Desmanthus is more persistent than lucerne through drought on the North-West Slopes of NSW

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Abstract: *Lucerne (*Medicago sativa*) and desmanthus (*Desmanthus *spp.) were the most persistent species in mixes with digit grass (*Digitaria eriantha*) after 4 years in experiments at Bingara and Manilla in northern NSW. Plant frequency assessments (assessed over time providing a measure of persistence) were continued through the 2018–19 drought until autumn 2021. At both locations the plant frequency of all lucerne cultivars and burgundy bean (*Macroptilium bracteatum*) declined during the drought and failed to recover post drought. Plant frequency of the most persistent cultivars of desmanthus (cvv. Marc and JCU 2) increased post drought to be highest of the three legume species assessed. The importance of management to allow seed set and recruitment to maintain desmanthus long term is discussed.*

Key words: Tropical grass based pastures, recovery, seed set, management, North-West Slopes

Introduction

Sown tropical perennial grasses are an important component of the feed base for grazing systems in northern inland NSW. They are highly responsive to fertiliser, particularly nitrogen, but regular applications are required to maintain productivity (Boschma et al. 2014a, 2016). Productive companion legumes that are nodulated with effective rhizobia are a cost effective and sustainable means of providing nitrogen in tropical pastures (Peck et al. 2012). Additionally, in a mixed pasture legumes are important for animal production due to their high protein content.

The North-West Slopes is characterised by hot summers and frequent winter frosts (Hobbs and Jackson 1977). Also, it has a summer dominant rainfall distribution (≥60% falling October–March). This environment offers both opportunities and challenges for a range of temperate and tropical annual and perennial companion legumes (Boschma et al. 2014b) and research has evaluated these different types of legumes (e.g. Harris et al. 2019; Boschma et al. 2021). In a 4-year study which concluded in autumn 2016, we identified lucerne (Medicago sativa L.) and desmanthus (Desmanthus spp.) as the most persistent perennial legumes of those evaluated. Additionally, several lines of burgundy bean also persisted at Bingara (Boschma et al. 2021). We maintained these experiments beyond 2016 with irregular assessments. Drought was a factor during the experiment, especially at the Bingara site, but the 2018–19 period was particularly dry. Significant rainfall in autumn 2020 allowed tropical pastures to regrow followed by good rainfall during the 2020–21 summer. These summers provided an opportunity for us to assess the persistence of these legumes during extended drought.

This paper describes the persistence (assessed as plant frequency) of lucerne, desmanthus and burgundy bean (Macroptilium bracteatum (Nees & Mart.) Maréchal & Baudet) over the 8-year period to autumn 2021. The last 3 years included both drought and drought recovery periods. Our hypothesis was that lucerne, desmanthus and burgundy bean would have similar persistence post drought.

Methods

Our study consisted of two experiments located at sites near Bingara (29°42’39” S, 150°27’07” E; 297 m above sea level (ASL); 740 mm annual average rainfall [AAR]) and Manilla (30°42’11” S, 150°30’10”; 412 m ASL; 616 mm AAR) on the North-West Slopes of northern NSW. These sites had Brown Chromosol soils (pH_{Ca} 5.0–6.1) and represent areas where tropical perennial grasses are currently grown.

Our experiments consisted of 18 treatments: 14 cultivars of eight species of tropical legumes, and four cultivars of two temperate perennial legumes. A full list of species and cultivars is provided in Boschma *et al.* (2021). The cultivars described in this paper are: lucerne cvv. Pegasis, Q31 and Venus; desmanthus cvv. Marc, JCU 1, JCU 2, JCU 3, JCU 4 and JCU 5 and burgundy bean cv. B1 and experimental lines AT101 and AT121). All legumes were sown as mixes in plots with digit grass (*Digitaria eriantha* Steud.) cv. Premier. Each experiment was a randomised complete block design with three replicates (total 54 plots). The grass and legumes were sown in alternate rows into plots 1.5 × 6.0 m. The Manilla experiment was sown in December 2012 and the Bingara experiment in January 2013. Digit grass was sown at 1 kg/ha viable seed and the legumes at commercially recommended rates (adjusted for germination percentage). All legumes were inoculated with the recommended strain of Rhizobia. We applied 200 kg/ha single superphosphate (8.8% P, 11% S) during spring most years. The experiments were mown not grazed. Full details on sowing, site history and management can be found in Boschma *et al.* (2021). We used rainfall data recorded in a manual rain gauge located 2.5 km from the Bingara experimental site. For the Manilla site we used the BOM site located 8 km from the experimental site (55331).

Data collection

We assessed the frequency of plant occurrence, herein called plant frequency, of digit grass and legumes in a fixed location in each plot in spring and autumn each year 2013–16 and irregularly 2017–21. Plant frequency was assessed as the proportion (%) of cells containing a portion of a live digit grass or sown legume plant (Brown 1954). Estimates were generally taken 0–10 days after defoliation when there was green leaf present. At each assessment, we placed a 1.0 × 1.0 m quadrat (divided into 100 cells, each cell 0.1 × 0.1 m) across the middle 4 rows of a plot in an area that had good plant density of both digit grass and the sown legume. We assessed plant frequency a total of 10 times at both Bingara and Manilla. The temporal response of plant frequency over multiple assessments provided a measure of the persistence of a species.

Statistical analyses

We modelled frequency of the legume and grass components of each treatment over time with smoothing splines within a linear mixed model (Verbyla *et al.* 1999) using the R package ASReml (Butler 2018). Frequency at the last assessment was analysed by linear model with terms for treatment (legume/grass combination) and replicate. We did not need to transform the data. Least significant differences of means (P = 0.05) were calculated for significant effects.

Results

Rainfall at Bingara site was below average (≤80% of LTA) during 4 of 8 years that the experiment was conducted (Fig. 1). The period 2018–19 was exceptionally dry with annual rainfall being 40 and 20% of the LTA. Rainfall at the Manilla site was below average 2 of 8 years; 2018–19 being particularly dry years with annual rainfall 52 and 40% of the LTA respectively. Good rainfall was received January–May 2020; suitable for tropical pasture recovery (Fig. 1). Additionally, rainfall during summer 2020–21 was also above average e.g. 50% above LTA at Bingara.

At the Bingara site, plant frequency of the legumes was highly variable at the initial assessment; lucerne cultivars had the highest values, burgundy bean intermediate and desmanthus variable ($P < 0.05$). Plant frequency of lucerne peaked in 2015 then had a downward trend which accelerated from 2019 with final values in autumn 2021 of 11–17%. Desmanthus cultivars were variable at the initial assessment and this variability continued through the 8-year period. Cultivars Marc and JCU 2 consistently had the highest plant frequency throughout the 8 years; plant frequency values increased following rainfall in 2020–21 to be highest of the legumes in the experiment in autumn 2021 ($P < 0.05$; Fig. 2a). Burgundy bean had lowest plant frequency values in autumn 2021 ($P < 0.05$); the values were lower than those preceding the 2018–19 drought period. Plant frequency of digit grass was lowest in 2015, then increased. The range in values remained relatively consistent irrespective of the companion legume, although values increased from 10 units in 2016 to be 17 units by autumn 2021 (Fig. 2c).

At the Manilla site, plant frequency of the legumes peaked within 3 years of establishment then declined as dry conditions commenced (Fig. 2b). Plant frequency of burgundy bean peaked in 2014, lucerne peaked in 2014–15 while the most persistent cultivars of desmanthus (cvv. Marc and JCU 2) peaked in 2015–16. The

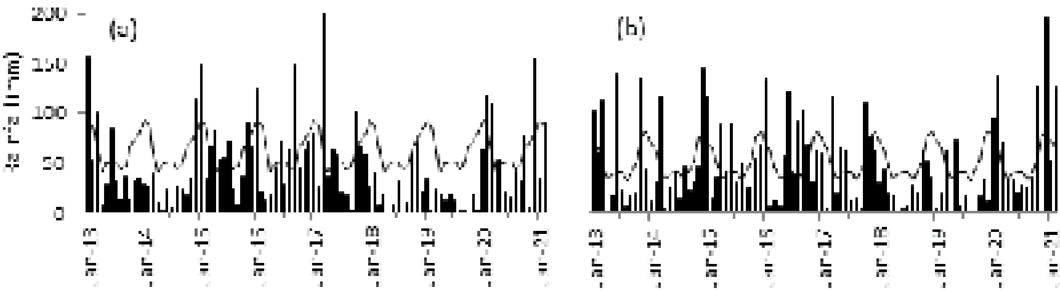

Figure 1. Actual (bars) and long term average (line) monthly rainfall (mm) at (a) Bingara and (b) Manilla, January 2013–February 2021. Long term average data are from BOM sites (a) 054004 (1878–2021) and (b) 55331 (1983–2021).

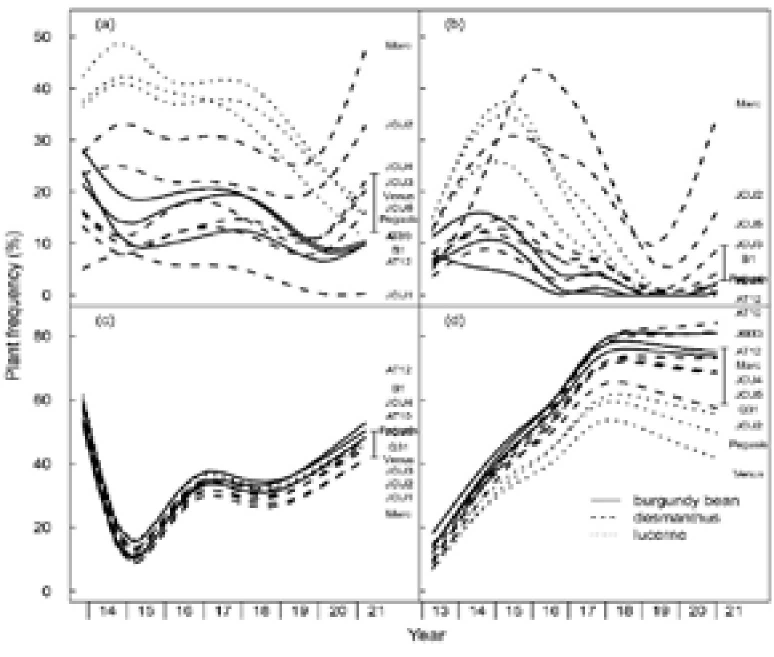

Figure 2. Predicted plant frequency of (a, b) legume and (c, d) digit grass in legume–grass mixtures at (a, c) Bingara and (b, d) Manilla, NSW, from February 2013 to February 2021. Shown on each figure are a least significant differences (P = 0.05) bar for comparison among treatment means at the final assessment, also the cultivar names.

lowest plant frequencies of all three species were recorded in 2018–19. Of the three species, desmanthus was the only species that showed strong recovery post drought. However, there was significant variation among cultivars with cv. Marc having the highest plant frequency in autumn 2021 (37%) followed by cv. JCU 2 ($P < 0.05$). Plant frequency of digit grass increased from the initial assessment (Fig. 2d). Plant frequency either peaked or plateaued in 2017–18. Unlike the Bingara site, the range in values diverged over time. Digit grass was generally ranked high in mixes with burgundy bean but ranked lowest in mixes with lucerne.

Discussion

Desmanthus cvv. Marc and JCU 2 were clearly the most persistent cultivars, with all cultivars of lucerne and burgundy bean showing poor drought recovery, thus our hypothesis is rejected. In a previous paper we reported that lucerne and desmanthus were the most persistent species in mixes with digit grass (Boschma *et al.* 2021). However, we noted that lucerne may have been declining at the Manilla site, while desmanthus had increased, plateauing at a higher level than that at establishment. Now 8 years after establishment and following severe drought the longer-term persistence of the legumes is evident. Plant frequency values of lucerne have declined to levels where resowing would be recommended. The persistence of lucerne for about 5 years is typical for the region when lucerne is managed well, despite the drought. Also, burgundy bean had low plant frequency and did not recover post drought. In contrast, plant frequency of desmanthus cv. JCU 2, and especially cv. Marc, increased post drought.

Digit grass is a productive and persistent grass in this region (Boschma *et al.* 2014a). The high and/or increasing plant frequency values of digit grass post drought for most treatments substantiates this. We noted a lower plant frequency of digit grass in mixes with lucerne in 2016 at the Manilla site (Boschma *et al.* 2021). We suggested it was likely due to competition between the two species and now, 5 years later, the effect of competition is clear with both species affected.

The experiment was left undefoliated from around April each year to allow seed set. We conclude that desmanthus was able to recover post drought due to seedling recruitment from this seed bank. The success of cvv. Marc and JCU 2 both *D. virgatus* (L.) Willd., and failure of *D. leptophyllus* Kunth cv. JCU 1 was likely due to species/cultivar adaption rather than seed set alone. Seed set and recruitment are important characteristics and grazing management needs to be targeted to allow plants to set seed at least every 2–3 years to maintain a large seedbank. Strategic grazing is required to ensure recruited seedlings establish successfully to form part of the productive legume stand. The different flowering maturities of the desmanthus lines needs to be considered with grazing management for seed set. For example, cv. Marc is early flowering, therefore resting the pasture following significant rainfall anytime from December could allow seed set. Conversely longer season cultivars such as JCU 1 flower later in the growing season and we recommend they are best to rested from around March to allow seed set. Desmanthus has high levels of hard seed (Lawrence et al. 2012), although differences have been observed between desmanthus cultivars (Boschma *et al.* 2018).

Conclusions

We observed that plant frequency of all lucerne cultivars fell sharply during the dry 2018–19 period and failed to recover with the return of reasonable seasonal conditions. In contrast, the frequency of several desmanthus cultivars increased, in particular cvv. Marc and JCU 2. Desmanthus stands can thicken due to seedling recruitment. Plant frequency of burgundy bean was declining prior to 2018–19 and failed to recover. We conclude that grazing management which allows seed set and recruitment of adapted species/cultivars is important for their persistence through variable seasons.

Acknowledgments

We appreciate technical support provided by Geoff Bevan, Karen Lowien and Peter Sanson and review by Bernie Dominiak. We thank Phillip and Annette Butler, 'GlenAyr' Bingara, and Robert and Lea Bowman 'Bonnie Doon', Manilla for providing sites. Seed was provided by Barenbrug, Agrimix and Auswest Seeds. This study was funded by NSW DPI and Meat and Livestock Australia (B.PSP.0001).

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