Nitrogen fertilised tropical grass pastures allow higher stocking rates resulting in greater lamb production

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Abstract: *Nitrogen fertiliser is important to enhance the productivity of tropical grass pastures. A study was conducted at Tamworth in northern NSW over a single summer growing season to monitor the production of 5-month-old first cross Poll Dorset lambs grazing digit grass (*Digitaria eriantha*) pastures that were either fertilised (100 kg/ha nitrogen) or unfertilised under a continuous and rotational grazing system. The nutritive value, in particularly crude protein, of fertilised digit grass improved with nitrogen fertiliser, especially during the initial months of the growing season. Lamb growth rates were 111 and 102 g/day on the fertilised and unfertilised pastures respectively. The principal production benefit was the higher stocking rate maintained on the fertilised pasture, providing a greater number of total grazing days (+22%) and resulting in 38% more lamb (kg/ha) produced over the growing season. Plant frequency of the digit grass increased over the season and was unaffected by either the grazing system or fertility status.*

Key words: metabolisable energy, ADF, NDF, persistence, growth rate

Introduction

Tropical perennial grass pastures are an important component of the feedbase for livestock production in northern New South Wales due to their high summer productivity and persistence (Harris *et al.* 2014). Adequate soil fertility is required to maintain this productivity, particularly nitrogen (N) (Boschma *et al*. 2015; Murphy *et al.* 2022). Plant phenological development and nutritive value, in particular crude protein concentration, are also enhanced by N fertilisation (Boschma *et al.* 2017). The improved productivity and quality of fertilised pastures provide the opportunity to increase both individual livestock weight gain and carrying capacity.

Grazing management is critical to utilise pasture herbage and maintain the pasture in the vegetative growth stage. Summer growth can lead to rapid plant phenological development resulting in stem accumulation and rank pasture if grazing pressure is insufficient, reducing livestock accessibility and utilisation, particularly by sheep (Boschma *et al.* 2026). While tropical pastures are widely used in beef systems, there is limited information on their performance in sheep grazing systems. Sheep differ from cattle in grazing behaviour and their ability to utilise taller or stemmier swards (Graham 2017), raising questions about the suitability of tropical pastures for lamb production.

This study investigated the combined effects of nitrogen fertilisation and grazing system (continuous versus rotational grazing) on pasture productivity, nutritive value, animal performance and pasture persistence. The objective of this study was to determine the effect of nitrogen fertilisation on pasture nutritive value and lamb productivity of sheep grazing digit grass under continuous and rotational grazing systems, and to assess short term changes in pasture persistence during the 2021–22 growing season.

Methods

Pasture and site establishment

A mixed pasture of digit grass (*Digitaria eriantha*) cv. Premier and desmanthus (*Desmanthus* spp.) cv. Progardes® was established in spring 2018. The pasture was located at the Tamworth Agricultural Institute, Tamworth (31.146°S 150.967°E, 405 m above sea level, 638 mm annual average rainfall [AAR]) on a Brown Chromosol soil (pH_{Ca} (0–10 cm) 5.2, 0.2% total nitrogen, 20 mg/kg KCl40 sulfur, Colwell phosphorus 45 mg/kg, organic carbon 1.8%, potassium 1.1 cmol(+)/kg).

Fences were erected to create plots (15 x 10 m) for a randomised complete block experiment with four treatments and three replicates. The plots were arranged in a 4 x 3 array with a laneway between replicates and around the perimeter of each replicate. Extra areas adjacent to the plots were also fenced to provide additional pasture for the sheep. The total experimental area was 0.6 ha. A desmanthus-digit grass grazing experiment was conducted on the area in 2020–21 but was discontinued when desmanthus failed to persist (Boschma *et al.* 2026, this proceedings).

Treatment details

The experiment was 2x2 factorial consisting of two nitrogen treatments (100 kg N/ha; +N and 0 kg N/ha; -N) and two grazing systems (continuous and rotational). The treatments are listed in Table 1. The plots of each N treatment were communally grazed (Kemp et al. 2000). That is, fences were constructed to allow sheep to graze all replicate plots of each pair of N treatments (i.e. the continuous and rotationally grazed +N treatments were communally grazed, as were the continuous and rotationally grazed -N treatments). The rotationally grazed plots were closed from grazing (i.e. stock excluded) when herbage mass fell to ~1000, minimum 800 kg DM/ha green leaf and reopened for grazing when the pasture had regrown to 3–4 green leaves/tiller.

Table 1. Grazing treatments imposed in the fertilised digit grass grazing experiment.

ID	Treatment
1	+Nitrogen (100 kg/ha N), continuously grazed
2	+Nitrogen (100 kg/ha N), rotationally grazed (pasture rested when green leaf declined to ~800 kg DM/ha and reopened for grazing when pasture regrew with an average 3-4 green leaves/tiller
3	-Nitrogen (0 kg/ha N), continuously grazed
4	-Nitrogen (0 kg/ha N), rotationally grazed (rest periods applied as per Treatment 2)

Single super phosphate (125 kg/ha, 8.8% phosphorus and 11% sulfur) was applied to the entire experimental area on 28 October 2021. Nitrogen fertiliser (100 kg N/ha) was also broadcast onto the +N fertilised plots and associated communal areas (laneways and extra area). The experiment was flail mown to about 0.15 m and herbage removed from the plots on 1 November to reset the pasture. The experiment commenced on 3 November 2021 when 5-month-old first cross Poll Dorset lambs were placed on the plots.

Regular faecal egg counts were conducted to monitor sheep internal parasites. The lambs were drenched before commencing grazing (3 November 2021) with derquantel (10 g/ml a.i.) + abamectin (1 mg/ml a.i.) oral drench and vaccinated with 5 in 1 for clostridial diseases. Barbervax (purified *Haemonchus contortus* antigen min 5 μg/ml) vaccine was used to prevent Barber's Poll worm (*Haemonchus contortus*) infestation. The initial vaccinations were applied over a 4-week period commencing 3 November 2021 and booster vaccinations applied every 6 weeks for the duration of the experiment. Lambs were drenched with multicombination oral drench levamisole hydrochloride (40 g/L a.i.) + closantel (37.5 g/L a.i.) + abendazole (25 g/L) + abamectin (1 g/L a.i.) on 25 January 2022 for internal parasites. Lambs were backlined with cryomazine (60 g/L a.i.) as a preventative against fly strike on 23 December 2021.

Data collection

Herbage production was generally assessed at least fortnightly; before plots were open or closed (rotational grazing), or there was a change in green herbage mass availability requiring a stocking rate adjustment. Dry matter was assessed using a calibration score technique (Boschma *et al.* 2021a). Plots were divided into six strata and each assessed for total herbage mass and percent digit grass. The calibration quadrats (n = 15), representing the range in herbage mass across the experiment, were cut to 10 mm and material sorted into digit grass and other. The proportion of green leaf, green stem, dead leaf and dead stem was also estimated for each plot to monitor the change in plant structure and proportion of the total dry matter available for the sheep. All samples were dried at 80°C for 48 h then weighed. Scores were regressed against the dried sample weights and converted to kg DM/ha. These data were used to calculate stocking rates with the aim to maintain approximately 1000–1500 kg DM/ha of green leaf, and no less than ~800 kg DM/ha. Stock numbers were determined using the calculation:

Number of sheep = (S-R+G*T)/(DMI*30)

Where S was the average standing green herbage mass of the treatment before grazing (kg DM/ha), *R* was the residual herbage mass (kg DM/ha), *G* was the estimated growth rate (kg DM/ha/d), and *T* the time period for grazing (days). Dry matter intake (DMI, kg DM/sheep/d) was set at 1.5 kg DM/sheep/d.

At each herbage mass assessment, forage samples from each communal grazing treatment were collected for assessment of nutritive value (i.e., +N and -N). Pluck samples of the pasture were selected to represent what the animals were eating (i.e., green leaf). Samples were dried at 65°C, ground (2 mm sieve) and analysed by NSW DPIRD Feed Quality Service laboratory for crude protein, metabolisable energy, and neutral and acid detergent fibre (NDF and ADF).

Sheep were weighed whenever stocking rates were adjusted but generally every ~2 weeks when pasture herbage mass was assessed. Calculations included: daily growth rate (g/day/hd), total number of grazing days (days; number sheep/ha * number of days), weight gain/ha (kg/ha; change in sheep weight * number sheep/ha) and daily weight gain/grazing day (kg/ha/grazing day; weight gain/ha/number of grazing days).

Digit grass persistence was assessed at the start and end of the experimental period (October 2021 and April 2022) using the frequency of occurrence method (Brown 1954). Plant frequency was assessed in four fixed locations in each plot using 1 m^2 grids each consisting of 100 cells of 0.1 x 0.1 m. The number of cells containing the base of digit grass were recorded.

Rainfall

Actual and long-term average (LTA) monthly rainfall data were sourced from a local Bureau of Meteorology site (055325) located 13 km from the experimental site. Rainfall was below average (50% of the LTA) during establishment (2018–19), and above average (142% LTA) November 2020–October 2021. During this study (November 2021–March 2022), 534 mm rainfall was received, 151% of the LTA. Rainfall received in November 2021 and March 2022 were more than twice the LTA while the other months were nearer average.

Results

Differences between the continuous and rotational grazing systems were minor relative to the effect of N application, therefore the results are discussed primarily by N treatment.

Pasture production

Herbage mass was assessed 13 times over the 149 day growing season. At the commencement of the experiment in November 2021, total herbage mass across all treatments averaged 2359 kg DM/ha and consisted almost entirely of green leaf (Fig. 1). As the season progressed, herbage mass of the unfertilised (–N) treatments averaged approximately 1000 kg DM/ha under continuous grazing and 1250 kg DM/ha under rotational grazing. In contrast, herbage mass of the nitrogen fertilised (+N) treatments was higher, averaging around 1700 and 2000 kg DM/ha under continuous and rotational grazing, respectively (Fig. 1). Pasture structure also changed over the growing season and differed between nitrogen treatments. Early in the season, all treatments were dominated by green leaf with little stem or dead material (data not shown). From December, stem content increased in all treatments but more rapidly in the fertilised pastures. As a result, the proportion of green leaf declined markedly in the +N treatments, with green leaf accounting for 32% of total herbage mass by the end of the growing season. In contrast, a higher proportion of green leaf was maintained later into the season on the unfertilised (–N) treatment plots, particularly under continuous grazing where green leaf accounted for 62% of total herbage mass at the final assessment. The proportion of dead leaf was similar between nitrogen treatments, reaching an average of ~13% in both N treatments at the end of the growing season.

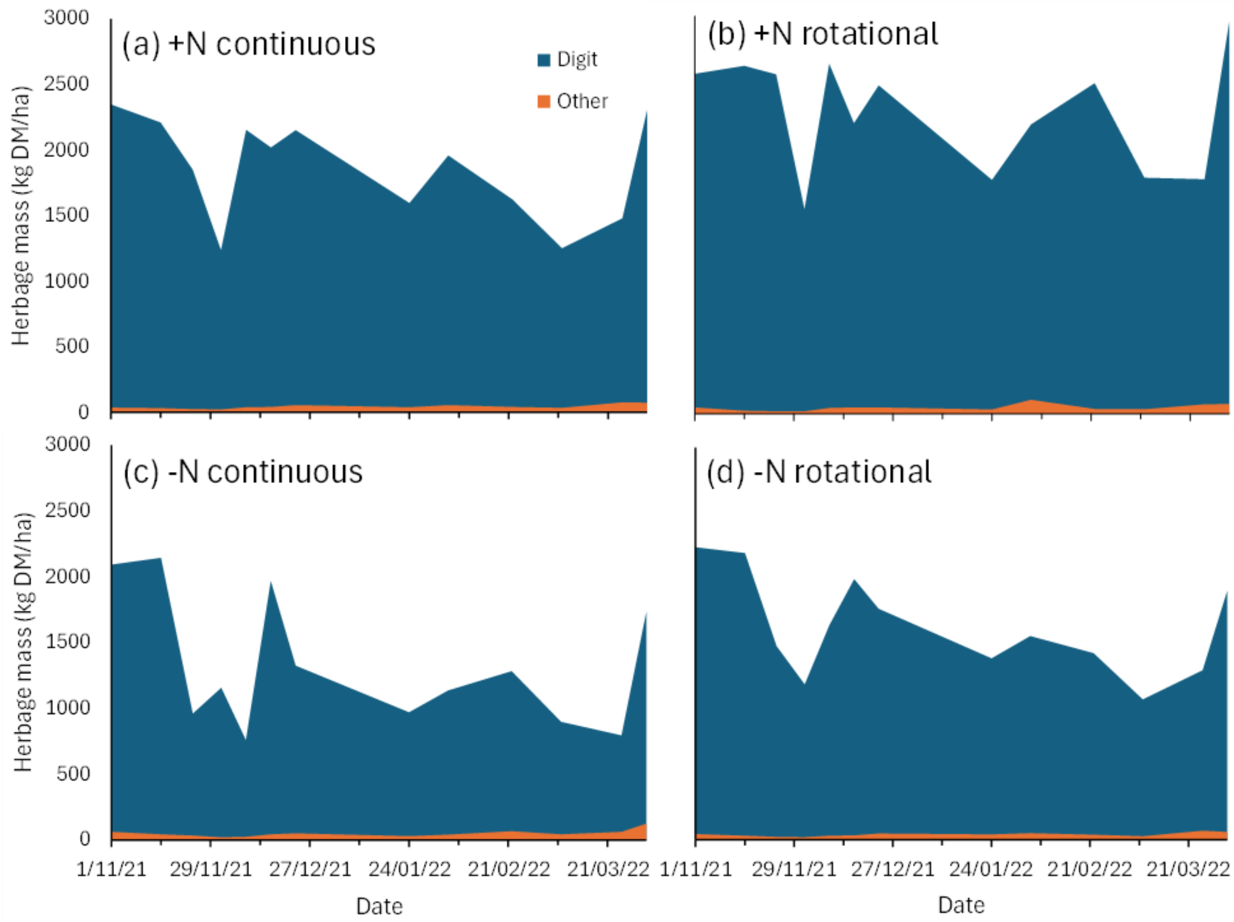

Figure 1. Herbage mass (kg DM/ha) during the 2021–22 growing season for the treatments (a) +N continuous grazing, (b) +N rotational grazing, (c) -N continuous grazing, and (d) -N rotational grazing.

Pasture quality

The nutritive value of the N fertilised (+N) digit grass green leaf was higher than the unfertilised (-N) digit grass. The difference in crude protein between the N treatments were greatest during spring (up to 7% units), declining as the season progressed (average 3% units over the growing season). Crude protein levels were ≥10% for the unfertilised grasses from November until early January while the fertilised grass had crude protein levels ≥10% at all assessments except one (Fig. 2a). These values are suitable for livestock production but limiting for high lamb growth.

Metabolisable energy levels were consistently higher, albeit small, in the +N than -N digit grass. Values were highest (maximum 9.8 and 8.7 MJ/kg DM for +N and -N treatments, respectively) and differences between the treatments greatest (up to 1.3 MJ) in late spring–early summer but only averaged 0.6 MJ difference over the whole growing season (Fig. 2b). These levels are suitable for maintenance to moderate animal production.

Fibre concentrations were slightly lower in the fertilised (+N) than the unfertilised (-N) treatment plots (Fig. 2c,d). Over the growing season, NDF of predominately leaf material averaged 61 and 65% for +N and -N treatments respectively while ADF averaged 28 and 30% respectively.

Animal production

Stocking rates ranged from 108 sheep/ha (+N treatments) in November declining to 7 sheep/ha in March as growth rates declined (Fig. 3). The +N treatment area generally maintained higher stocking, especially during spring and early summer. Stocking rates over the growing season averaged 32 and 26 sheep/ha for the +N and -N treatments, respectively.

Sheep liveweights increased during the growing season. The average weights of the sheep were 35 and 42 kg on the +N and -N fertilised plots at the start of the growing season, while final average weights were 51 and 57 kg for the +N and -N treatments, respectively. Over the 5-month growing season, the average growth rate for sheep grazing the +N treatments was 111 g/d cf. 102 g/d for those on the -N treatment plots.

Although there was little difference in the weight gain of individual animals over the growing season, the +N pasture was able to maintain a higher stocking rate resulting in a greater number of grazing days and weight gain/ha over the growing season (Table 2). The total number of grazing days for the -N treatment area was 3876 days compared with 4741 days for the +N treatment area (+22%). The total liveweight gains were 383 and 528 kg/ha (+38%), equivalent to a daily weight gain of 1.62 and 2.23 kg/ha/d for the -N and +N treatment areas respectively.

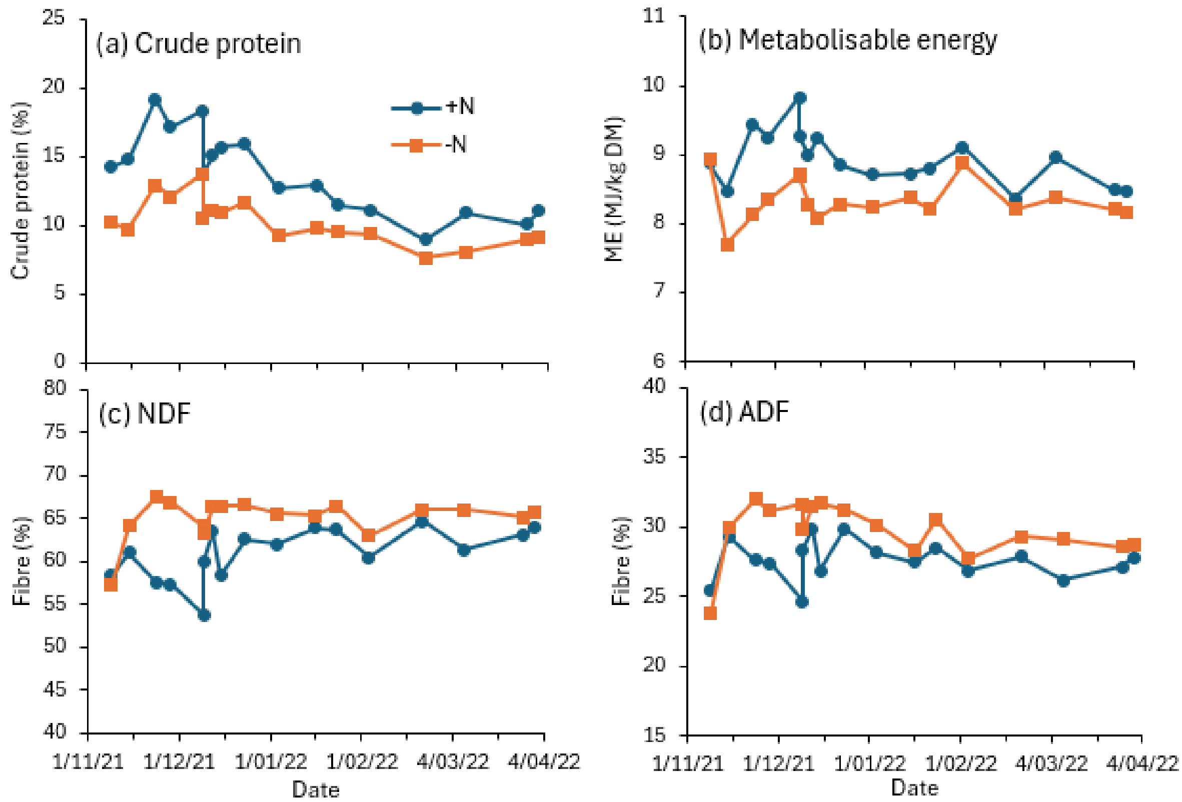

Figure 2. (a) Crude protein (%), (b) metabolisable energy (ME, MJ/kg DM), (c) NDF and (d) ADF (%) of digit grass leaf in the +N and -N fertiliser treatments during the 2021–22 growing season.

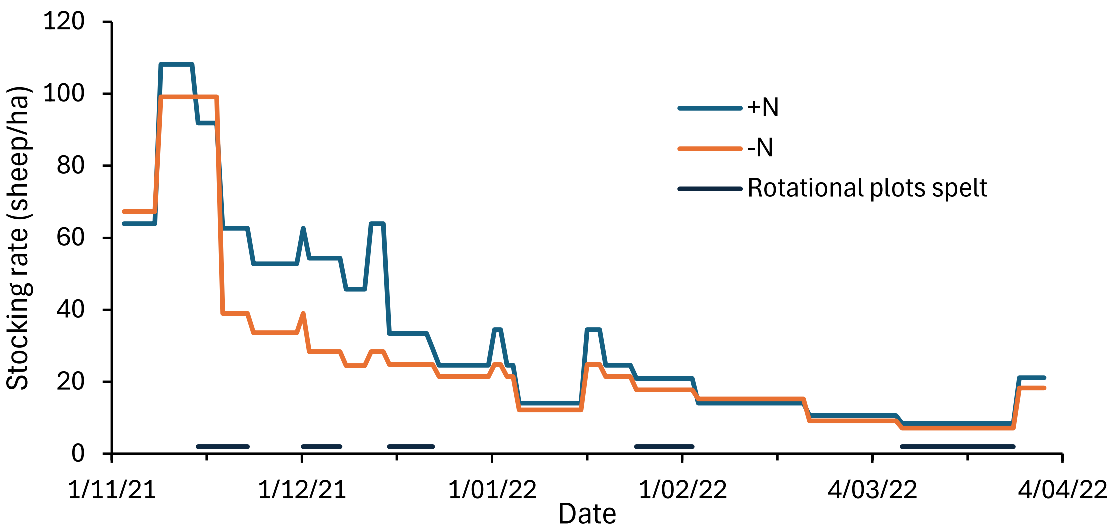

Figure 3. Stocking rates (sheep/ha) on the nitrogen fertilised (+N) and unfertilised (-N) treatment plots 3 November 2021–1 April 2022. Periods when the rotationally grazed plots were closed for spelling are denoted by the black bar.

Table 2. Stocking rate (hd/ha), number of grazing days, total and daily weight gain (kg/ha and kg/ha/grazing day) of sheep which grazed the experiment for the duration of the growing season.

	+N fertiliser				-N fertiliser			
Date	**Stocking rate (hd/ha)**	**No grazing days**	**Weight gain (kg/ha)**	**Daily wt gain (kg/ha/grazing day)**	**Stocking rate (hd/ha**	**No grazing days**	**Weight gain (kg/ha)**	**Daily wt gain (kg/ha/grazing day)**
9/11/21	64	383	32	0.083	67	404	90	0.222
15/11/21	108	649	54	0.083	99	595	132	0.222
19/11/21	92	368	54	0.148	99	396	-22	-0.056
24/11/21	63	313	46	0.148	39	195	-11	-0.056
2/12/21	53	422	52	0.122	34	269	21	0.078
3/12/21	63	63	8	0.122	39	39	3	0.078
9/12/21	54	326	40	0.122	28	170	13	0.078
13/12/21	46	183	26	0.143	24	98	12	0.119
16/12/21	64	192	27	0.143	28	85	10	0.119
23/12/21	33	234	50	0.214	25	173	33	0.190
2/01/22	25	246	38	0.155	25	248	24	0.095
4/01/22	34	69	11	0.155	25	50	5	0.095
6/01/22	25	49	8	0.155	21	43	4	0.095
17/01/22	14	155	14	0.091	12	134	14	0.106
20/01/22	34	103	15	0.146	25	74	22	0.292
25/01/22	25	123	18	0.146	21	107	31	0.292
4/02/22	21	209	-28	-0.133	18	177	-12	-0.067
22/02/22	14	253	61	0.241	15	275	33	0.120
9/03/22	11	158	-9	-0.056	9	137	8	0.056
28/03/22	8	159	21	0.132	7	135	17	0.123
1/04/22	21	84	-11	-0.125	18	73	-43	-0.583
Total		***4741***	***528***			***3876***	***383***	

Pasture persistence

Plant frequency of digit grass increased over the course of the growing season in all treatments from an average of 61% in spring 2021 to 92% in April 2022. There were no significant differences between treatments.

Discussion

This study demonstrated that N fertilisation of digit grass pastures increased lamb production primarily through the ability to sustain higher stocking rates, rather than through large increases in individual animal growth rates. While fertilised pastures had higher crude protein levels, the effects on metabolisable energy were modest resulting in relatively small differences in lamb growth per head. Consequently, carrying capacity was the principal driver of increased productivity on the N fertilised pastures.

Nitrogen fertilisation consistently increased crude protein content of digit grass, particularly during spring and early summer, although the advantage declined as the season progressed. Improvements in metabolisable energy were small and generally limited to early in the growing season as well. As metabolisable energy is the primary nutritional driver of liveweight gain in livestock (Graham 2017), these modest differences explain the limited response in individual lamb growth rates despite improved crude protein levels of the fertilised pasture. Additionally, the higher initial lamb weights, especially in the -N treatment may have limited growth potential, making meaningful differences due to fertiliser unlikely. The +N treatment also had a higher stem content that may have negatively impacted diet quality, and a higher relative stocking pressure to reduce herbage mass and leaf content similar to the -N treatment, may have increased performance from this treatment.

The predominant benefit of N fertilisation in this study was the ability to maintain higher stocking rates for longer periods during the growing season. Fertilised digit grass pastures supported a greater number of grazing days and resulted in a substantial 38% increase in lamb production/ha. This gain highlights that, despite only modest improvements in metabolisable energy due to N fertilisation, the ability to increase carrying capacity provided an overall improvement in system productivity.

The average growth rate of the sheep used in our experiment grazing digit grass (n = 50) for the 5-month growing season exceeded (173%) those of the remainder of the flock (n = 268) they were removed from. The remainder of the flock grazed a combination of forage oats, lucerne and native pasture over the same period the experiment was conducted further demonstrating the value of digit grass in the feedbase for summer growth.

From an economic perspective, the increased lamb production on the fertilised pasture translated to a substantial financial benefit. Based on indicative prices (January 2026), the liveweight gain from the fertilised digit pasture was equivalent to $2670/ha compared with $2115 for the unfertilised pasture; fertilising resulting in a $555/ha benefit. These costs were based on urea costing $1025/t, applied at 100 kg N/ha with an application cost of $20/ha, and a lamb market price of $5.52/kg ($12/kg carcass weight) for a 50 kg liveweight processor lamb (TRLX Tamworth; 19 January 2026). The application cost of $20/ha was included in the calculation despite single superphosphate being applied to both the fertilised and unfertilised treatments. These figures reinforce the potential value of N inputs where stocking rates can be increased, although the benefit is dependent on having a livestock production system, such as lamb trading, that can take advantage of the additional feed when it is grown.

Differences between continuous and rotational grazing systems on animal production were limited by the communal grazing design, but other differences were also small. These minor differences are likely due to the lack of difference in both pasture persistence and nutritive value. It is also not known to what degree stocking rate was influenced by the two grazing treatments, only the combined impact of both and suggest that under favourable seasonal conditions and with stocking rate adjustment, both continuous and rotational grazing can be successfully used to manage digit grass pastures without substantially affecting pasture condition over a single growing season.

Tropical grass pastures are considered better suited to cattle than sheep (Graham 2017) and previous work has shown that rank pasture growth that contains large proportion of plant stem can reduce the ability of sheep to both access and utilise the pasture (Boschma *et al.* 2026, this proceedings). However, the present study demonstrated that digit grass pastures can support lamb growth when they are managed to maintain green leaf and limit stem accumulation. When pastures are well utilised and the herbage accessible, lambs readily graze the digit grass sward. These findings reinforce the importance of active grazing management when tropical pastures are used in sheep production systems.

Over a single growing season with overall good seasonal conditions, digit grass showed good short-term persistence under both continuous and rotational grazing. No adverse effects of grazing management or nitrogen fertilisation on digit grass persistence were observed during the study period. However, longer-term studies are required to determine whether grazing system or fertiliser strategies influence persistence under sustained grazing pressure and variable seasonal conditions.

Conclusions

Digit grass pastures fertilised with N supported higher stocking rates and produced more lamb kg/ha than unfertilised pastures. While individual lamb growth rates were only slightly higher on fertilised pastures, the primary production benefit was increased carrying capacity rather than enhanced animal performance. Digit grass maintained high plant frequency across all grazing systems during the season, indicating persistence can be maintained short-term under the seasonal and management conditions imposed. These results demonstrate that well-managed, nitrogen-fertilised digit grass pastures can play a valuable role in sheep production systems in northern NSW.

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