. Stars indicate the presence of significant differences (calculated as greater twice the predicted standard error) between the grass species.

When the water use of annual and perennial species are compared (e.g. Ridley *et al* 1997; Sandral *et al*. 2006), it is assumed that the results are relevant to a wide range of conditions (environmental, management etc.). The results for the 1995/6 spring-autumn period clearly show that longer rest intervals decrease soil moisture storage. The most likely explanation being that longer rest periods allow the grasses to accumulate LAI and thereby maintain higher rates of evapotranspiration.. Given that experiments that investigate annual versus perennial species, are usually managed to have rest intervals of > 5 weeks, then it is likely that, where demonstrated, differences between annual and perennial species could be considered a maximum. This assumes that grazing interval over the spring-autumn period would have little influence on the water extraction by annual pastures as demonstrated by Lodge *et al*. (2003) and Bird *et al*. (2004).

Conclusion

Longer rest intervals can a have a significant effect on soil moisture storage under grazed perennial pastures. Experiments should include a range of grazing treatments that cover normal farm practice and maximum potential water-use of perennials.

References

Bird PR, Jackson TT, Kearney GA, Saul GR, Waller, RA and Whipp G (2004) The effect of improved pastures and grazing management on soil water storage on a basaltic plains site in south-west Victoria. Australian Journal of Experimental Agriculture 44, 559-569.

Chapman DF, Mccaskill MR, Quigley PE., Thompson AN, Graham JF, Borg D, Lamb J, Kearney G, Saul, GR, and Clark SG (2003) Effects of Grazing Method and Fertiliser Inputs on the Productivity and Sustainability of Phalaris-Based Pastures in Western Victoria. Australian Journal of Experimental Agriculture 43, 785-798.

Lodge GM, Murphy SR, and Harden S (2003) Effects of continuous and seasonal grazing strategies on the herbage mass, persistence, animal productivity and soil water content of a Sirosa phalaris–subterranean clover pasture, North-West Slopes, New South Wales. Australian Journal of Experimental Agriculture 43, 539-552.

Murphy SR, Lodge GM, and Harden S (2004) Surface soil water dynamics in pastures in northern New South Wales. 3. Evapotranspiration. Australian Journal of Experimental Agriculture 44, 571-583.

Ridley AM, White RE, Simpson RJ, Callinan L (1997) Water use and drainage under phalaris, cocksfoot, and annual ryegrass pastures. Australian Journal of Agricultural Research 48, 1011-1023.

Sandral GA, Dear BS, Virgona JM, Swan AD, Orchard BA (2006) Changes in soil water content under annual- and perennial-based pasture systems in the wheatbelt of southern New South Wales. Australian Journal of Agricultural Research 57, 321–333.

Schroder PM, Clifton CA, Trebilcock B and Graham JF (1998) The effect of pasture type and management on soil matric potential and root profile. Proceedings of the 9th Australian Agronomy Conference, Wagga Wagga.

Virgona JM, and Bowcher AJ (2000) Effects of grazing interval on basal cover of four perennial grasses in a summer-dry environment. Australian Journal of Experimental Agriculture 40, 299-312.