The Brigalow Catchment Study: Comparison of soil fertility, forage quality and beef production from buffel grass vs. leucaena-buffel grass pastures

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Abstract

This paper assesses the fertility status of soils and forages in two grazed pasture systems in central Queensland: 1) buffel grass only, and 2) leucaena-buffel grass. Trends observed in our preliminary results indicate that the paddock with leucaena had similar or lower soil fertility (0 to 10 cm) than the grass only paddock based on concentrations of available phosphorus, organic carbon, nitrate and ammonia; however, the leucaena paddock had similar or better pasture quality based on crude protein and total phosphorus. This can be partly explained by the deeper root system of leucaena which can utilize nutrients further down the soil profile than grass pastures. Furthermore, greater live weight gains of cattle in the leucaena-grass paddock can be attributed to higher crude protein concentrations found in leucaena vs. grass leaves.

Introduction

Leucaena hedgerows planted with companion pasture grasses are one of the most productive, profitable and sustainable grazing systems in tropical and subtropical Australia (Dalzell *et al*. 2006, Shelton and Dalzell 2007). In managed agricultural scenarios, leucaena has many reported benefits, including reduced soil erosion, improved runoff water quality, and enhanced soil fertility (Dalzell *et al*. 2006, Shelton and Dalzell 2007). Beef production on leguminous pastures in central Queensland is becoming more common, as there is an increase in the availability of data that demonstrates greater biomass and nutritive value of forage from leucaena-grass paddocks vs. grass only paddocks. This paper links data on soil and pasture fertility status with beef production per hectare between pastures with and without legumes.

Methods

Study site

This research was conducted on the Brigalow Catchment Study (BCS) site near Theodore in central Queensland. The BCS commenced in 1965 and is an ongoing long-term study on the impact of land development on hydrology, productivity and resource condition. This project compares two paddocks from the BCS site: 1) buffel grass (*Cenchrus ciliaris* cv. Biloela) pasture that was originally cleared in 1982 and planted in 1983, and 2) leucaena (*Leucaena leucocephala* cv. Cunningham) and buffel grass pasture that was originally cleared ~1968 and cropped for 10 to 15 years before converting into a grazed paddock. The leucaena was planted in 1998 on 8 m hedgerows. Both paddocks are predominantly grey and black Vertosols with an average slope of 2.5%, and neither paddock has a history of fertiliser application.

Soil fertility and forage quality

Soil was sampled at approximately three month intervals from December 2008 until October 2009. Six samples 0 to 10 cm from the soil surface were collected from three permanent monitoring sites within both the grass only (N=18) and leucaena-grass paddock (N=18) for each sampling period. The samples were analysed for Colwell available phosphorus (P), Walkley and Black organic carbon (OC), nitrate (NO_3-N), and ammonia (NH_4-N). Pasture was sampled at approximately three month intervals from December 2008 until March 2010. Six samples 1x1 m were collected from the same three permanent monitoring sites within both the grass only (N=18) and leucaena-grass paddock (N=18) for each sampling period. The samples were analysed for total Kjeldahl nitrogen (TKN) and phosphorus (TKP). Crude protein (CP) was later calculated as 6.25 x TKN.

Beef production

Two drafts of weaner cattle were grazed on the grass only and leucaena-grass pastures; the first draft from May 2008 to May 2009 and the second draft from June 2009 to March 2011. Similar stocking rates were used for the first grazing period with 2.1 ha per head for the grass only paddock and 2.2 ha per head for the leucaena-grass paddock. In the second grazing period, the stocking rate was decreased in the grass only paddock to 3.4 ha per head and increased in the leucaena-grass paddock to 1.5 ha per head to match feed availability. Production was measured as cumulative weight gain of the cattle per ha. Values reported are based on results from Thornton and Buck (2011).

Statistical analyses

Means and standard errors were calculated in GenStat (v.14) for soil and pasture fertility. Furthermore, one-way ANOVA's with protected Fisher's LSD for pasture type were performed (P<0.05).

Results

Soil fertility and forage quality

Overall, there was a trend of lower organic carbon and available phosphorus in soils of the leucaena-grass pastures (OC mean 1.22% ± S.E. 0.03%; P mean 9.25 mg/kg ± S.E. 0.29 mg/kg) than in the grass only pastures (OC mean 1.77% ± S.E. 0.04%; P mean 11.89 mg/kg ± S.E. 0.35 mg/kg) (Fig.1). Both of these nutrients exhibited little variation, with an overall detectable difference between paddocks (OC $F_{1, 178}$=85.96, P<0.001; P $F_{1, 178}$=29.13, P<0.001).

Nitrate concentrations were higher in the grass only (mean 3.64 mg/kg ± S.E. 0.25 mg/kg) than leucaena-grass paddock (mean 2.99 mg/kg ± S.E. 0.26 mg/kg) (Fig.1). Nitrate in the grass only paddock was lower in the wet season from November to March than in the dry season; however, the late commencement of sampling from the leucaena-grass paddock does not currently allow seasonal variations to be determined. Overall, large variability was observed in the results for the last three sampling periods and no difference could be detected between the two pasture systems ($F_{1, 178}$=3.01, P=0.084).

Ammonia was similar between the two pasture systems in the last three sampling periods; however, concentrations were overall higher in the leucaena-grass (mean 5.50 mg/kg ± S.E. 0.27 mg/kg) than grass only paddock (mean 4.81 mg/kg ± S.E. 0.22 mg/kg) (Fig.1). Little variation was observed in the data, but an overall difference between the paddocks was detected ($F_{1, 178}$=3.97, P=0.048).

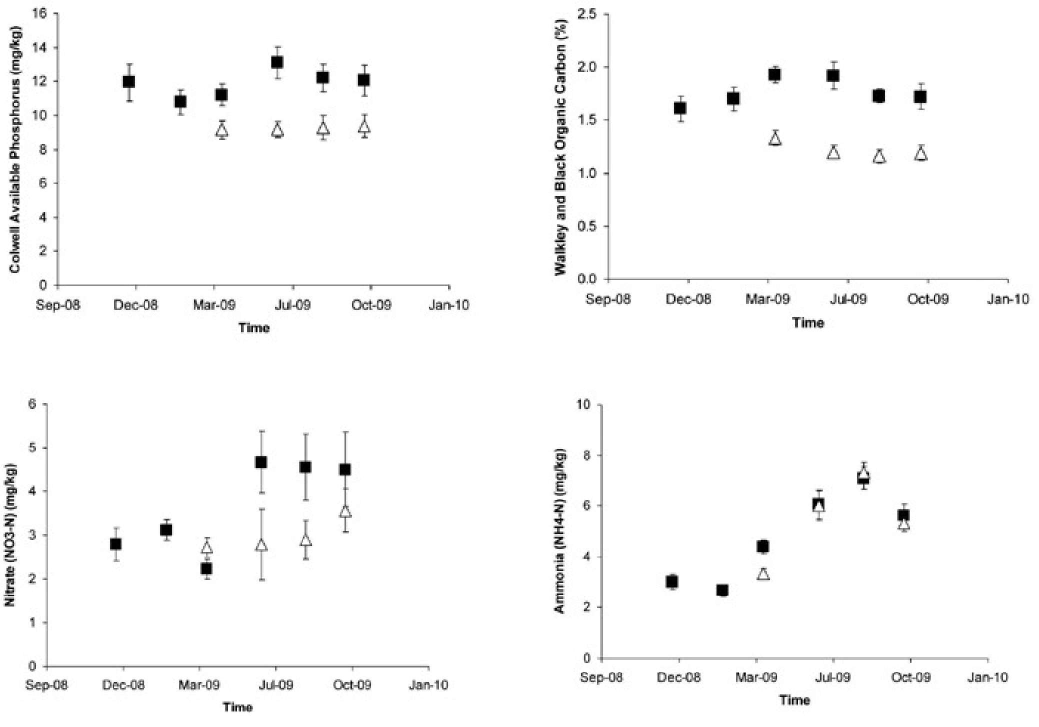

Figure 1. Fertility of soil (0 to 10 cm) based on available phosphorus, organic carbon, nitrate and ammonia concentrations in the grass only (black square) and leucaena-grass (white triangle) pastures; mean ± standard error bars.

Forage yield was greater in the grass only (mean 1617.0 kg/ha ± S.E. 134.5 kg/ha) than in the leucaena-grass paddock (mean 906.5 kg/ha ± S.E. 56.3 kg/ha), whilst yield from leucaena leaves was much lower (mean 385.9 kg/ha ± S.E. 51.3 kg/ha) (Fig.2). Although variability within sampling periods was larger in the grass only paddock, overall, differences were detected between all three pasture types ($F_{2, 336}$=30.59, *P*<0.001).

Crude protein of pasture grasses from the grass only (mean 4.44% ± S.E. 0.15%) and the leucaena-grass paddock (mean 5.88% ± S.E. 0.27%) were similar over time (Fig.3). In contrast, crude protein of leucaena leaves (mean 16.70% ± S.E. 0.59%) from the latter paddock was much higher than from the companion pasture grasses in the same paddock. Variability within each treatments sampling period was small, and overall, a difference between all three pasture types was detected ($F_{2, 318}$=322.54, *P*<0.001).

Total phosphorus concentrations were similar between pasture grasses from the grass only (mean 0.10% ± S.E. 0.005%) and the leucaena-grass paddock (mean 0.12% ± S.E. 0.004%), and also leucaena leaves (mean 0.12% ± S.E. 0.004%) from the latter paddock (Fig.3). Although data from all three pasture types exhibited variability in concentrations overtime, overall the grass only paddock had a detectably lower concentration that the other two pasture types ($F_{2, 318}$=10.20, *P*<0.001).

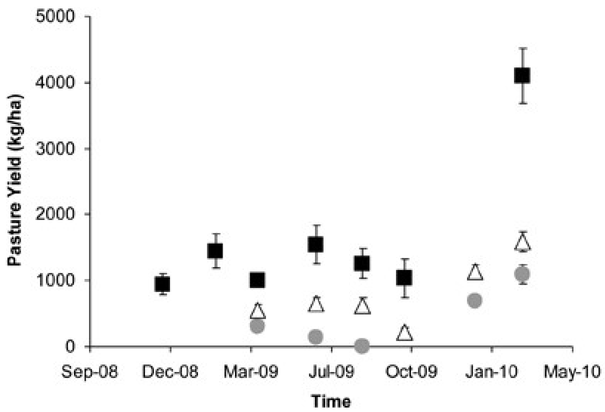

Figure 2. Total yield of pasture from the grass only (black square) and leucaena-grass (leucaena = grey circle, and grass = white triangle) paddocks; mean ± standard error bars.

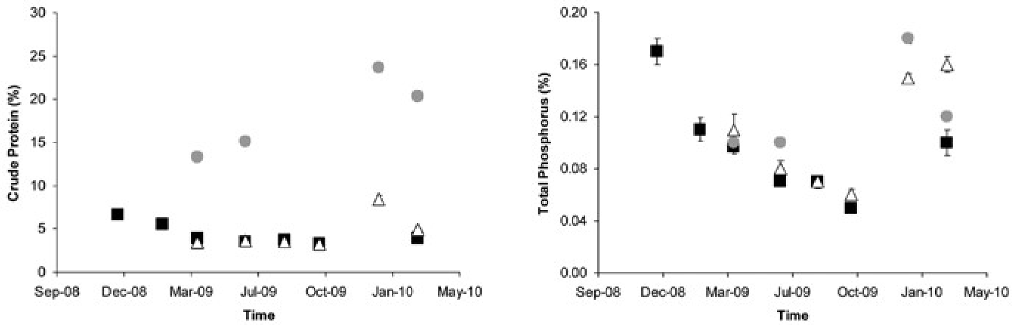

Figure 3. Nutritive value of pastures based on crude protein and total phosphorus in the grass only (black square) and leucaena-grass (leucaena = grey circle, and grass = white triangle) paddocks; mean ± standard error bars.

Beef production

During the first grazing period when the two pasture systems had similar stocking rates, the cumulative live weight gain of cattle per ha was comparable, though slightly higher in the leucaena-grass (94 kg/ha) than in the grass only paddock (81 kg/ha) (Fig.4). During the second grazing period when stocking rates were adjusted to match feed availability, beef production per hectare was much higher in the leucaena-grass paddock (117 kg/ha) whereas it remained consistent in the grass only paddock (57 kg/ha) (Fig.4).

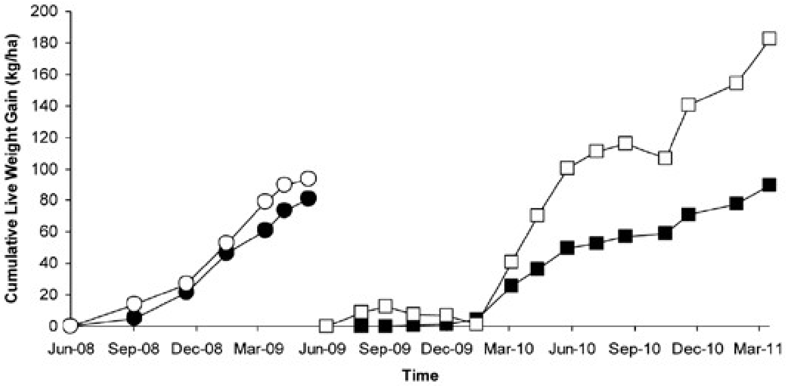

Figure 4. Cumulative live weight gain of cattle grazed on grass only (black shapes) and leucaena-grass (white shapes) paddocks at similar (circle) and feed on offer (square) stocking rates. The two stocking rate treatments used a different draft of cattle. Source: Thornton et al. (2010), Thornton and Buck (2011).

Discussion

In this study, soil fertility was similar or lower in the leucaena-grass paddock than the grass only paddock. However, the nutritive value of grass forages was similar or better for the leucaena-grass paddock. The contrasting results can be partly explained by soil sampling depth (0 to 10 cm) and the physiology of the studied plants. That is, leucaena has a deep root system that can access subsoil moisture and nutrients that are typically beyond the reach of grass roots. The deep root system of leucaena enables the plant to remain productive during the dry season; thus, enabling continued cattle production (Radrizzani *et al.* 2010). However, the results in this paper are in contrast to other literature which discuss the importance of grass in leguminous pastures to utilise mineral nitrogen (Fillery 2001) and improvements to soil fertility through nitrogen fixation (Shelton and Dalzell 2007). Thus, it is surprising that the nutritive value of grass from both the grass only and leucaena-grass paddock are similar over time, as it indicates that the transfer of nitrogen from leucaena to the grass is inefficient or not occurring at all. Based on feed availability, the leucaena-grass paddock was able to stock more cattle resulting in greater beef production per hectare than the grass only paddock. Due to the lower concentrations of organic carbon, phosphorus and nitrate in soils from the leucaena-grass paddock, the greater cattle stocking rates and live weight gains observed can be attributed to the higher concentrations of crude protein found in the leucaena leaves (Shelton and Dalzell 2007).

Acknowledgments

This work was jointly funded by the Department of Natural Resources and Mines and the Reef Rescue Research and Development Program (Project RRRD009).

References

Dalzell SA, Shelton HM, Mullen BF, Larsen PH and Mclaughlin KG (2006) Leucaena: A guide to establishment and management. Meat and Livestock Australia Ltd., Sydney, Australia.

Fillery IRP (2001) The fate of biologically fixed nitrogen in legume-based dryland farming systems: A review. *Australian Journal of Experimental Agriculture* 41, 361-381.

Radrizzani A, Dalzell SA, Kravchuk O and Shelton HM (2010) A grazier survey of the long-term productivity of leucaena (*Leucaena leucocephala*)-grass pastures in Queensland. *Animal Production Science* 50, 105-113.

Shelton M and Dalzell S (2007) Production, economic and environmental benefits of leucaena pastures. *Tropical Grasslands* 41, 174-190.

Thornton C and Buck S (2011) Beef production from buffel grass pasture compared to leucaena-buffel grass pasture in the brigalow belt of Central Queensland. Northern Australia Beef Research Update Conference.

Thornton C, Radford B, Buck S and Cowie B (2010) The Brigalow Catchment Study: Beef production on buffel grass pasture compared to buffel grass and leucaena pasture. Leucaena Network Conference.