Soil water dynamics and water use efficiency of tropical pastures in Central West NSW

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Abstract: *Studies in northern New South Wales (NSW) demonstrated that tropical pastures can improve pasture productivity and resilience of grazing enterprises. Producers in Central West NSW are highly interested in these species due to their persistence, ability to respond to summer rainfall and production of large quantities of feed for livestock. This paper compares the soil water use, herbage production and water use efficiency (WUE) of three species of tropical perennial grass with lucerne (Medicago sativa) and an annual summer forage over the 2020–21 spring-summer growing season. Bambatsi panic (Panicum coloratum) had the highest total water use (486 mm), while lucerne had the lowest (460 mm). Digit grass (*Digitaria eriantha*), Gatton panic grass (*Megathyrsus maximus*) and Sudan grass (*Sorghum sudanense*) had similar water use (468–473 mm). Bambatsi panic produced the maximum herbage mass (18789 kg DM/ha), while lucerne produced the minimum (6317 kg DM/ha). Digit grass, Gatton panic and Sudan grass produced similar herbage mass (~15400 kg DM/ha). Water use efficiency was highest in Bambatsi panic (39 kg DM/ha/mm) and lowest in lucerne (14 kg DM/ha/mm). Sudan grass, digit grass and Gatton panic had similar water use efficiency (32–34 kg DM/ha/mm). All the species extracted stored soil water to a depth of 1.8 m, but Bambatsi panic extracted the greatest volume (116 mm). Our experiment will continue for three years.*

Key words: tropical pasture, herbage mass, water use efficiency

Introduction

Producers in Central West New South Wales (NSW) have shown great interest in tropical perennial grasses and legumes recently, with high attendance at field days. While the Koeppen climate class of this region is primarily temperate with no dry season, rainfall seasonality varies between a slight summer dominance in the north (Coonamble) to a slight winter dominance in the south (Grenfell) (Rawson 2016). The floodplains in the north of the region are subtropical, while higher elevations of northern slopes have warm summers. This region has a medium annual rainfall (400–600 mm), with winter rainfall generally more effective than summer rainfall. Studies of tropical grass and legume species in northern NSW have shown that they are both productive and resilient (Boschma *et al*. 2015; Murphy *et al*. 2018). This is significant, especially in a changing and highly variable climate. Producers are interested in adopting these grasses into their grazing systems, however, there is little quantitative data on their growth, productivity and soil water dynamics in this medium rainfall region. Our study's objective is to quantify the herbage production, water use dynamics and water use efficiency of several tropical perennial grasses with lucerne (*Medicago sativa* L.) and an annual summer forage in Central West NSW. In this paper we reported findings from the 2020–21 spring-summer growing season.

Methods

A randomised complete block design experiment, with five treatments and three replications, was established at the Trangie Agricultural Research Centre (31°59'40.53"S, 147°56'20.65"E, 215 m elevation). The soil is a brown Chromosol (Isbell 1996) with soil pH 5.1 and 1% organic carbon (Boschma *et al.* 2018). The average annual rainfall in the study area is about 490 mm without distinct seasonality. The site was maintained as a weed-free fallow for two months before establishing the experiment. The treatments consisted of three species of tropical perennial grass (Bambatsi panic (*Panicum coloratum* L.) cv. Bambatsi, Gatton panic (*Megathyrsus maximus* (Jacq.) B.K. Simon & S.W.L. Jacobs) cv. Gatton, digit grass (*Digitaria eriantha* Steud.) cv. Premier), a summer-growing temperate perennial legume (*Medicago sativa* L. lucerne cv. SARDI Grazer) and a summer-growing annual forage (Sudan grass (*Sorghum sudanense* (Piper) Stapf) cv. Bankers). Each plot is 6.6 x 5 m, arranged in three rows of five plots (33 x 15 m). The perennial grasses were sown in early November 2019. Lucerne was first sown in autumn 2019, but failed due to fungal disease and was resown in November 2020. Sudan grass was sown in December 2020. All species were sown at industry recommended rates. The plots were mulched with sugarcane mulch to provide some cover for the emerging seedlings, (2000 kg DM/ha). The plots were irrigated with 20 mm of water every five days over four weeks, with 100 mm of water applied in total to assist with pasture establishment.

An aluminium access tube was installed in the centre of each plot to a depth of 2.0 m in August 2020 to measure changes in soil water content. Soil water content was estimated at 3-week intervals using a neutron moisture meter (CPN 503DR Hydroprobe; Boart Longyear Co., Martinez, CA, USA), calibrated for local conditions (Mc Kenzie *et al.* 1990). Neutron moisture meter readings were taken in the middle of 0.2 m layers down the soil profile (i.e. 0.1–0.3, 0.3–0.5,…,1.7–1.9 m). Total stored soil water for the profile (0.1–1.9 m) was calculated by summing values for each layer. Stored soil water changes and total herbage production were determined for 13 August 2020 to 8 March 2021 for the 2020-21 spring-summer growing season. Rainfall and temperature data were collected from the Bureau of Meteorology weather station located about 1 km from the study site. Water use efficiency (WUE, kg DM/ha/mm) of total herbage production (kg DM/ha) was calculated by dividing total dry matter by total water use. Herbage production was assessed every 6-weeks from September 2020 using a calibrated visual assessment technique in 4 strata of each plot, similar to Murphy *et al.* (2018). After each assessment, herbage was removed using a rotary mower to a height of 50 mm for all species except Sudan grass which was cut to 70 mm.

Results and discussion

Rainfall in the 2020–21 growing season was well above average with total rainfall for September–March approximately double the long-term average (459 *v.* 234 mm) (Figure 1a). For February and March alone, monthly rainfall was nearly three times the long-term average (135 *v.* 50 mm) and (127 *v.* 42 mm), respectively. In months with above-average rainfall, mean maximum temperatures were slightly below average (Fig. 1b). Minimum temperatures were similar to the long-term average apart from January and February when temperatures were below average.

At the start of the growing season (August 2020), soil water content was consistent among the treatments and increased gradually with depth (0.24–0.26 m^3/m^3) (Figure 2). By the end of the growing season (March 2021), all treatments were significantly drier to a depth of 1.8 m. Over the five months, Bambatsi panic extracted 116 mm of stored soil water, followed

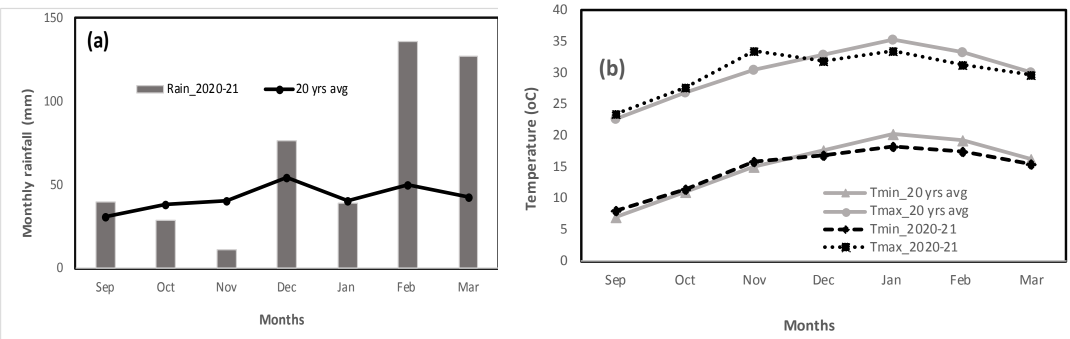

Figure 1. (a) Monthly and long term average rainfall (mm) received at the study site, and (b) monthly and long term average maximum and minimum temperatures (oC) recorded at the study site September 2020–March 2021 and the 20-year averages.

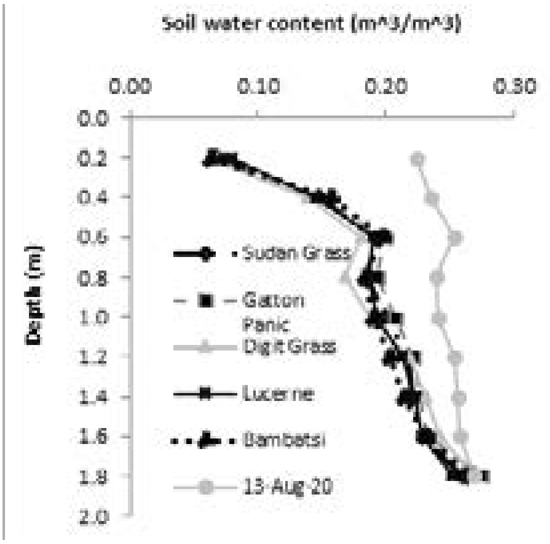

Figure 2. Soil water content (m³/m³) at the start of the season (average of all treatment on 13 August 2020) and each treatment at the end of summer (8 March 2021)

by digit grass (104 mm), Gatton panic (101 mm), Sudan grass (99 mm) and lucerne (91 mm). All treatments extracted more soil water from the upper profile (0.1–0.7 m, Figure 2), representing about 60% of total extraction. Extraction from the middle and lower layers represented 28% and 12%, respectively (Table 1). Bambatsi and digit grass extracted more water from the middle and lower profile layers (42–47 mm) than the other species (36–39 mm).

Bambatsi produced the highest total herbage mass (18793 kg DM/ha), while lucerne produced the least (6317 kg DM/ha). Low productivity of lucerne is to be expected in an establishing stand. Digit grass and Bambatsi panic produced a similar amount of herbage in spring, but digit grass lagged behind Bambatsi panic during summer. Herbage mass varied for specific assessments, but the total herbage production was similar for digit grass and Gatton panic. Total herbage mass of Sudan grass sown in November was higher than Gatton panic and digit grass (Table 2). The low cutting height (70 mm) used for Sudan grass likely impacted its regrowth and subsequently, its total production. A higher cutting height of 150 mm for Sudan grass is more in line with commercial practice, and will be used in future seasons.

For the 2020–21 growing season, total water use by Sudan grass and lucerne (460 and 468 mm, respectively) was less than other treatments (Table 2). The water used by the three tropical perennial grasses was similar (486, 473 and 470 mm, respectively). The subsequent water use efficiency was highest for Bambatsi panic (39 kg DM/ha/mm), while those for digit grass, Gatton panic and Sudan grass were similar to each other (33, 32 and 32 kg DM/ha/mm, respectively). Lucerne, by contrast, had a low

Table 1. Changes in stored soil water (mm) for different soil layers between the start of the season (13 August 2021) and the end of summer (8 March 2021).

Soil profile layer (m)	Sudan grass	Gatton panic	Digit grass	Lucerne	Bambatsi panic
0.1–0.7	60	64	62	52	69
0.7–1.3	27	26	30	26	33
1.3–1.9	13	11	12	13	14
0.1–1.9	99	101	104	91	116

Table 2. Herbage mass (kg DM/ha) and components of the water balance used to calculate water use efficiency (WUE, kg DM/ha/mm) for treatments during the 2020–21 growing season. Water balance components are rainfall (mm), profile stored soil water (0.1–1.9 m, SSW, mm) at the start (13 August 2020) and end (8 March 2021) of the growing season, total water used (mm) and water use efficiency.

Treatment	Total herbage mass (kg DM/ha)	Rainfall (mm)	Start SSW (mm)	End SSW (mm)	Total water use (mm)	WUE (kg DM/ha/mm)
Bambatsi panic	18793	370	457	341	486	39
Digit grass	15282	370	442	339	473	32
Gatton panic	15090	370	454	354	470	32
Lucerne	6317	370	432	342	460	14
Sudan grass	16094	370	442	344	468	34

water use efficiency of 14 kg DM/ha/mm. The data presented in this paper are for spring and summer, however in this zone the full growing season of all these species also includes autumn. Therefore, the data presented here do not represent total growing season production. Lucerne is a particular case. Lucerne is a 'summer active' legume, the optimum temperatures for lucerne growth are 25–30°C (Moot *et al.* 2008), therefore greater production in spring and autumn would be likely.

Conclusions

Our preliminary data provide a snapshot of the water use, herbage mass and water use efficiency of a range of perennial and annual pasture and forage species over a single spring-summer growing season. Based on the WUE data we found that Bambatsi panic had higher WUE followed by Sudan grass, digit grass and Gatton panic. Lucerne had the lowest WUE for this summer-based growing season. Measurements will continue for the next 2-years to determine the relative differences in total production, WUE, and persistence of these species.

Acknowledgments

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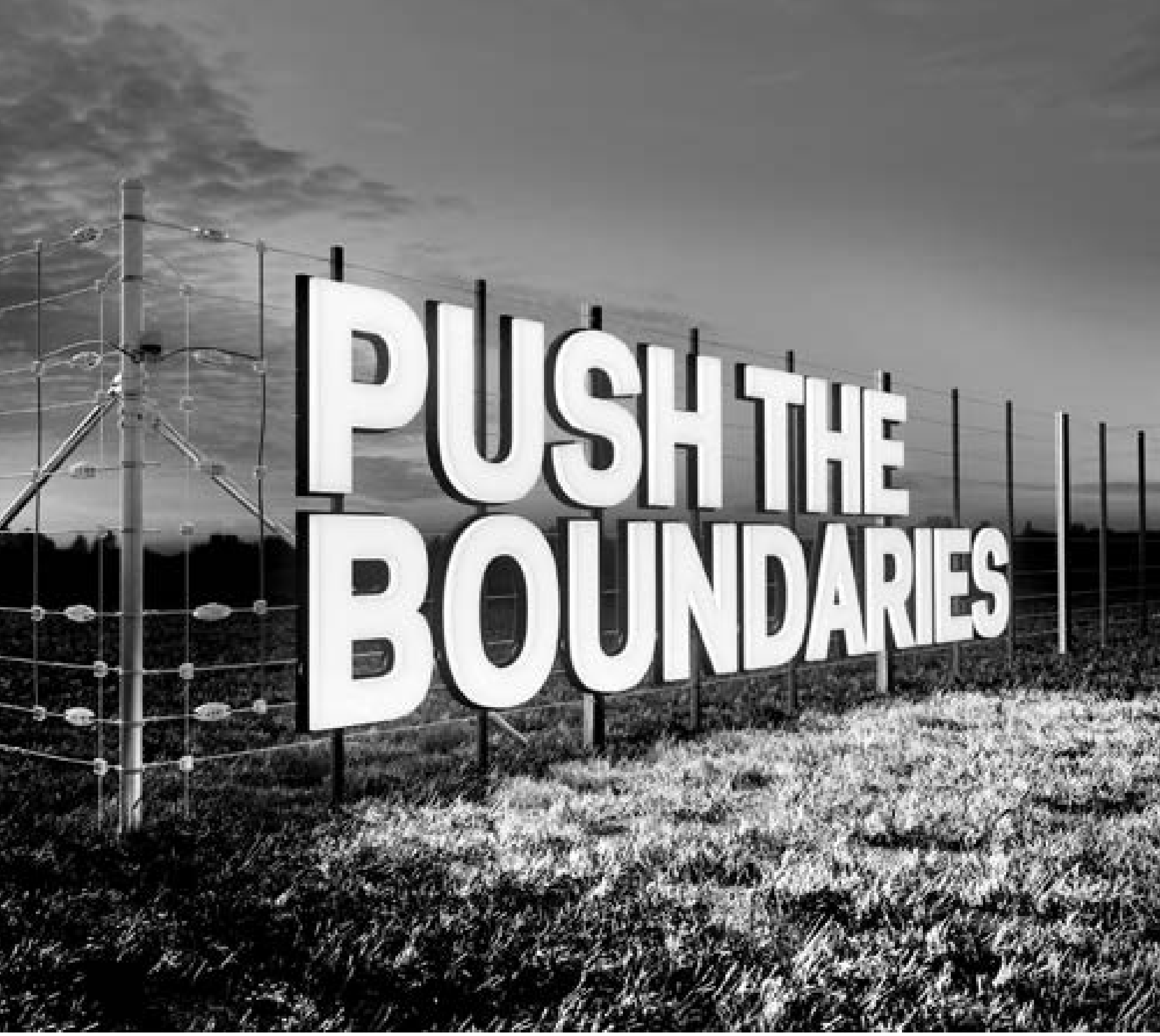

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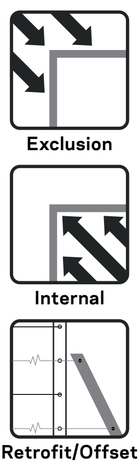

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