Nitrogen fertiliser may pay on tropical grass pastures

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Low productivity in sown grass pastures due to a lack of available soil nitrogen can reduce beef production by up to 50% across Queensland. The feasibility of strategic nitrogen (N) fertiliser applications to address these losses was assessed by desktop analyses using data from published studies, local fertiliser trials and expert opinion. These analyses suggest that applying nitrogen to rundown sown grass pastures can produce dramatic increases in dry matter yield and animal production. However, high and consistent response rates in pasture productivity, stocking rates and growth rate of cattle were required for the application of nitrogen fertiliser to be profitable. For the suggested 100 kg N/ha fertiliser rate: average gross margins in the year of application were calculated to increase by 121-217% when dry matter yield responses of 40 kg DM/kg N (i.e. an additional 4000 kg/ha) and an additional liveweight gain of 0.2 kg per adult equivalent (AE)/day can be achieved (i.e. an extra 70 kg AE/year). These economics were very sensitive to the assumed response rates in pasture growth, stocking rate and liveweight gain and did not account for uncertainty in climate and beef prices. New research is proposed to re-assess the responses used in this analysis that are largely based on research 25-40 years ago when soils were generally more fertile and pastures less rundown.

Key words
Sown pasture degradation, sown pasture rundown, nitrogen, dry matter production

Introduction

Sown pastures can produce more feed, of better quality, for longer periods of time than native pastures alone. Since the 1970s, sown pastures have been established on approximately 12 million ha across northern Australia, mostly in Queensland (Peck *et al*. 2011), to improve production and economic returns for the beef industry (Walker *et al*. 1997). These sown pastures and forages underpin up to $1.4 billion per annum of beef production in the ‘Mixed farming zone’ of southern and central Queensland and represents approximately 40% of Queensland’s total beef output. Many of these pastures have suffered declines of up to 50% in pasture productivity caused by a lack of available soil nitrogen as pastures age (Graham *et al.* 1981). The mineral nitrogen in these aging pastures becomes immobilised in the established grass plants and soil organic matter (Graham *et al.* 1985). While this pasture degradation (or rundown) affects all grass and grass-legume pastures, it is most severe in the grass-only pastures that represent up to 70% of the total area planted in Queensland (Walker *et al*. 1997).

The effects of rundown can be mitigated by increasing the nitrogen supply to the soil with either fertilisers or legumes. There is wide industry consensus that adapted legumes provide the best option to improve productivity of rundown sown grass pastures (Peck *et al.* 2013). Legumes provide good returns on capital investment as long as they can be successfully established (Ash *et al.* 2013). However, most graziers use high-risk establishment methods with little ground preparation. Subsequent establishment failures have led to the perception that legumes are difficult to establish and has renewed interest in nitrogen fertilisers that are more reliable and easy to apply.

Commercial use of nitrogen fertilisers to promote pasture yields in Queensland is limited, and advisers have used a generalised ‘response rate’ of 30 kg dry matter (DM) for every kilogram of nitrogen (N) applied (Graham *et al*. 1981). However, ‘response rates’ of up to 60 kg DM/kg N have been measured in recent research across Queensland (Lawrence *et al*. unpublished data). This paper, based on desktop analyses, evaluated the possible impact of these higher response rates on beef productivity and economic returns.

Method

The project developed a range of generalised scenarios to assess possible total DM production for selected pastures, stocking rate increases, liveweight gains and estimated gross margins for a range of fertiliser response rate to a single ‘one-off’ fertiliser application only. While on-going trials suggest that larger DM responses may be possible from repeated applications, the lack of available data precluded further analyses. All responses are static averages and do not include the effects of seasonal variation.

Pasture scenarios

Two hypothetical buffel grass pastures were investigated; one with lower DM production (3000 kg DM/ha/yr), another with higher DM production (4500 kg DM/ha/yr) to represent the range of rundown pastures in Queensland. Nitrogen fertiliser was assessed at 100 kg N/ha applied as urea to reflect the practices of those graziers currently using nitrogen fertilisers. A ‘half-rate’ of 50 kg N/ha was also included to assess the likely impact of using a lower rate over a larger area on the property. Urea contains 46% nitrogen and was costed at $700 per ton delivered to the property. Both rates were applied by a fertiliser spreader with the same application costs. Pasture response rates of 20-50 kg DM/kg N were included to allow for higher and lower responses that may be expected due to different combinations of location, soils and climate, along with the seasonal conditions and the underlying level of rundown in each pasture.

Animal production and carry capacity

Table 1. Parameters for an unfertilised buffel grass pasture producing 3000 or 4000 kg DM/ha/yr

Pasture production (kg DM/ha/yr)	3000	4500
Forage consumed (kg DM/ha/yr)	750	1350
Forage spoiled (kg DM/ha/yr)	450	900
Residual forage (kg DM/ha/yr)	1800	2250
Forage utilisation (%)	25	30
Stocking rate (AE/ha)	0.21	0.37
Liveweight gain (kg/AE/yr)	150	150
Beef production (kg/ha/yr)	31	56

Animal production was estimated on the initial ‘baseline’ unfertilised pastures (Table 1). Initial stocking rates were calculated as hectares per Adult Equivalent (AE, a dry animal of 450 kg liveweight (LW)). The subsequent economic analysis used the average weight of stock over the grazing period to account for their growth while on a 100 ha pasture. Average DM intake per AE was estimated at 2.2% of LW over the year, i.e. 10 kg DM/day or 3650 kg DM/yr. Stocking rate was derived by dividing 3650 by the forage consumed (kg DM/ha/yr) by the estimated intake by an AE (3650 kg DM/yr).

Two parameters were increased in response to fertilisation. The spoilage of forage increased with additional pasture production (15% <4500 kg DM/ha; 20% 4501-7500 kg DM/ha; 25% >7500 kg DM/ha), and liveweight gain (LWG) was increased in two scenarios for each fertiliser rate, that is 0.05 or 0.1 kg/AE/day with 50 kg N/ha, and 0.1 or 0.2 kg/AE/day with 100 kg N/ha.

Economic assessment

The paddock level enterprise modelled in this analysis was a trading enterprise in the southern Brigalow belt of central Queensland that purchased store steers and sold finished Ox direct to the meatworks. The boundaries of the enterprise were the physical paddock boundaries. The only expenses incurred by the paddock enterprise were those that varied with the number of cattle run in the paddock, such as husbandry and selling costs. An allowance was made for the amount of additional effort and cost required to apply the fertiliser. The enterprise budgets were compiled in the form of paddock gross margins and were used to identify the profitability of differing levels of fertiliser response within paddocks. Stock were purchased at $1.64/kg and sold at $1.66/kg reflecting the small historical margins in the market and the prices expected at the time. Full details of the economic assessment are contained in Chudleigh (2013).

Estimating relative profit at the paddock level using a gross margin format allowed the costs and incomes associated with the remainder of the business, that do not change with a change in fertiliser use, to be ignored, thereby simplifying the analysis.

Results and discussion

The modelled average increase in beef production per hectare from 100 kg N/ha ranged from 170% up to 721%, and based on the model assumptions, the relative increases were greater when higher response rates in forage yield and/or LWG per steer were used. While a comprehensive coverage of all scenarios is beyond the scope of this paper, several selected scenarios provide insight into the likely impacts.

It has been assumed that pastures that remain in good condition (e.g. with a good density of plants) will respond to applied nitrogen at a rate of around 40 kg DM/kg N. Using this response rate 100 kg N/ha was calculated to increase beef production by 210-250 kg/ha on the more productive 4500 kg DM/yr pasture (Table 2). The increases were smaller on the less productive 3000 kg DM/ha pasture but produced higher relative increases. The lower rate of 50 kg N/ha was also estimated to provide lower increases in beef production of 102 to 115 kg/ha/yr. Table 2 summarises the impacts of the different assumptions with the suggested 100 kgN/ha application to a rundown pasture in a favourable district that produces 4500 kg DM/ha/yr on average.

Table 2. Average beef production increase due to 100 kg N/ha fertiliser with extra liveweights gains of 0.1 to 0.2 kilograms per AE per day and a range of 20 to 50 kg extra dry matter per kg of N applied

Base pasture (4500 kg DM/yr)	**LWG 0.1 kilograms/AE per day**				**LWG 0.2 kilograms/AE per day**			
Pasture response (kg DM/kg N)	**20**	**30**	**40**	**50**	**20**	**30**	**40**	**50**
Extra pasture growth (kg DM/ha/yr)	2000	3000	4000	5000	2000	3000	4000	5000
Forage spoiled (kg DM/ha/yr)	1300	1500	2125	2375	1300	1500	2125	2375
Residual forage (kg DM/ha/yr)	2250	2250	2250	2250	2250	2250	2250	2250
Forage consumed (kg DM/ha/yr)	2950	3750	4125	4875	2950	3750	4125	4875
Stocking rate (AE/ha)	0.81	1.03	1.13	1.34	0.81	1.03	1.13	1.34
New LWG (kg/AE/yr)	185	185	185	185	220	220	220	220
Extra LWG (kg/ha/yr)	150	190	209	247	178	226	249	294

The gross margin for this 100 kg N/ha application on the 4500 kg DM pasture again varied with the fertiliser response rates and LWGs. The expected fertiliser response rate of 40 kg DM/kg N boosted the gross margin from $52 to $115 /ha when a high extra LWG (0.2 kg/AE/day) was assumed (Figure 1). However, if the extra LWG was only 0.1 kg/AE/day, the gross margin fell to $36/ha, and was even worse at $18/ha when the traditional response rate of 30 kg DM/kg N was assumed (Chudleigh 2013). Further analysis not reported here estimated that Internal Rate of Return of 11% was possible for the same dry matter response rate of 40 kg/kg N rate if potential carryover nitrogen responses were included in subsequent years and the additional LWG was more conservatively spread across two years (50 kg/AE in the first year and 20 kg/AE in the second year).

These figures suggest that nitrogen fertiliser has the potential to increase gross margins where the fertiliser impacts significantly on both stocking rates and LWGs. However, it is clear that the use of nitrogen fertiliser may also lose money if the response rate is below 30 kg DM/ha or the additional liveweight gains are low. It should also be remembered that these analyses were based on average figures without the additional risks from seasonal variability or price variation.

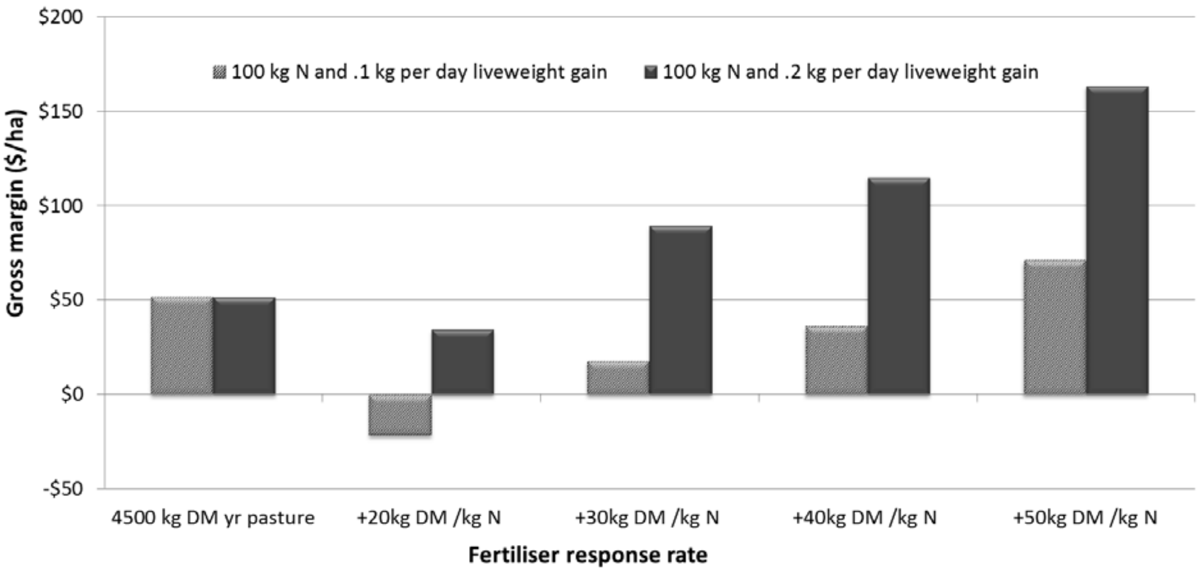

Figure 1. Average gross margins when 100 kg N was applied to a pasture producing 4500 kg DM/ha/yr and livestock having a LWG of 0.1-0.2 kg/AE/day

The analysis highlights the sensitivity of beef production and profitability to the underlying assumptions on the fertiliser response rate and the additional liveweight gains that can be achieved. The economic analysis also highlights that the impressive increases in beef production require a large additional investment in stock numbers and this investment reduces the economic returns, especially when stock are all purchased as they were in the simple scenarios studied here.

Conclusions

The desk-top scenario analyses in this study suggest that applying nitrogen fertilisers to rundown sown grass pastures will produce dramatic increases in DM production and animal productivity. However, a relatively high and consistent response rate in both pasture yield and quality, and hence per head and per hectare livestock production, was required for any reasonable likelihood of the application of nitrogen fertiliser being profitable.

The analyses in the project were largely based on average results and did not include any variability in seasonal conditions. Seasonal variability will increase risk in these fertiliser scenarios, or indeed, any effort to intensify production in the beef industry. For fertiliser, these risks may be managed by restricting applications to seasons in which conditions are already good and avoiding applications in dry seasons, or seasons with the prospect for continuing low rainfall.

Recent trials and reviews of past research suggest a 40 kg DM/kg N response rate is achievable. However, the economic analyses suggest that this need to be coupled with large improvements in weight gain per head for beef producers to be better off. Lower DM response rates and LWGs will fail to provide major benefits, or lose money. Much of the research on pasture rundown, fertiliser responses and LWGs was done over 30 years ago, and most likely on less 'rundown' pastures. New research is now needed to clarify the anecdotal evidence of higher DM responses and to see if they can be converted into profitable livestock responses.

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