Tropical grass pastures capture winter rainfall

S.R. Murphy, G.M. Lodge and M.A. Brennan

Industry & Investment NSW, Primary Industries,
Tamworth Agricultural Institute, 4 Marsden Park Road, Calala NSW 2340
sean.murphy@industry.nsw.gov.au

Abstract: *Measurement of soil water content below stands of 3 species of tropical grass, a native grass mixture, and a fallow for 2 years after establishment indicated that Katambora Rhodes grass dried the profile by 199 mm and extracted water from a depth (1.6 m) that appeared greater compared with the other species (Premier digit 176 mm, 1.2 m; Swann bluegrass 158 mm, 1.2 m; Native grasses 98 mm, 1.0 m). While tropical grasses may be a desirable pasture option on the North-West Slopes as both a forage source and for utilising stored soil water in the summer dominant rainfall region, it appears that their potential for success may be in part due to their efficient capture of winter rainfall and its effective use for growth in spring and early summer. Tropical grasses captured 55 to 64% of winter rainfall, native grasses captured 51%. High capture efficiencies for winter rainfall and its subsequent effective use during the growing season may aid the tropical species to achieve their high values of water use efficiency.*

Introduction

The North-West Slopes region of New South Wales (NSW) is a summer dominant rainfall environment, with Goonoo Goonoo Station (near Tamworth) in the Namoi Catchment receiving 33% (or 220 mm) of average annual rainfall (671 mm) between December and February (131 years of record). Perennial grasses with a C4 photosynthetic pathway, such as tropical perennial grasses, are logically suited to this environment because of matching seasonal growth and rainfall patterns (Murphy 2004). However, 40% of total annual rainfall occurs between April and September when tropical grasses are dormant. For Goonoo Goonoo Station, 277 mm of rainfall occurs on average during the cool season.

Stream salinity and water quality are major issues for the Goonoo Goonoo Creek catchment and may be exacerbated by the mostly historical sowing of winter cereal crops and forage crops across large areas of the catchment, which can lead to sediments and salts draining to streams by overland and groundwater flows. Tropical grasses may be a viable option as both a desirable perennial forage source and in limiting deep drainage for this region of northern NSW. The influence of pastures on the hydrological balance and, so, their ability to limit deep drainage has been determined by measuring the pattern and depth of soil drying achieved by plant roots (e.g. White *et al.* 2003). Frequent measurement of soil water content during a soil drying phase is likely to indicate maximum depth of drying and so plant rooting depth (Murphy & Lodge 2006).

For winter–grown cereal grain crops in northern NSW, a fallow period is used to accumulate stored soil water to ensure levels are sufficient to produce adequate grain yields. Values of the proportion of rainfall stored during the fallow (*i.e.* fallow efficiency) in northern NSW may range from 0 to 40%, with values of 22–25% considered good (Dalgliesh & Foale 1998). Losses over summer, primarily by evaporation and surface runoff, are large, thereby reducing efficiency.

Storing soil water during the dormancy of tropical grasses may increase the overall success of these species on the North-West Slopes by supplementing rainfall during the growing season. Particularly, stored soil water may boost growth of tropical grasses in spring and early summer.

Studies were undertaken to determine depth and amount of soil drying achieved through the growing season and subsequent capture of winter rainfall achieved by 3 tropical grass species, a native perennial grass-based pasture, compared with a fallow.

Methods

An experimental site was established on a red chromosol to study the effects of tropical grasses on soil water dynamics at 'Dunreath' (31°16S, 150°52'E, 490 m a.s.l.) in the Goonoo Goonoo Creek catchment on the North-West Slopes of NSW. Three tropical grasses (*Digitaria eriantha* cv. 'Premier'; *Chloris gayana* cv. 'Katambora'; *Bothriochloa bladii* cv. 'Swann') and a mix of native perennial grasses (a mix of redgrass, *Bothriochloa macra*; bluegrass, *Dicanthium sericeum*; windmill grass, *Chloris truncata*; wallaby grass, *Austrodanthonia linkii* cv. Bunderra) were randomly allocated to plots (6 x 9 m) across 3 replicates. Other treatments including lucerne, annual forage crops and saltbush were also sown, but results are not presented here. A further treatment maintained fallow with 3000 kg DM/ha of sugarcane mulch applied. Sown plots were fallowed for 6 months to increase stored soil water prior to sowing. Treatments were sown on 5 December 2005 at a target rate of 2 kg/ha of viable seed with seed placed at a depth of 10 mm into a prepared seed bed by using a band seeder with press wheels. Native grasses were established by both transplanting tussocks (redgrass and bluegrass) and broadcasting seed (windmill grass and wallaby grass). Tropical grass treatments were fertilised with Greentop (N 32.5%, K 11%, S 3%) at a rate of 125 kg/ha.

A single neutron probe access tube was installed in the centre of each plot to a depth of 1.7 m and extracted soil cores were used to calibrate a neutron moisture meter (CPN-503DR Hydroprobe) for volumetric soil water content. Soil water content was measured at 20 cm depth intervals to a maximum depth of 1.6 m one-day prior to sowing and subsequently at 3-week intervals until September 2008. To demonstrate soil drying achieved by the grasses over the summer growing season, volumetric soil water content (vol/vol) and change in profile stored soil water (mm, 0–1.7 m) were calculated for two periods. The first began at sowing (5 December 2005) with a near full soil water profile and ended in the following autumn (5 April 2006). The second began with a near full profile in mid winter (30 August 2006) and ended in the following autumn (18 April 2007).

Rainfall capture efficiency (*i.e.* change in stored soil water (mm, 0–1.7 m) divided by total rainfall for the period), was calculated for 3 cool seasons (2006–08), with the starting point determined by onset of soil water replenishment (associated with dormancy) and the end point determined by onset of soil drying (associated with break of dormancy). The first cool season began just 4 months after sowing. Rainfall was recorded by an automatic weather station on the site.

Results and discussion

At sowing, initial profile of stored soil water was high (~550 mm) providing a good starting point to record soil drying achieved by the grasses. While Katambora established more rapidly than the other treatments, soil drying (56 mm) by the end of the first growing season (5 April 2006) was comparable with that of Premier (53 mm, Fig. 1*a*, *b*). However, Katambora showed a change in soil water content to a maximum depth of 0.8 m, compared with 0.6 m for Premier and 0.4 m for the other grass treatments. Fallow showed no appreciable change (Fig. 2*e*). Swann and the native grasses were considerably slower in establishing and showed less soil drying by the end of the first season with 31 and 21 mm, respectively (Fig. 1*c*, *d*).

The second growing season began also with high profile stored soil water (~560 mm) and by the following autumn (18 April 2007) treatments showed a change in soil water content to greater depth and extent compared with the initial season. Katambora showed a change in soil water content to a depth of 1.6 m and had extracted 199 mm of stored soil water from the profile (Fig 2*a*). Premier showed a change in soil water content to a depth of 1.2 m and had extracted 176 mm of soil water (Fig 2*b*). Swann showed a change in soil water content to a depth of 1.2 m also, but had extracted 158 mm

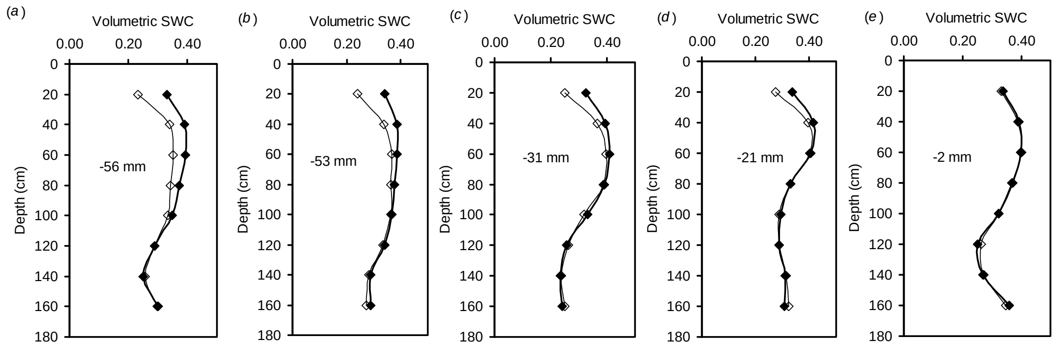

Figure 1. Volumetric soil water content at sowing on 5 December 2005 (◆) and at the end of the first growing season on 5 April 2006 (◊) for, *a*) Katambora, *b*) Premier, *c*) Swann, *d*) native perennial grasses, and *e*) fallow. Change in profile stored soil water is given in mm.

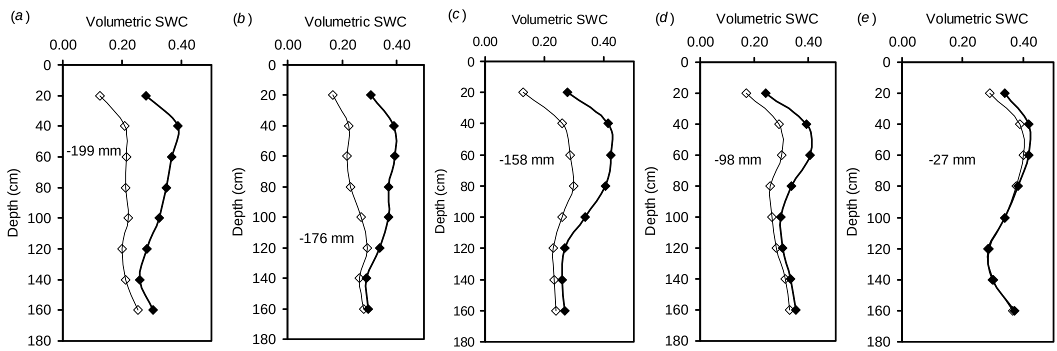

Figure 2. Volumetric soil water content on 30 August 2006 (◆) and at the end of the second growing season on 18 April 2007 (◊) for, *a*) Katambora, *b*) Premier, *c*) Swann, *d*) native perennial grasses, and *e*) fallow. Change in profile stored soil water is given in mm.

of soil water (Fig 2*c*). Native grasses, however, showed a change in soil water content to just 1.0 m with considerably less drying of 98 mm (Fig 2*d*). Fallow showed a change in soil water content to 0.4 m and drying of 27 mm due to evaporation alone (Fig 2 *e*).

These data indicate that at the end of the second growing season likely plant root depth was at least 1.6 m for Katambora, 1.2 m for Premier and Swann, and 1.0 m for native grasses. These depths were considerably less than those estimated for a mature redgrass dominated grass-based pasture on a Red Chromosol at Barraba (1.88 m, Murphy & Lodge 2006). However, the data here were for stands in only their second season after establishment and maximum depth of soil water measures was 1.6 m compared with 2.0 m for the Barraba data. The change in profile stored soil water also suggested that Katambora had a greater capacity to extract soil water (199 mm) and so possibly buffer against large rainfall events and have higher rainfall capture efficiency in winter.

Dormancy in the tropical grasses and associated soil water replenishment began from 5 to 30 April in each of the 3 years. The duration of dormancy and soil water replenishment was 147 days in the first year and 126 days for the latter years. Total rainfall during these periods was 167.5 mm in the first and last year, and 282 mm for the middle year.

Grass treatments showed values of rainfall capture efficiency that in the first year tended to be less compared with those in latter years. In the first year, grass treatments captured 5–24% of winter rainfall, while in latter years values ranged from 38 to 70% (Table 1). The reason for generally lower efficiency values in the first year

Table 1. Rainfall capture efficiency values (change in stored soil water divided by total rainfall for the autumn–winter period) for 3 tropical grasses, a native grass pasture and a fallow in 3 years, 2006–2008.

Treatments	Rainfall capture efficiency (%)			
	2006	2007	2008	Mean of 2007–08
Katambora	15	70	58	64
Premier	24	49	61	55
Swann	22	46	63	55
Native grasses	5	38	63	51
Fallow	19	11	29	20

was that the grasses were in their establishment year and had so far developed only moderate profile drying (Fig. 1) and total stored soil water remained high (500–537 mm). For the two latter years, the more established grasses created greater soil drying in the growing season (Fig. 2) and so a greater opportunity was created to capture winter rainfall by the soil profile being drier (total stored soil water 334–450 mm, 2007; 351–418 mm, 2008). The fallow treatment showed generally lower efficiency values ranging from 11% in 2007 to 29% in 2008, which reflected the higher values of stored soil water content for this treatment (547–564 mm). Mean values of rainfall capture efficiency for the established pastures were 51 and 64% for native grasses and Katambora, respectively, while Premier and Swann were both 55% (Table 1). It is interesting to note that these efficiency values are more than double those cited for summer fallows in cropping systems in a similar environment (e.g. 22–25% Dalgliesh & Foale 1998) where evaporation and runoff losses can be high. Conditions during winter are more conducive to rainfall capture because of lower evaporation demand and generally lower rainfall intensities.

Goonoo Goonoo Station receives 277 mm of rainfall on average for the period April to September. Therefore, rainfall capture efficiencies calculated here would suggest that pasture systems based on these perennial grasses are likely to capture between 141 and 177 mm of soil water each winter. High water use efficiency (WUE, herbage mass produced per increment of evapotranspiration, kg DM/ha.mm) is dependent upon the effective use of rainfall and herbage yield is positively correlated with stored soil water at the beginning of the growing season (Hatfield *et al.* 2001). For the grass treatments here, the tropical species were reported to have WUE values that were 2–5 times greater than for native grasses (Murphy *et al.* 2008). High rainfall capture efficiencies for winter and its subsequent effective use in the growing season may aid the tropical species to achieve their high values of WUE.

References

Dalgliesh, N & Foale, M (1998) "Soil matters; monitoring soil water and nutrients in dryland farming"(Agricultural Production Systems Research Unit, Toowoomba, Queensland, Australia) 122p.

Hatfield, JL, Sauer, T &, Prueger, JH (2001) Managing soils to achieve greater water use efficiency: A review. *Agronomy Journal* 93, 271–280.

Murphy, SR (2004) Soil water balance – what can pastures do for farming systems? In 'Proceedings of the 19th Annual Conference of The Grassland Society of NSW, 27–29 July 2004.' pp. 37–44. (Eds S Boschma, G Lodge) (Grassland Society of NSW Inc.: Orange).

Murphy, SR & Lodge, GM (2006) Root depth of native and sown perennial grass-based pastures, North-West Slopes, New South Wales. 2. Estimates from changes in soil water content. *Australian Journal of Experimental Agriculture* 46, 347–359.

Murphy, SR, Lodge, GM & Brennan, MA (2008) Water use indices of tropical grasses in a temperate environment. In 'Multifunctional Grasslands in a Changing World' p. 837 (Edited by Organising Committee of IGC/IRC Congress. – Guangzhou), (Guangdong People's Publishing House, 2008. 06).

White, RE, Christy, BP, Ridley, AM, Okom, AE, Murphy, SR, Johnston, WH, Michalk, DL, Sanford, P, McCaskill, MR, Johnson, IR, Garden, DL, Hall, DJM & Andrew, MH (2003) SGS Water Theme: influence of soil, pasture type and management on water use in grazing systems of the high rainfall zone of southern Australia. *Australian Journal of Experimental Agriculture* 43, 907–926.