The economic performance of legumes grown in strips – preliminary findings from Spyglass Research Facility

Key finding

Establishing legume strips cost $650–$800/ha with increased carrying capacity and liveweight gains. All legume treatments had high gross margins compared to undeveloped native pastures. Leucaena delivered the highest gross margin, despite higher costs than the other legumes. These preliminary results will be validated through a multi-year analysis on mature pastures.

Dry season feed quantity and quality are major constraints to steer growth in North Queensland's seasonally dry tropics. Palatable, perennial and productive legumes adapted to relatively dry conditions, such as leucaena, desmanthus and stylos, have the potential to:

- improve dry season nutrition, resulting in higher liveweight gains for longer periods
- support higher stocking rates
- improve nutrient cycling within pastures[1].

An 80-hectare trial site was established at the Queensland Department of Primary Industries Spyglass Beef Research Facility to investigate whether strip planting these legumes into existing pastures can improve productivity and overcome dry season feed limitations.

The alluvial soil site includes 4 treatments (2 replicates each) sown in five-metre-wide cultivated strips occupying about 45% of each paddock (Figure 1):

- Redlands leucaena[2]
- desmanthus mix
- stylo mix
- grass mix

Located adjacent to the Burdekin River, the site proved to be frost-prone, with substantial reductions in legume and grass growth in 2 of the 4 years after sowing.

Figure 1. The strip trial during the dry season.

The preliminary economic analysis in this study uses diet and animal production data collected in 2024 during a frost-affected year which followed a year with minimal frost impacts. A native grassland scenario based on local

[1] Shelton, M., Dalzell, S., Tomkins, N., & Buck, S. R. (2021). Leucaena – The productive and sustainable forage legume

[2] Recently developed psyllid-tolerant leucaena variety with the potential to extend adoption into the humid tropics, particularly on fertile soils (Shelton, M., Giles, H., & Lambrides, C. (2017). Psyllid resistant leucaena to market)

production statistics, while not physically tested, is included to represent business as usual. This paper includes two analyses:

1. Measured 2024 animal production and stocking rates from the trial site (**Part A**).
2. Calculated potential stocking rates, derived from pasture composition and yield measured at the end of the 2023–2024 growing season (**Part B**).

This analysis focuses on the establishment phase results, with a full assessment of mature pasture performance to be completed as additional data becomes available. The stylos and desmanthus, although less productive than leucaena, are more broadly adapted and have lower establishment and ongoing costs. All legumes can reduce the cost of dry season nitrogen supplementation by supplying digestible protein as leaf.

Part A: Measured trial results

Establishment process and costs

The trial was established over 2 years on an alluvial soil site of degraded sown pasture, which had reverted to a mix of sown and native grasses, broad-leaved weeds and light eucalypt regrowth. Grass and legume strips (desmanthus, stylo and leucaena) were sown into the pastures in February 2021 and grazed intermittently to encourage legume establishment. Grazing began in 2022, aiming to improve dry-season feed quality, and was repeated in 2023 after wet season spelling. In 2024, the paddocks were stocked from mid-April until late-September (165 days) to improve dry season diet when cattle growth typically declines.

Table 1 summarises paddock preparation, planting and post-planting costs. Input prices were sourced locally, and operations costed at contractor rates using typical work rates and fuel use. Fertiliser comprised 35–44% of establishment costs due to a high application rate (300kg/ha of a custom blend) and freight costs, together totalling $286/ha. The high fertiliser rate was expected to provide 'nutrient banking' and extend the time until further fertiliser applications are needed. The native grassland scenario has no costs, as it is assumed to be already established.

Table 1. Establishment operations and costs for 20ha assuming no establishment failure

	Leucaena	Desmanthus	Stylo	Sown grass	%
Infrastructure costs (fences, water)	$2,076	$2,076	$2,076	$2,076	13–16
Pre-planting					
Clear into windrows & burn (Dozer)	$1,004	$1,004	$1,004	$1,004	6–8
Offset discing 5m rows/5m spacing	$810	$810	$810	$810	5–6
Cultivate rows, tined plough & roller	$990	$495	$495	$495	3–7
Spray cultivated strips with glyphosate	$359	$359	$359	$359	2–3
Fertilise 300kg/ha, custom P, S, Ca blend	$5,714	$5,714	$5,714	$5,714	35–44
Planting					
Plant seed with planter or spreader	$3,542	$1,719	$1,528	$4,578	12–28
Includes seed costs	*($2,742)*	*($1,566)*	*($1,375)*	*($4,425)*	
Roll rows before and after planting	–	$1,080	$1,080	$1,080	0–8
Apply Spinnaker™ by boom spray	$359	–	–	–	0–2
Post-planting					
Apply Albatross™ by aerial application	$287	–	–	–	0–2
Apply Verdict™ by boom spray	$48	–	–	–	0–0.3
Total establishment costs (for 20ha)	**$15,189**	**$13,257**	**$13,066**	**$16,116**	**100%**
(per ha)	**$759**	**$663**	**$653**	**$806**	

Treatments had similar infrastructure and pre-planting costs, ranging from $523–$548/ha. Planting and post-planting costs varied more, ranging from $130/ha for stylo to $283/ha for sown grass. Stylo, desmanthus and sown grass were distributed with an ATV spreader, followed by rolling. Legume seeds were inoculated with the recommended rhizobium strain ($128 per 25kg of desmanthus/stylo seed or 50kg of leucaena seed).

Stylo and desmanthus had the lowest establishment costs due to low sowing rates (3kg/ha) and no weed or pest control requirements. The stylo mix comprised equal parts Unica, Seca and Verano (uncoated). Sown grass had the highest establishment cost due to a 10kg/ha sowing rate comprising of 7% Katambora Rhodes ($14.09/kg), 31% Sabi ($21.36/kg), 31% Gatton panic ($22.27/kg) (all uncoated) and 31% coated Bisset bluegrass ($26.82/kg).

The leucaena establishment cost was $759/ha. Seed was planted in double rows on 10m centres at 1.7kg/ha. As weed control is vital for successful leucaena establishment, imazethapyr (Spinnaker™) was applied at planting for an additional $359. An additional haloxyfop (Verdict™) application was required to control grasses on 20% of the rows (where previous herbicide had not been effective). To account for grasshopper risk, the modelling included post-planting application of fipronil (Albatross™) in one in every 4 years.

Ongoing annual costs

Table 2 shows the annual activities and costs for each treatment under the trial 2024 stocking rates. No additional fertiliser is expected to be needed in the first 3-6 years due to high pre-planting application rates. On the alluvial soil site, vigorous leucaena growth requires mechanical pruning every second year before the wet season (starting in year 3 after establishment). Figure 2 shows the leucaena after pruning and the regrowth 4 months later. Pruning maintains cattle access to leaf, supports inter-row pasture competitiveness and helps meet Leucaena Code of Practice[3] requirements.

Table 2. Ongoing total annual costs for the 2024 trial stocking rate 20-hectare scenario

	Leucaena	Desmanthus	Stylo	Sown grass	Native grassland
Stocking numbers (head) **Total adult equivalents**	18 23 (1.17/ha)	14 16 (0.79/ha)	14 16 (0.82/ha)	14 16 (0.82/ha)	8 7 (0.34/ha)
Pruning/mechanical slashing	$1,000	–	–	–	–
Leucaena control (labour)	$35	–	–	–	–
Rumen inoculum	$92	–	–	–	–
Fencing maintenance costs	$42	$42	$42	$42	$42
Dry season supplementation[4]	$421	$414	$478	$477	$273
Estimated total annual costs	**$1,590**	**$456**	**$520**	**$519**	**$315**

Figure 2. Leucaena post pruning in December 2023 followed by regrowth in March 2024

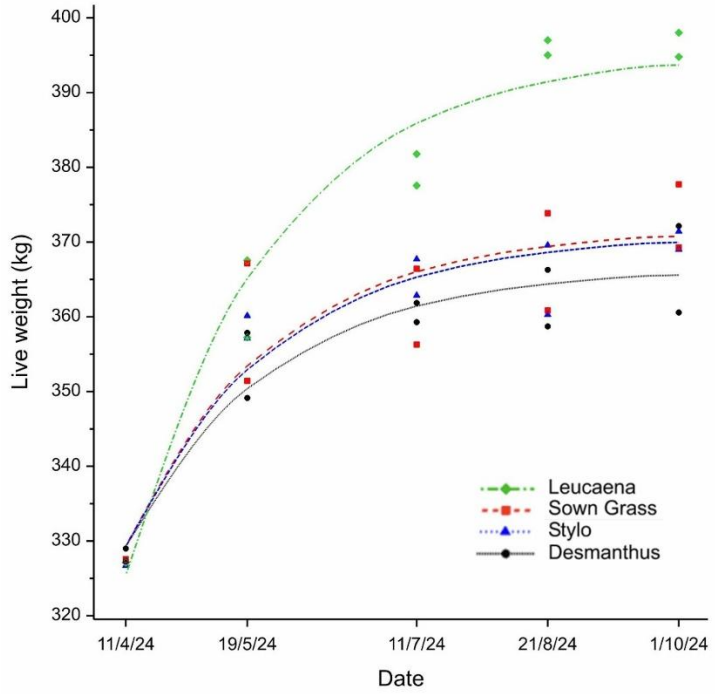
[3] For further details: https://www.leucaena.net/the-leucaena-code-of-practice

[4] Supplementation included in calculations even though diet quality only tended to reduce below critical threshold during frost years

Cattle naive to leucaena were inoculated (one in 10 animals) to detoxify mimosine, averaging $5.11/head. Following a July 2024 frost, all treatment cattle received dry season nitrogen supplementation with Uramol™. During the trial, ad-libitum consumption was measured to range between 101g/head/day for stylo and 69g/head/day for leucaena.

Forage and cattle production increase

In 2024, the trial pastures were grazed during the dry season, with some out-of-season rainfall in August (Figures 3 and 4). Dietary crude protein, measured using faecal NIRS, declined for all species during the grazing period, with a sharper decline for the leucaena in July when heavy frosts caused rapid leaf loss (Figure 5).



Average gain over grazing period:
Leucaena 111kg
Sown grass 84 kg
Stylos 85 kg
Desmanthus 77kg

Figure 3. 2024 grazing period measured liveweight gain of steers on different treatments

Crude protein levels improved following August rainfall, but animal growth slowed across all treatments after the frost event, which reduced available green leaf and dietary protein (Figure 4). Liveweight gains were highest in the leucaena (averaging 111kg) supported by strong early growth and higher protein levels. Animals grazing desmanthus, stylos and sown grass gained an average of 77kg, 85 kg and 84kg, respectively.

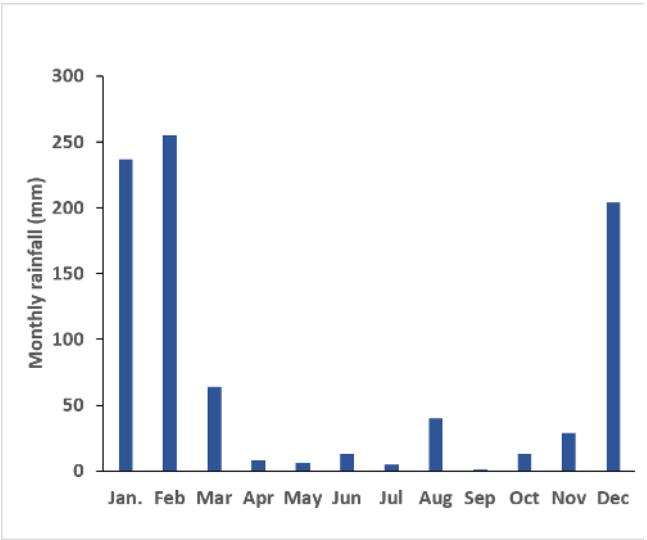


Figure 4. 2024 mean monthly rainfall

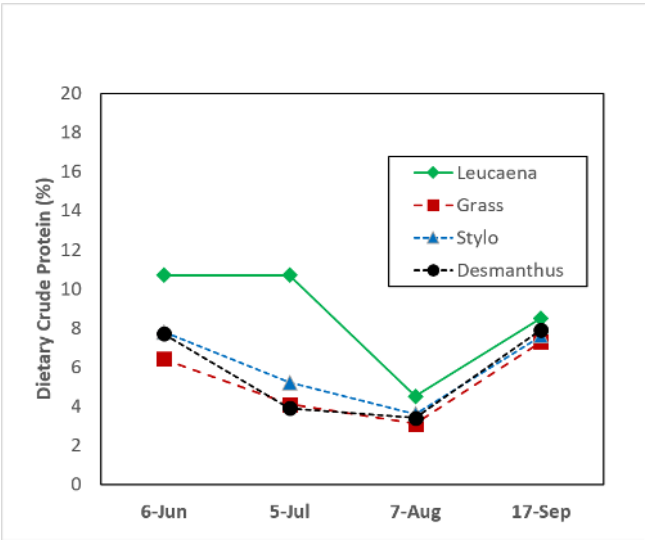


Figure 5. Changes in dietary crude protein (%DM).

Key assumptions

Table 3 shows the main assumptions used in the gross margin analysis. Steer prices are 10-year averages recorded at the Charters Towers saleyard. The steers are purchased at 292kg for $3.24/kg (liveweight) and sold with varying weights (depending on the treatment grazed) at $3.27/kg (liveweight). The assumptions are based on standard practices for the region, including travel distances, common husbandry costs and selling costs. As cattle were grazed for only 165 days, transport weight loss to and from saleyards was not included. This will be incorporated in the future whole-of-investment analysis. Uramol™ supplementation was included because diet quality declined following frost damage, although it may only be required in frost-affected areas.

Table 3. Key assumptions used in the gross margin analysis

Category	Details	
Cattle prices	Purchase: $3.24/kg (liveweight) Sale: $3.27/kg (liveweight)	
Freight	Cost $2.50/km/deck Distance: 170km	
Husbandry costs	Botulism C&D booster: $1/head NLIS tags: $2.77/head	
Supplementation costs	Uramol™: $2.05/kg with varying intakes	Leucaena $23.38/head
		Desmanthus $29.54/head
		Stylo $34.18/head
		Sown grass $34.11/head
Leucaena extra costs	Rumen inoculum: $5.11/head Pruning: $100/ha/two years	
Selling costs	Levies: $17/head Commission: 4% of selling price	

Gross margins

A full investment analysis will be completed once additional production data are collected. This will assess whole-farm profitability, including establishment costs (including forgone production during the establishment period), pasture longevity and seasonal variability. This preliminary analysis focuses on gross margins, calculated as revenue minus variable costs during the 2024 grazing period.

The 2024 gross margin analysis year reflects conditions 3 years after planting. Frosts occurred in both 2022 and 2024, reducing legume populations, particularly in stylo and desmanthus. Each frost event resulted in a loss of leaf of all legumes; however, the damage was only temporary in the leucaena.

The gross margin analysis assumes 50% *Bos indicus* steers are purchased at 17 months old and grazed for 165 days from April to September, before selling through the saleyards at 23 months old (Table 4). Stocking rates reflected the actual trial numbers used in 2024, determined by a feed budget of the edible pasture, allowing for 10kg of dry matter intake per adult equivalent per day. This intake is calculated as 3% bodyweight consumption, growing at 0.4kg/head/day for 200 days with a residual biomass of 1,500kg/ha. The stocking rates were conservative to reduce the risk of feed shortages during the establishment phase, particularly given uncertainty around frost damage. A utilisation rate is not shown due to frost substantially altering pasture availability during the grazing period. Potential stocking rates, based on measured end-of-growing season pasture yields and no frost events, are assessed separately in Part B.

Despite having the highest direct costs, leucaena generated the highest gross margin of $182 per head ($164/ha). This was driven by higher liveweight gain and sale weight. Stylo and sown grass produced similar gross margins ($150/head and $105/ha) reflecting comparable costs and sale weights. Desmanthus returned a lower gross margin of $131 per head ($92/ha) due to lower sale weights.

The native grassland reference generated a negative gross margin (-$7/head) under this specific short-term trading scenario. This should not be interpreted as indicating that native pasture systems are inherently unprofitable. Rather, under the assumptions used (purchasing steers, grazing for only 165 days in the dry season, and selling through the saleyards) liveweight gain was insufficient to offset trading and selling costs.

Table 4. Gross margin results for the 2024 dry season grazing period (165 days) using the actual trial stock numbers (for 20ha)

	Leucaena	Desmanthus	Stylo	Sown grass
Steer numbers of head purchased	18	14	14	14
Total purchase cost	$17,029	$13,245	$13,245	$13,245
Freight, husbandry, and supplementation costs	$714	$641	$706	$705
Leucaena control, inoculum & pruning costs	$1,127	–	–	–
Fencing maintenance	$42	$42	$42	$42
Total direct costs	**$18,912**	**$13,928**	**$13,993**	**$13,992**
Steer purchase weights (kg)	292	292	292	292
Average Daily Gain (kg)	0.67	0.47	0.51	0.51
Steer sale weights (kg)	403	369	377	376
Beef produced (kg)	1,998	1,078	1,190	1,176
Steer numbers sold (head)	18	14	14	14
Sale revenue (net of selling costs)	**$22,196**	**$15,765**	**$16,105**	**$16,093**
Gross margin (herd) – 20ha	**$3,284**	**$1,837**	**$2,112**	**$2,101**
Gross margin (per head)	**$182**	**$131**	**$151**	**$150**
Gross margin (per AE)	**$143**	**$115**	**$132**	**$131**

Part B: Productive potential (modelled)

Gross margins

Gross margins were also calculated using potential stocking rates, calculated from the quantity of pasture available for utilisation following the 2023–2024 wet season (Table 6). The analysis assumes stocking rates are increased to sustainably utilise available forage while maintaining adequate residual biomass at the end of the dry season. Dry matter intake and adult equivalent (AE) ratings were calculated using QuikIntake[5], based on average liveweights, growth rates, and ages during the grazing period. Carrying capacity for each treatment was estimated from available dry matter, utilisation rates and animal feed requirements, shown in Table 5.

This calculation differs from the measured trial results presented in Part A as it reflects a modelled scenario that assumes all available forage is utilised at sustainable levels in a *non-frost* year and represents the productive potential of a year with minimal frost impacts. It also assumes animal performance (particularly liveweight gains) observed in the trial would be maintained at the higher stocking rates. As in Part A, the analysis assumes steers are purchased at 17 months of age, grazed for 165 days through the dry season, and sold at 23 months of age.

Leucaena produced the highest quantity of palatable dry matter, generating more than 3 times the forage available when compared to the native grassland reference on similar land types. Higher feed quality, including greater digestibility and crude protein content, supported superior animal performance and the highest estimated carrying capacity (1.37 AE/ha). All improved pasture treatments substantially increased carrying capacity compared with the native grassland reference (0.27 AE/ha).

[5]McLennan SR, Poppi DP (2019) 'QuikIntake version 6 spreadsheet calculator.' (Department of Agriculture and Fisheries, Queensland: Brisbane, Qld)

Table 5. Dry matter produced in 2023–24 wet season and subsequent carrying capacity calculations

	Leucaena	Desmanthus	Stylo	Sown grass	Native grassland
Palatable dry matter produced (kg DM/ha)[6]	**6,833**	**4,290**	**4,232**	**3,883**	**2,000**
Herbaceous legume content [% dry weight (DW)]	15	40	35	18	–
Leucaena content (% DW)	26	–	–	–	–
Dry matter digestibility (%)	54	50	51	51	50
Utilisation rates (%)	**45**	**37**	**37**	**36**	**25**
Palatable dry matter available for consumption (kg DM/ha)	**3,100**	**1,588**	**1,556**	**1,393**	**500**
End of dry residual (kg DM/ha)	2,708	2,059	2,041	1,907	1,200
Dry matter intake (kg/head/day)	10.4	10.0	10.2	10.2	7.8
Dry matter required (kg/head)	**1,723**	**1,644**	**1,691**	**1,680**	**1,279**
Carrying capacity (AE/ha)[6]	**1.37**	**0.69**	**0.66**	**0.62**	**0.27**
Mortality (%/year)[7]	1	1	1	1	2

Gross margins calculated using the modelled carrying capacities are presented in Table 6.

Table 6. Gross margin results for the 2024 dry season grazing period (165 days) using calculated potential stocking rates based on available biomass produced in the 2023–24 wet season

	Leucaena	Desmanthus	Stylo	Sown grass	Native grassland
Steer numbers purchased	36	19	18	17	8
Total purchase cost	$34,059	$17,976	$17,029	$16,083	$7,569
Freight, husbandry, and supplementation costs	$1,427	$870	$908	$856	$403
Leucaena control, inoculum & pruning costs	$1,219	–	–	–	–
Fencing maintenance	$42	$42	$42	$42	$42
Total direct costs	**$36,747**	**$18,888**	**$17,979**	**$16,981**	**$8,014**
Average Daily Gain (kg)	0.67	0.47	0.51	0.51	0.21
Steer purchase weights (kg)	292	292	292	292	292
Steer sale weights (kg)	403	369	377	376	327
Beef produced (kg)	3,996	1,463	1,530	1,428	280
Steer numbers sold	36	19	18	17	8
Sale revenue (net of selling costs)	**$44,392**	**$21,396**	**$20,706**	**$19,542**	**$7,962**
Gross margin (herd) – 20ha	**$7,645**	**$2,508**	**$2,727**	**$2,561**	**-$52**
Gross margin (per head)	**$212**	**$132**	**$152**	**$151**	**-$7**
Gross margin (per AE)	**$163**	**$117**	**$129**	**$128**	**-$8**

[6] Pasture yield based on a calibrated visual scoring method (Botanal) on 13 March 2024
[7] For the analysis, mortalities are found to be less than one animal

Increasing stocking rates to match available forage (no frost scenario) improved total herd gross margins per 20 ha paddock across all treatments by 22%-133% compared with the measured trial results. Under this scenario, leucaena generated the highest gross margin of $212/head ($382/ha). Stylo and sown grass produced similar gross margins of approximately $151/head ($128–136/ha), while desmanthus returned $132/head ($125/ha). The native grassland scenario remained marginally unprofitable at -$7/head (-$3/ha) under the trading scenario analysed.

These results highlight that the economic advantage of the legume treatments was driven by both improved animal performance and increased carrying capacity. However, the estimates should be interpreted cautiously, as they assume liveweight gains can be maintained at the higher stocking rates, and are based on a single year of pasture production data. Further analysis using mature pasture systems and multiple seasons of data will provide a more robust assessment of long-term profitability. Figure 6 shows the trial in January 2025.

Risk analysis

Two areas of economic risk include success of legume establishment and cattle sale prices.

Establishment success: The cultivated strip-planting method and sowing rates used in this trial should result in a low risk of establishment failure through the provision of a seed bed conducive to good seedling establishment and adequate plant populations. Following established best practices is recommended to mitigate against failure[8]. The cost of establishment failure will vary by circumstance, and future analysis will provide details on the effects of this risk on long-term profitability. Trial data analysed to date indicate a 20% establishment failure will cost between $132–$148/ha to remedy.

Sale price: Price risk is significant for trading scenarios, such as analysed in this case study. Table 7 shows the gross margins if cattle sale prices were 20% higher or lower, assuming the potential stocking rates are used.

Table 7. Gross margin sensitivity analysis for sale prices ($/head)

Sale price	Leucaena	Desmanthus	Stylo	Sown grass
-20%	-$41	-$100	-$85	-$86
-10%	$86	$16	$33	$33
+10%	$339	$248	$270	$269
+20%	$465	$364	$388	$387

Acknowledgements

This economic analysis is part of a broader activity to quantify the legume opportunity in Queensland as part of the Queensland Pasture Resilience Program and the Queensland Reef Water Quality Program. The Queensland Pasture Resilience Program is a partnership between the Department of Primary Industries, Meat & Livestock Australia and the Australian Government through the MLA Donor Company program.

Figure 6. The strip trial, January 2025

[8] For detailed guidance on successfully establishing leucaena: https://futurebeef.com.au/wp-content/uploads/2019/09/How-to-reliably-establish-leucaena-PDF-3.04-MB.pdf