Grain-Graze as sustainable farming systems in sub-tropical Queensland

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Abstract

Soil fertility decline in sub-tropical mixed farming areas may be arrested by legume based pasture leys. Ley pastures need to provide adequate returns to farmers from livestock production as well as improve soil fertility for subsequent cropping cycles. This study at Brian Pastures Research Station in southeast Queensland, Australia compared forage and animal production from eight tropical pastures. Lablab (*Lablab purpureus*) produced the most liveweight gain/ha with growth rates from 0.60 to 0.86 kg/head/day. Growth rates on other legumes varied from 0.39 to 0.79 kg/head/day and there were some differences in the duration of grazing. Liveweight gain/ha was similar for *Clitoria ternatea and Macroptilium bracteatum* and was higher than for *Vigna trilobata*, followed by *Macrotyloma daltonii*. On grass and grass-legume pastures, growth rates ranged from 0.39 to 0.71 kg/head/day with legume-based pasture producing gains of 30 to 70 kg/ha more than the grass only pasture over 5 years. The response of grain sorghum to the various periods of annual legumes and grasses were investigated using a no-till system. Two to four years of the tropical legumes *M. daltonii* and *V. trilobata* and lablab resulted in soil nitrate N (0-90 cm depth) ranging from 36 to 102 kg/ha compared with 5 to 11 kg/ha after grass only pastures. Grain sorghum produced in excess of 3000 kg/ha in the 4 crops following the removal of the legume pastures.

Media summary

Productive grain systems that deplete soil nitrogen can be sustained by phases of highly productive pastures and beef production in the animal-cropping systems of sub-tropical regions.

Key Words

Grain-graze, steer liveweight gain, tropical legumes, sorghum, nitrogen accumulation, leys.

Introduction

Beef cattle production and cropping are the major agricultural industries on large areas of central and southeast Queensland although the integration of livestock and cropping has been limited even on properties where both enterprises are practiced. With long-term cultivation and cropping on clay soils lower yields and grain protein levels are associated with a decline in soil nitrogen. At the same time higher quality forage is needed to increase cattle growth rates and reduce age at turnoff to meet more demanding beef markets. In northern Australia where research in the 1980s investigated the potential for using tropical legumes in leys in cropping and livestock systems, their use commercially was limited until the live cattle export trade increased demand for high quality pasture. In southern Queensland, although ley pastures based on lucerne and annual medics have been shown to arrest soil fertility decline and improve crop yield and protein content (Dalal et al. 1991), their adoption has been slow. There is now a good range of tropical legumes and grasses that can be used in leys. To continue and increase the rate of adoption of leys in farming/livestock systems, the more complex issues of management now need to be addressed. These include the strategies necessary to maximise the accumulation of nitrogen in the ley and optimise its use during the subsequent crop, and to improve the value of grazing from the pasture phase. This paper reports some aspects of animal production from a range of forage and pasture types grown on a vertosol in the Burnett region of Queensland. N accumulation and the response of grain sorghum in a subsequent cropping phase is also reported.

Methods

Experiments were located at Brian Pastures Research Station, Gayndah, Queensland, Australia (25?39’S, 151?45’E) on a moderately to strongly self-mulching Vertosol (Black Earth) on a 3-10 % slope. Eight pasture treatments, each replicated twice, were sown into 16 paddocks of 2.5ha each from 4th to 6th February 1998. The pasture treatments were: (1) Lablab (*Lablab purpureus* cv. Highworth) (2) *Macrotyloma daltonii* CPI 60303 (3) *Vigna trilobata* CPI 13671. (4) Butterfly pea (*Clitoria ternatea* cv. Milgarra) (5) Burgundy bean (*Macroptilium bracteatum* CPI 27404) (6)Grass (*Bothriochloa insculpta* cv. Bisset; *Dichanthium sericeum and Panicum maximum* var *trichoglume* cv. Petrie); (7) Butterfly pea with grass (8) Caatinga stylo (*Stylosanthes seabrana* cvv. Primar and Unica) with grass. Lablab, being an annual forage, was resown on 7th December 1998, 4th January 2000 and 13th December 2000.

Animal production phase

All pastures were grazed with Brahman crossbred steers at a range of stocking rates and steers were weighed at 6-week intervals except when grazing the small areas of legume in 2001. On the grass and grass-legume pastures, the first grazing commenced in August 1998 for 293 days at a stocking rate of 1.25 ha/steer. Subsequent grazing, all at the same stocking rate, occurred from July 1999 (324 days), from November 2000 (288 days) and September 2001 (270 days). The 5 forage legume-only treatments were grazed for the same period in year 1 (0.5-0.6 ha/steer), but in later years grazing time varied depending on forage availability (0.4-1.25 ha/steer). Grazing in the 3 annual legume treatments (lablab, *V. trilobata* and *M. daltonii*) was in late summer/early autumn. The perennial legumes, Milgarra butterfly pea and burgundy bean provided grazing earlier and over a longer period and again for 160 to 176 days from December 2001. Details of pasture growth, composition and legume density are reported in Clem (2004).

Grain production phase

Grain sorghum was grown over four seasons from 1999 to test the crop response to 2, 3 and 4 seasons of pasture growth and test the duration of the response. Four pasture treatments were selected for testing, namely the improved grass pasture, the annual lablab pasture and the self-regenerating legume pastures *Macrotyloma daltonii* and *Vigna trilobata*. In November 1999 approximately one third of the 2 ha replicated treatments previously sown to *M. daltonii, V. trilobata* and *L. purpureus* and a smaller area in the grass pasture was sprayed with herbicide, kept free of weeds and planted to sorghum on 7 January 2000. Similarly on 3 January 2001 and 13 December 2001 these same areas and a further one third of the plots were planted to sorghum. In the fourth season (2002/2003) only the *M. daltonii* and *L. purpureus* treatments were continued with sorghum planted on 12 Febuary 2003. Within each of the areas sown to sorghum, all crop and soil measurements were confined to a representative test area (10 ? 30 m). These test areas were divided into two plots (10 ? 15 m), one of which received 80 kg/ha of N as urea in an equal split at 4 and 8 weeks after planting, and the other receiving none. Grain sorghum was planted each year using a no-till planter. Sorghum grain and stover were harvested at maturity to determine yield and nitrogen concentration. Soil samples were taken in each plot prior to planting and following harvest of each crop and analysed for nitrate nitrogen and water content. Complete experimental details can be found in Whitbread and Clem (2004).

Results

Steer liveweight gain

On the forage treatments grazed for shorter periods (from 70 to 200 days) at higher stocking rates, liveweight gain/head ranged from 0.35 to 0.86 kg/head/day while overall gains averaged over the 4 season from 1998/99 varied from 59 to over 126 kg/ha/year (Figure 1). Steers grazing lablab consistently gained weight at high rates with up to 0.86 kg/steer/day, and over 4 years lablab has produced the most liveweight gain/ha. Growth rates of steers on *M. daltonii* were less than those recorded from other pastures despite high legume dry matter yields, and ranged from 0.35 to 0.66 kg/steer/day due to lower palatability of this legume relative to the other legumes (Cattle were observed to avoid grazing this legume). In comparison, *V.trilobata* was noticeably the most palatable of the legumes and steer growth rates have been high, with a range of 0.55 to 0.79 kg/steer/day. The perennial legumes, butterfly pea and burgundy bean provided higher liveweight gain than the annual legumes that had to regenerate from seed each year.

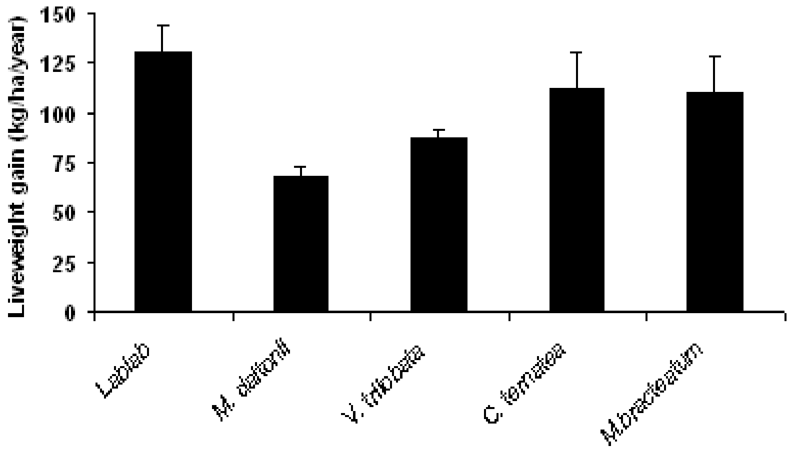

Figure 1. Liveweight gain of steers grazing forage legumes. Annual legumes averaged over the 1998/99 to 2000/2001 seasons and perennials averaged over the 1998/99 to 2001/2002. Bars represent the s.e.m calculated across the years.

On the grass/legume pastures, grazing periods were longer (270 to 324 days) at the lower stocking rate of 1.25ha/steer than on the annual and perennial legume forages with growth rates ranging from 0.4 to 0.71kg/steer/day (Figure 2). After four years of grazing, the grass/legume pastures have provided useful benefits in animal production over the grass-only pastures.

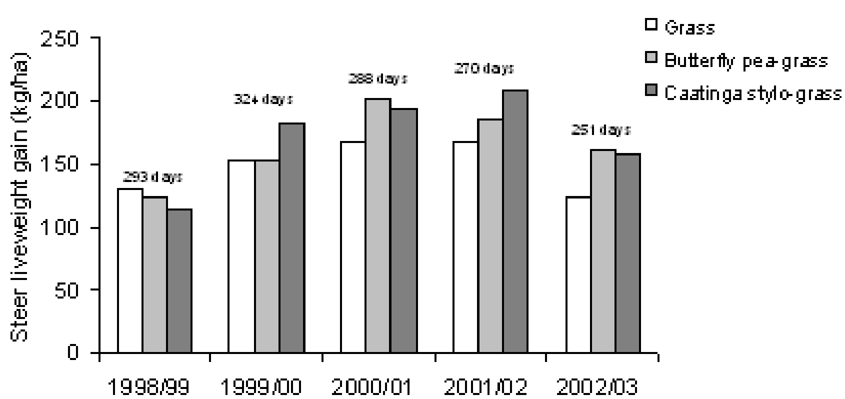

Figure 2. Liveweight gain of steers grazing grass or legume-grass pastures. (Differences between treatments were not significant in any of the years- C.V. ranged from 9-20 %).

Sorghum production

Sorghum grain yield following lablab was higher than the other treatments in 2000/01 and 2002/03 (Table 1). After the first season, comparing sorghum yield between the newly established areas and the areas that had grown a previous sorghum crop, no significant difference was found in the 2000/01 and 2001/02 crops. By 2002/03, however, there was a decline in sorghum grain yield with an increase in the number of preceding sorghum phases that was not ameliorated by fertiliser N. In this year, grain yield was 18 %

lower in the 3rd crop of sorghum and 27 % lower in the 4th crop of sorghum compared with the treatment where one previous sorghum crop had been grown (data not shown). Despite the lack of response in grain yield to fertiliser N, grain protein increased from 6.5 % to 11 % with the addition of 80 kg/ha of N.

The sorghum grown on the grass treatment yielded very poorly in the first year (1999/00) and continued to yield less than the other treatments. This was primarily due to N deficiency (Figure 3) as described by Robertson et al. (1994) in grassland pastures of Central Queensland, but also due to the treatment being located on a shallower soil profile than the legume treatments. These grass treatments were not included in the statistical analysis of sorghum grain yield.

Nitrate dynamics

The soil N status before the pasture treatments were imposed is not known, but it can be reasonably assumed that long term cropping would have depleted this. In the first season following 2 years of legume pastures, soil nitrate N ranged from 36 to 86 kg N in the profile (0-90 cm) and declined to virtually zero following 4 sorghum crops (Figure 3) in the treatments where no fertiliser N was applied. Although the amount of N mineralised between the harvest of a sorghum crop and the sowing of the next sorghum crop was similar in each year (averaged across the legume treatments it was 26, 43, 39 kg/ha nitrate N in 2000, 2001 and 2002) the starting soil nitrate successively declined with the removal of N in each sorghum crop. There was no significant increase found in the concentrations of nitrate with legume pasture that continued for 3 and 4 seasons indicating that the nitrogen fixation declined with increases in soil nitrate as found by Armstrong et al. (1999).

Table 4. Grain production (kg/ha) of the sorghum phases over the 4 seasons. Yields after year 1 are an average of the new and old areas sown to sorghum.

	1999/00	2000/01	2001/02	2002/03
M. daltonii	2825 a^{+}	3641 b	3053 a	3352 b
V. trilobata	2401 a	3860 b	3113 a	-
Lablab	4098 a	5362 a	3738 a	4004 a
Grass	995 (244)*	2405 (339)	3053 (1159)	-

* Brackets indicate s.e. of the mean in the grass treatments only. $^{+}$Means followed by a different letter within columns are significantly different according to DMRT at P≤0.05.Figure 3.

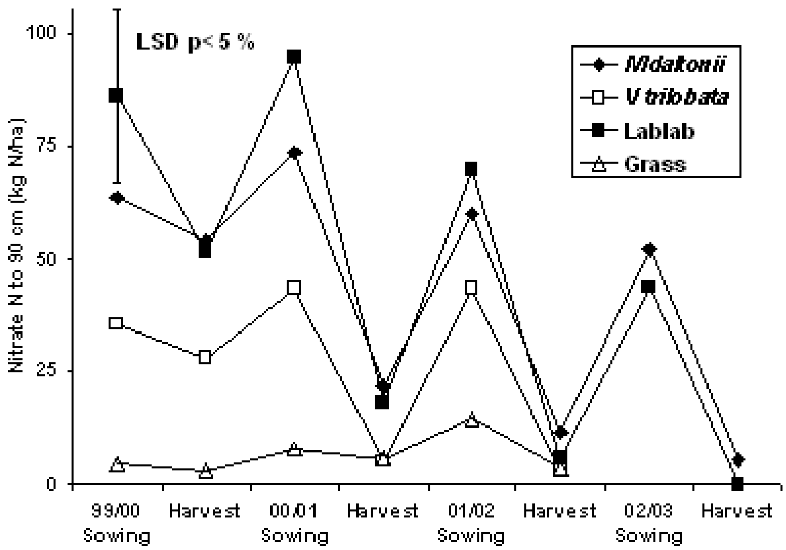

Figure 3. Total soil nitrate N (0-90 cm) measured at pre-sowing and post harvest in each season from 1999/00 to 2002/2003 in the treatments that received no additional N fertiliser.

Conclusion

There is great potential for productive grain systems to be sustained by phases of highly productive pastures and beef production in animal-cropping systems of sub-tropical regions. Animal production of 60 to 120 kg liveweight gain/ha/yr from all the forage types tested compares favourably with production from the higher producing extensive grazing areas such as buffel grass on the fertile clay soils of the brigalow lands of Queensland (Mannetje and Jones, 1990) and productive native pastures over-sown with stylo (Partridge et.al. 1996). Exceptional sorghum grain production that ranged from 3700 to 5300 kg/ha over 4 seasons indicates large responses to the nitrate accumulated in the lablab forage system. Sorghum growth following the grass pastures was initially poor and primarily the result of very low soil nitrate N concentrations present at sorghum sowing. Crop modelling with APSIM showed that sorghum production would exceed 3000 kg/ha in 80 % of seasons following 2 year legume leys in the South Burnett district (Whitbread and Clem 2004).

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