Second edition

Leucaena

The productive and sustainable forage legume

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Published by Meat & Livestock Australia Limited November 2021

The benefits of leucaena

✓ **Better weight gains for longer.** Leucaena is the most productive and most sustainable tropical forage legume. No other forage plant can put the same weight on stock over so long a period of the year.

✓ **Top nutritional value.** Leucaena leaf is high in protein and is easily digested by ruminants; it rivals lucerne in feed value.

✓ **Highly palatable.** Cattle prefer leucaena to most other forages, making for high intake and subsequent weight gains.

✓ **No danger of bloat.** Leucaena does not cause bloat—unlike lucerne or clovers.

✓ **Flexible markets.** Excellent weight gains allow you to target the best markets at times when prices are highest.

✓ **Drought proofing.** Leucaena keeps producing high-quality green leaf through dry periods during summer, autumn and early winter.

✓ **Long life, lower cost.** Once leucaena is established, it can last for more than 30 years; no need for annual forage crops.

✓ **Improves soil fertility.** Nitrogen fixed by leucaena reverses 'nitrogen run-down' seen in pure-grass swards and improves grass quality and quantity.

✓ **Reduces soil erosion.** Leucaena and vigorous grass planted across the slope encourage water infiltration and reduces run-off.

✓ **Prevents rising water tables and salinity.** Leucaena's deep roots can extract water from the soil to a depth of 3–5m thus preventing rising water tables that can bring salt to the soil surface.

✓ **Reduces greenhouse gasses.** Carbon is sequestered in the woody growth. Highly digestible leucaena diets can reduce cattle methane production by 20–40%.

but ...

Agronomic considerations

? **Only on good soils.** Leucaena grows best on deep fertile soils.

? **Costly to establish.** Leucaena seedlings do not compete well against grasses or weeds, which must be effectively controlled.

? **No frost tolerance.** Frost kills leaf and stems to ground level (although plants regrow from root crown).

? **Psyllid insects** can devastate new leaf, especially under coastal humid conditions.

Management considerations

? **High palatability** means that leucaena needs suitable management to prevent overgrazing or wasteful utilisation.

? **Mimosine toxicity.** Leucaena can be toxic if the animals are not inoculated with special rumen bacteria.

Environmental considerations

? **Heavy seed production** in ungrazed areas, such as roadsides, can allow leucaena to spread and become an environmental weed.

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Foreword

From very humble beginnings in 1955, when variety trials were first conducted at CSIRO Samford Research Station, the area of land in northern Australia under leucaena pasture has grown to cover 200,000–300,000 hectares with some 4000–6000ha of new plantings each year. Leucaena now makes a substantial contribution to the diet for well over 200,000 cattle each year. Continuing seed sales indicate that this area and its economic significance will increase substantially in the future.

Since the first edition of this book, leucaena continues to thrive and create wealth for the beef industry. Whilst adoption is growing at a moderate pace, there have been significant developments. It is now eighteen years since a new breeding proposal for a new psyllid-resistant variety was accepted and funding approved. The variety now named cv. Redlands has been released and grazing trials are in progress. The results so far, after ten months of grazing, have shown similar performance to cultivar Wondergraze iin a low psyllid environment. In psyllid-prone environments Redlands will give superior results, thus considerably extending the area suitable for leucaena development.

Another important advance has been the development of a pasture-fed cattle standard that is now officially known as PCAS (the Pasturefed Cattle Assurance Scheme). The Teys Aust. 'Grasslands' brand is now well established and attracts premiums above grain-fed beef in both domestic and US markets. Leucaena is a major driver of this brand.

Further research has been done on the management of leucaena toxicity. Studies in Indonesia by Max Shelton and his team demonstrate that cattle without the manual introduction of *Synergistes jonesii* were not affected with toxicity problems. The cattle in the grazing trial with cv. Redlands that is currently being conducted have not been inoculated, have suffered no ill effects and are performing well. Much discussion is also being centred around the need for an applied *Rhizobium* for nitrogen fixation by the leucaena, and this area requires additional research as areas of feral leucaena, where the seed has never been inoculated, grow strongly with good leaf colour.

Finally, I would like every leucaena grower to pause and give a thought to all the people who have been involved in the research and development of this remarkable plant. There are too many to mention all but I will mention one who has made an enormous contribution. Professor Jim Brewbaker from the University of Hawaii has made an outstanding and lifelong contribution to teaching and research supervision of students from around the world. His research on the genetics and breeding of the *Leucaena* genus has directly contributed to the varieties now available in Australia.

Greg Brown
North Queensland Grazier
Current member of North Queensland Beef Research Committee
Former member of Northern Australian Beef Research Council
Former President of the Cattle Council of Australia

Preface

The first historical records of the use of leucaena by man date back several millennia from excavations in Mexico where it was used as a food for humans. The first known use as forage for livestock has been more recent – Asian smallholders were feeding leucaena to cattle in eastern Indonesia in the 1930s and in the Philippines in the 1970s.

Research into leucaena's value as forage in Australia began in the 1950s, but it was not until the 1990s that large-scale adoption gained momentum, with many factors contributing to this lag between first research and uptake of the technology by graziers.

Since the 1980s, dedicated champions – researchers, advisors and innovative graziers – have worked together to solve the outstanding problems. Improved establishment and management practices have led to markedly increased adoption in the 1990s.

Key developments have included:

- solving the mimosine toxicity problem
- more reliable establishment practices, especially weed control
- improved plant and animal management
- improved varieties, seed quality and treatment
- comprehensive economic analysis of the costs and returns
- greater appreciation of the positive and negative environmental impacts of leucaena.

The formation of The Leucaena Network in 2000 brought together many forward-thinking graziers who negotiated with Queensland Government agencies on policies for the responsible use of leucaena. It worked closely with research agencies firstly with the University of Queensland, and the Queensland Department of Agriculture and Fisheries (QDAF) to support research and training initiatives.

University of Queensland researchers, with decades of experience, teamed with successful leucaena graziers to ensure a balance of theory and practice, and delivered 30 Leucaena for Profit and Sustainability training courses between 2004 and 2010.

With financial support from MLA, the course notes were upgraded into the first edition of the Leucaena book in 2006. Since then, much new information has been generated from around the world and has been collated in this 2020 updated edition. The information will be invaluable to new and existing growers, extension specialists, students and researchers wishing to learn more about the best ways to establish and manage leucaena.

Max Shelton, Scott Dalzell, Nigel Tomkins and Stuart Buck

Acknowledgements

This book is an upgrade of the earlier edition entitled *Leucaena – a guide to establishment and management*. The authors wish to acknowledge those who contributed to the earlier publication, namely Ben Mullen, Peter Larsen and Keith McLaughlin.

The authors acknowledge those who have contributed to this new publication. These include Maree Bowen, Fred Chudleigh, Joe Rolfe and Bernie English of the Queensland Department of Agriculture and Fisheries (QDAF) for the chapter on economic analysis, and David McNeill and Tim Huggins for the information on nutrition.

Special thanks to graziers who provided advice and suggestions or case studies: Don Heatley, John O'Neill, Scott Smith, Craig Antonio, Stuart Ogg, Jonathon Schmidt, Paul Harris, Andrew Richardson, Greg Brown, Bruce Mayne and Peter Larsen.

Students of the University of Queensland are acknowledged for use of their published and unpublished data: Dr Nahuel Pachas, Dr Michael Halliday, Dr Hayley McMillan, Dr Esnawan Budisantoso, Ms Fiona Coates, Dr Keith Galgal, Ms Hayley Poole, Dr Alejandro Radrizzani, Mr David Rowlings, Mr William Sheehan and Ms Sarah Streeter.

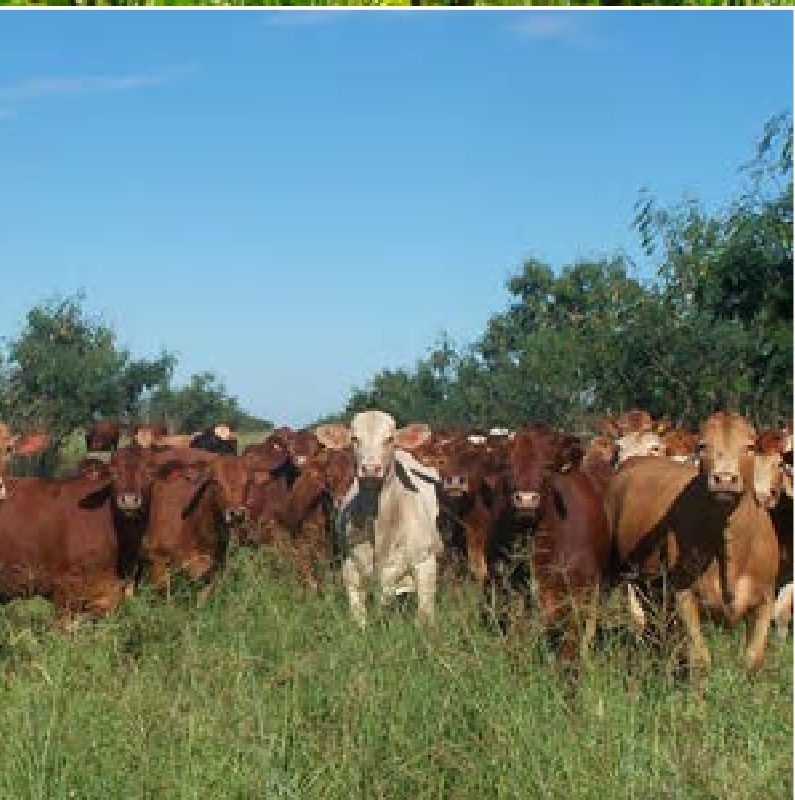
Photographs

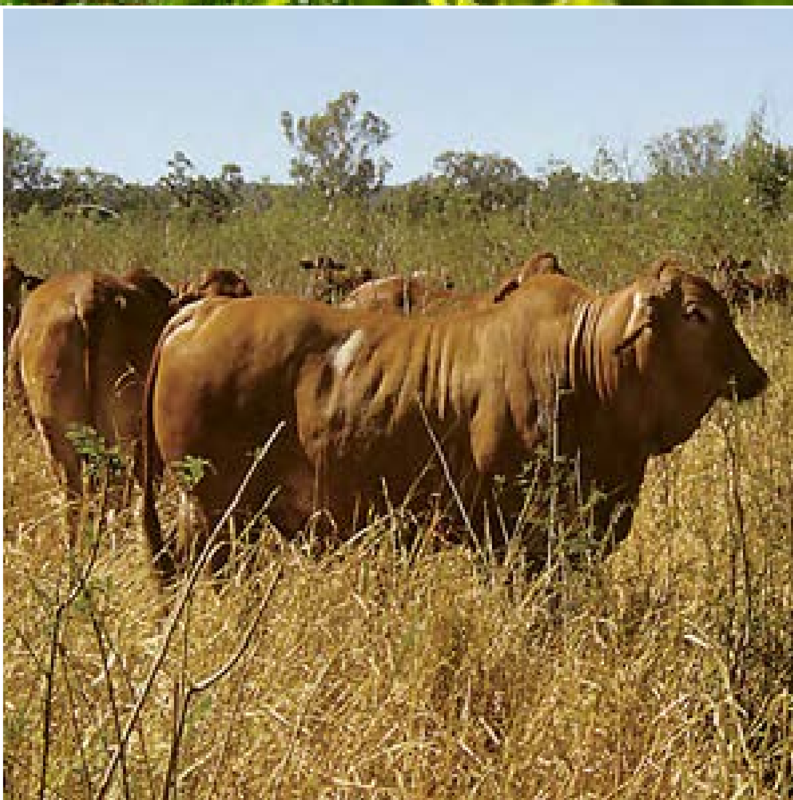
We thank CSIRO, Queensland Department of Agriculture and Fisheries (QDAF), Queensland Department of Natural Resources, Mines and Energy and many others including Craig Thornton, Michael Halliday, Max Shelton, Andrew Richardson, Col Middleton; Ian Partridge; Dr Milton Allison, Joe Gallagher and Alan Jensen; Trevor Hall; Bernie English; Dr Colin Hughes; Dr Raymond Jones; Dr Gunnar Kirchhof; Tim Larsen; Alex Liddle; Andrew Richardson; Dr Lynn Sollenberger; Dr Charles Sorensson; Ernie Young for permission to use various photographs:

Figures

We thank QDAF for permission to use and modify the figure of liveweight gains from pasture, and PROSEA (Plant Resources of South East Asia) for the illustration of the leucaena plant.

1. Why plant leucaena?





Chapter 1 - Index

1. Why plant leucaena?

1.1 What is leucaena?

Leucaena (*Leucaena leucocephala*) is a small-medium perennial leguminous tree with foliage of high nutritive value for ruminant production. It is palatable, nutritious, long-lived and drought-tolerant.

Leaves, flowers and pods of leucaena

In northern Australia, leucaena is planted in hedgerows with grass sown in the inter-row to form a highly productive and sustainable grass–legume pasture for cattle grazing. While it can be found growing in a wide range of soil environments, it performs best on deep, fertile soils in sub-humid environments where annual rainfall averages over 600mm.

Being deep-rooted, leucaena is able to exploit soil moisture beyond the reach of grass roots and so remain productive well into the dry season. Once established, leucaena-grass pastures can remain productive for over 30 years.

Leucaena stand planted in 1975 and grazed every year

A brief history of leucaena

The native distribution of the genus *Leucaena* stretches from southern Texas in North America through Mexico and Central America and into northern South America. Species in the genus have been used as human food for several thousand years.

It is thought that around the 1600s Spanish colonists transported leucaena westwards to the Philippines and South-East Asia for use as a shade plant in tea and coffee plantations. It is now a multipurpose plant in the region and is used for timber, fuel wood, green manure as well as forage for feeding ruminant livestock. In India, it used for paper pulp.

The history of leucaena in Australia is more recent. 'Wild' leucaena arrived on the coast of northern Queensland in the late 1800s, but it was not until the 1960s that the first forage variety was released by the CSIRO. Another decade passed before the first commercial stands were planted in the 1970s.

In the mid-1980s, the leucaena psyllid insect devastated productive stands in humid coastal districts, and commercial planting slowed. But as producers in the drier inland areas realised that the psyllid was only an intermittent problem, major plantings recommenced in the 1990s. A psyllid-tolerant variety, Redlands, is now available and has expanded the area of northern Australia suitable for leucaena development.

Some 500–1000 producers now grow an estimated 200,000 to 300,000ha of leucaena pastures – with the area increasing by some 4,000ha every year.

1.2 Why plant leucaena?

Leucaena and grass pastures are the most productive, sustainable and profitable system for producing grassfed beef in northern Australia.

High growth rates from leucaena pastures enable cattle to grow quickly throughout their lives despite a highly variable climate and severe dry seasons. This ensures flexibility in meeting market specifications for young cattle for feedlot entry, live export or slaughter.

Access to major export markets such as Japan, Korea, Europe and China requires animals to reach a target weight at a young age. Typical market specifications for grassfed animals in Australia are shown in Table 1.1.

Table 1.1: Market specifications for grassfed cattle

Market	Live weight (kg)	Dressed weight (kg)	Fat depth (mm)	Teeth
Grassfed Ox	550–760	300–420	5–22	0–8
European Union	440–550	240–420	5–22	0–4
Domestic	330–550	180–300	5–22	0–2
MSA	330–620	180–340	5–22	0–4
PCAS	330–620	180–340	6–22	0–4

Steers need to gain about 250–300kg per year to grade top quality in EU, domestic, Meat Standards Australia (MSA) or Pasture-fed Cattle Assurance Scheme (PCAS) markets. This can be reliably achieved from leucaena-grass but not from tropical grass-only pasture.

What's wrong with our grass pasture?

Steers on brigalow pastures of buffel grass, Rhodes grass and green panic typically gain 140–190kg live weight a year without supplementation.

Cattle need more than 13% crude protein (CP) in their diet to grow to their potential. Even on fertile soils, the CP content of the grass is generally too low (below 8% for most of year) for maximal beef production. Tropical grasses are also fibrous and with low in digestibility, low metabolisable energy content for much of the year.

In grass pastures, the nitrogen (N) needed for vigorous growth and quality becomes tied up in soil organic matter, especially after the pasture has been growing for a number of years. This 'nitrogen rundown' in grass pastures results in low cattle weight gains because it compromises feed quality.

Higher pasture production can be achieved when tied-up nitrogen is released by disturbing the soil, as seen when brigalow pastures are blade ploughed, but this is a short-term boost.

Grass – more fibre and less protein as it matures

Growing a vigorous legume such as leucaena with the grass is the best long-term option for a sustainable pasture.

What are the special benefits from leucaena?

Leucaena is one of the few tropical or subtropical legumes that will remain permanently productive on fertile alluvial or heavy clay soils. It not only improves the growth rates of cattle at critical times of the year but will keep on doing so for decades. On poorer soils, nutrient deficiencies of phosphorus (P) and sulphur (S) need to be corrected. Cattle on leucaena-grass pastures will gain 250–300kg per year, and at a higher stocking rate; production per hectare can be double that from rundown buffel grass, or up to four times that from native grass pasture (Table 1.2).

Table 1.2: Average productivity and gross margin of forage options on commercial properties in the Fitzroy catchment of central and southern Queensland

Forage system	Grazing days	Stocking rate (ha/AE)	LWG/ year (kg/ha)	Gross margin ($/ha/yr)
Perennial native grass pasture	224	2.7	76	98
Oats	116	1.0	93	31
Forage sorghum	107	0.6	108	54
Lablab	107	1.0	99	44
Butterfly pea-grass	181	1.7	125	143
Leucaena-grass	284	1.3	198	184

Source: Bowen et al. 2018. See Appendix for reference.

Leucaena-fed steers can reach 600kg live weight at 24–30 months of age (2 or 4-tooth). This is 6–12 months earlier than those on straight buffel grass, significantly increasing the carcase value and rate of steer turnover. Table 1.3 and Fig. 1 demonstrate the high carcase quality of cattle finished on leucaena-grass pasture.

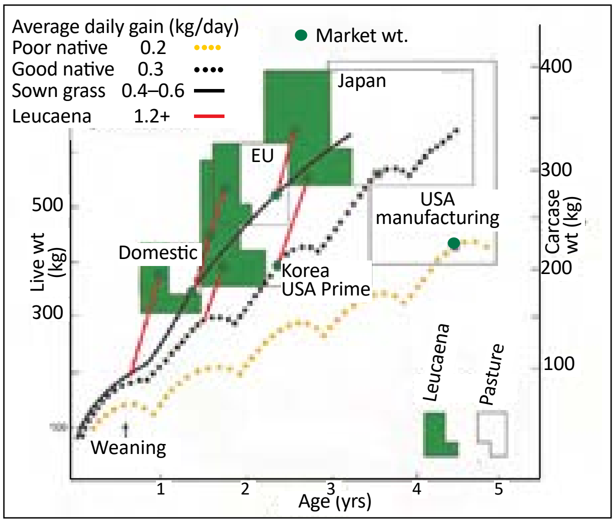
Table 1.3: Carcase grading from assorted drafts of cattle fattened on leucaena (from kill sheets)

Property location	No. of cattle	Average dentition	Average fat depth (mm)	Average carcase weight (kg)
Monto	33	1.9	15.0	322
Wandoan	10	1.6	14.9	330
Banana	62	2.0	13.0	326
Wandoan	42	2.3	16.0	367

1.3 Choose your market

A significant benefit of the rapid live weight gain of cattle grazing leucaena–grass pasture is increased flexibility in targeting domestic and export markets according to the best prices (Figure 1).

Figure 1: Major beef markets and pathways to meet these markets



Source: Adapted from Gramshaw D. and Lloyd D. See Appendix for reference.

The criteria to access both export and domestic beef markets are becoming increasingly stringent. The adoption of product quality standards such as MSA and PCAS set objective criteria with associated price incentives for producers.

High quality pasture systems such as leucaena make it easier to meet the high standards for some domestic and export markets without resorting to grain finishing.

Leucaena pasture can also be used for improving breeder condition, conception and branding rates in breeding herds, for growing out stud bulls and for backgrounding weaners before entry into feedlots.

1.4 Benefits and limitations from growing leucaena

Leucaena has nutritional, agronomic, economic and environmental benefits over other tropical pasture legumes.

Nutritional and agronomic benefits

- **Better weight gains for longer.** Leucaena is the most productive and most sustainable tropical forage legume available when grown under suitable conditions. No other forage legume can put the same weight on ruminant livestock over extended periods of the year. It also recovers quickly after drought following good rain.
- **Top nutritional value.** Leucaena leaf is high in protein and is easily digested by ruminants; it rivals lucerne in feed value. Part of the protein is protected by tannins and passes through the rumen and is more efficiently digested in the small intestine.
- **High palatability.** Cattle relish leucaena and eat it in preference to most other forages, ensuring high intake and weight gains. But it may need special grazing management to prevent over-grazing or wasteful utilisation.
- **Improved animal health.** Leucaena has anthelmintic properties and its consumption provides some control of gastro-intestinal parasites. Unlike lucerne, clover or medics, leucaena does not cause bloat.

Economic benefits

- **Costs and returns.** Commercial data from producers show that leucaena-grass pastures produce almost 2.5 times more beef than grass-only pasture, and gross margins are two-fold higher. Economic modelling shows that fattening cattle on leucaena is more profitable than other forage options in central Queensland because of its long life and low maintenance costs once established.
- **Flexible marketing.** Excellent weight gains over long periods allow producers to target either domestic or export markets, and to market finished animals when prices are highest.
- **Long life, lower cost.** Once leucaena is established, it can remain productive for more than 40 years provided soil mineral deficiencies are corrected with fertiliser, and regularly frosted paddocks are allowed to fully recover before grazing. It is a more profitable option than other short-term legumes or expensive annual forage crops.

Environmental benefits

- **Drought tolerance and animal welfare.** Leucaena's deep root system allows it to use water deeper in the soil profile than grasses. It keeps producing high quality green leaf through dry periods during summer, autumn and early winter – or until hit by frost. Producers with access to leucaena report improved animal welfare outcomes during dry times.
- **Reduced greenhouse gas emissions.** Carbon is locked up in the woody stems and roots of leucaena and in the increased growth of grass. Ruminants grazing high-quality leaf of leucaena may reduce methane production by 20–30%.
- **Improved soil fertility.** Much of the nitrogen fixed by leucaena is returned to the soil and used by the grass, reversing the 'nitrogen rundown' seen in pure-grass swards and improving grass quantity and quality.
- **Reduced soil erosion.** Leucaena planted across the slope with a vigorous grass encourages water infiltration and reduces run-off.
- **Reduced dryland salinity.** Leucaena is deep rooted. Whereas the roots of grass can extract water from the soil to a depth of 1.5–2m, leucaena roots can pull water from 3–5m, thus preventing rising water tables bringing salt to the soil surface.

Limitations of leucaena

Agronomic limitations

- **Only for better soils**. Leucaena does not grow productively on infertile or acid soils; it needs deep, fertile soils of neutral or slightly alkaline reaction with high levels of available phosphorus and sulphur. However, poorer soils which are deep and well drained may be suitable when nutrient deficiencies are corrected with fertiliser applications.
- **Susceptible to frost**. Frosted leaf drops and stems may be killed to ground level. Plants will regrow from the crown but need sufficient time to fully recover before grazing.
- **Slow to establish.** Leucaena seedlings suffer strongly from weed competition and often from attack by insects, kangaroos, wallabies and hares. Newly planted leucaena must be protected from weeds, wildlife and ruminants until at least 1.5m tall.

Management limitations

- **Psyllids**. Psyllid insects may attack leucaena, specially under humid coastal conditions. They can be controlled chemically or managed now by planting the psyllid tolerant variety cv. Redlands.
- **Mimosine toxicity.** Leucaena contains toxins and naïve animals need to be introduced slowly to leucaena until they become adapted. This may take two to four weeks and involve drenching cattle with a rumen innoculum.

Environmental limitations

- **Heavy seed production.** Poorly managed stands of leucaena can produce large amounts of seed resulting in unwanted volunteer plants, especially in ungrazed environments. Escaped plants need to be controlled. The Leucaena Network recommends specific management guidelines to minimise seed set in commercial plantings of leucaena.

The Leucaena Network

The Leucaena Network was formed in 2000 to promote the use of leucaena as a valuable forage plant.

With assistance from Queensland Department of Agriculture and Fisheries and The University of Queensland, the Network has developed a Code of Practice to encourage responsible management of leucaena so as to maximise beef cattle production and minimise the weed risk to the environment. The Code of Practice will help growers establish environmental credibility with the broader community.

Full details of the Code of Practice are presented in Appendix 1.

1.5 The future

There is potential to expand leucaena pastures in northern Australia. Some 5% (25 million ha) of northern Australia fits the requirements for growing leucaena with about 90% of this area in Queensland. Although most of this land will never be planted to leucaena, there is considerable potential for increasing beef productivity across northern Australia.

Leucaena is an appropriate option to address many of the current challenges facing the beef industry. It is a long-lived perennial legume which accommodates intensification (higher stocking rates on a smaller area of land), while enhancing the environment with nitrogen fixation, carbon sequestration and methane abatement. It provides drought mitigation and improved animal welfare while lifting beef productivity and profitability.

There continues to be concern about the potential of leucaena to become an environmental weed. To address this concern, factual information is being disseminated and the voluntary Code of Practice implemented for the responsible use of leucaena.

1.6. Producer experience: pioneers of broadscale leucaena pastures

John and Del O'Neill, 'Nyanda Station', Queensland

John and Del O'Neill were among the first group of innovative producers to pioneer commercial use of leucaena in Australia. They own 'Nyanda Station', 15,400ha of country nestled against the Carnarvon Gorge 65km south of Rolleston. Half of the property is mountainous and forested but around 2,600ha have been cleared for grazing.

The deep alluvial soils are high in phosphorus (~120 mg/kg) and perfect for leucaena growing. They planted their first 30ha of cv. Peru in 1980 and their last 100ha in 2005 giving a total area of 600ha of leucaena.

These original paddocks of cv. Peru still look green and lush after summer rain, with no sign of nutrient deficiency. John will plant more now that cv. Redlands seed is available. Some producers in the Carnarvon area who have planted cv. Tarramba have found that it grows too tall.

Establishment. John found that planting directly into a grass paddock resulted in poor leucaena growth. He now plants in single rows and inter-row cultivates during the first summer. Initial plantings were at a row spacing of 4.5m but later increased to 6m. He sprays a 1m wide band of a mixture of herbicides bentazone and fluazifop-P at 2kg active ingredients/ha for each herbicide, directly over young leucaena rows for control of emerging broad-leaf weeds and grass. This was effective on emerging weeds, but less so on older weeds, and allows leucaena plants to gain advantage. When leucaena plants are sufficiently advanced, cattle graze down the area before winter as leaf will be lost from frosting anyway.

Inter-row grasses. For the initial plantings, green panic and buffel were planted between leucaena rows. However, competition from the highly vigorous growth of leucaena and heavy stocking rates have weakened the grass.

Height management. Leucaena should be cut while still at a manageable height when the contractor's machines can travel through at a reasonable speed. Excess height of leucaena was controlled by driving along the rows with a bulldozer every five years. Height has also been controlled by frosting, occasionally by accidental burning. However, after a very hot burn, the stumps of the leucaena plants were burnt to 2–3cm below ground level and plants took about three years to recover.

Psyllids. In some years, infestations of the leucaena psyllid were bad and their sticky secretions reduced the palatability of the forage to cattle. For the first 15 years after planting, infestations of psyllids were severe every year, but recent infestations have been greatly reduced during the succession of dry years.

Weed leucaena. Leucaena plants have spread between rows but have been controlled by blade-ploughing. Some spread has also occurred in lane ways.

Animal management. Leucaena plants, though frosted every year, remain productive as long as they are allowed to recover. Cattle are rotationally grazed giving all paddocks 6–8 weeks of recovery. Water points are fenced off and spear traps are used to muster cattle.

Toxicity. Leucaena toxicity was an issue initially but occurs less frequently now. In the past, steers would lose hair from their tails and sheath when they first grazed leucaena but no cases of hair loss have occurred since cattle were inoculated with *Synergistes jonesii* in 1984–85.
However, several times when maiden heifers were joined with bulls while grazing on fresh leucaena, conception rates were low. John and Del now grow out heifers on leucaena after weaning, then graze them in a grass paddock for 6 months before joining. Bulls graze leucaena right up to mating with no observed negative effects on their fertility. Calves are weaned in May and grazed on leucaena, even when it is often frosted.

Target markets. The O'Neills target markets with steers at 30–33 months old, ranging from 340 to 360kg dressed weight with 70% of animals having a maximum of two permanent incisor teeth.
While leucaena pastures can be used for all classes of cattle, it is best used for fattening.

Their conclusions. Leucaena has been a major factor in the viability of 'Nyanda' as it has been highly productive for its entire life (now 40 years). This has made it a highly profitable forage resource as the only major cost was incurred at planting. John's original paddock was particularly good last year. One paddock has declined in vigour but this paddock frosts every year, and gets continuously grazed with little chance for recovery.

2. Establishing leucaena

Chapter 2 Establishing leucaena

2. Establishing leucaena

Leucaena is highly productive once established and will keep providing high quality feed for decades. However, its establishment needs care and attention to detail; a leucaena stand will never recover from poor establishment.

A leucaena stand never recovers from poor establishment.

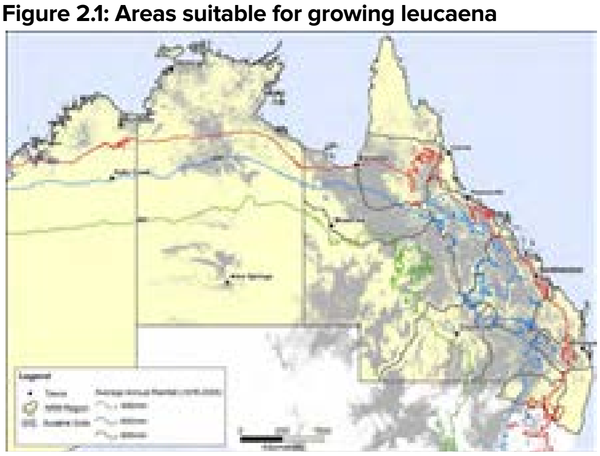
2.1 Where does it grow best?

Climate

While established leucaena can tolerate and produce leaf during dry spells and droughts, it performs best in areas that receive more than 600mm average annual rainfall. Leucaena thrives in 1,000+mm rainfall environments in the humid tropics but the psyllid insect causes serious damage to the older varieties (Wondergraze, Cunningham and Peru) under these more humid conditions.

Figure 2.1 shows where leucaena could be grown in northern Australia.

Figure 2.1: Areas suitable for growing leucaena



Areas suitable for growing leucaena in northern Australia based on soil type (depth >1m with pH>5.5) and rainfall (Kenny and Drysdale 2019).

Most leucaena in Australia has been planted in subhumid (600–800mm rainfall) inland Queensland because psyllid numbers are lower and serious infestation less frequent. The psyllid-tolerant cultivar Redlands will now allow leucaena to be grown in humid coastal environments.

Leucaena is a tropical legume and is adapted to hot environments; 75% of growth occurs during the warmer summer months in subtropical Queensland. Growth slows when daily maximum temperatures fall below 25°C in autumn, and stops when daily average temperatures fall below 13°C.

Soil temperatures need to be above 18°C for leucaena seed to germinate rapidly. Frost can kill seedlings of all cultivars outright, while established plants are susceptible to leaf damage but survive. Mild frosts (0 to –3°C) result in leaf drop and severe frosts (below –3°C) kill above-ground stems down to ground level. However, frosted plants will regrow vigorously from the root crown in spring with adequate soil moisture.

Leucaena on the lower slope (foreground) is frosted while plants further up are still green.

If part of a leucaena paddock is susceptible to frost, the whole paddock should be grazed heavily before the first frost. Cattle actively seek any lush, young regrowth on frosted leucaena, and plants in the frosted area can be severely weakened if cattle concentrate on this new growth before the plants have fully recovered. These areas need to be fenced and managed separately.

Climate

- Traditional cultivars require 600–800mm average rainfall per year.
- cv. Redlands is suitable for coastal higher rainfall zones with over 800mm per year.
- Over 75% of growth occurs in summer months when maximum temperatures are over 25°C.
- All varieties are susceptible to frost, but mature plants are not killed.
- Regular frosting and heavy grazing of regrowth will weaken plants.

Aerial parts of all leucaena cultivars are killed by frost but plants regrow vigorously from the base in spring with adequate subsoil moisture.

Soil type

Leucaena can grow on a wide range of soil types but grows best on deep, fertile, well-drained, neutral to alkaline soils; deep soils allow the plants to exploit subsoil nutrients and moisture below two metres. Soils should have the capacity to store more than 100mm of plant available soil water in the top metre of the soil profile.

Leucaena should be planted on the best soil types on the property. It is well suited to the scrub, brigalow and downs soils of central Queensland, the red volcanic soils of the Burnett, the basalt and red duplex soils in north Queensland and any fertile alluvial soil, but it can be grown on deeper duplex and loamy soils.

Leucaena will not grow well on the shallow, infertile duplex soils typically under native pasture or on strongly acidic soils. Although nutrient deficiencies and low pH can be overcome by applying fertiliser or lime, shallow rooting depth and low soil moisture availability will limit growth on these soils.

Soils for leucaena

- best on deep, fertile, well-drained neutral to alkaline soils
- suited to brigalow, scrub and downs country of CQ, basalt and red duplex soils of NQ, red volcanic soils of the Burnett and any fertile alluvial soils
- pH above 5.5, P above 20 mg/kg, S above 10 mg/kg sulphate
- deep roots can exploit moisture and nutrients in subsoil.
- growth is limited in shallow soils.
- does not tolerate prolonged waterlogging.

Note: parts per million (ppm) are now expressed as mg/kg.

2.2 Paddock selection and planning

Producers should consider a number of factors when selecting where to plant leucaena. Where possible:

- Select deep, well-drained and fertile soils.
- Cold hollows or flats that frost should be fenced off from frost-free areas to allow frosted leucaena to fully recover in spring.
- On sloping land, align hedgerows on the contour or in straight rows across the general slope to minimise soil erosion. Some producers align rows east-west to minimise shading of the inter-row grass pasture.
- Locate water or supplement licks outside the leucaena paddock with spear gates to muster cattle.
- Plant a minimum of 40ha to minimise the damage caused by hares, rabbits, kangaroos, wallabies, emus, ducks, locusts and other animals. Small ‘trial’ blocks of leucaena can be completely destroyed by predation.

The recommendations in the Leucaena Network Code of Practice aim to minimise the risk of commercial leucaena becoming an environmental weed (see Appendix 1 for a detailed description).

- Keep plantings away from watercourses such as creek banks and flood ways, maintain exclusion zones adjacent to boundary fences or other areas where livestock are not managed.
- Surround leucaena stands with ‘buffers’ of grass pastures to prevent seedlings from developing.

2.3 Which cultivar?

Six commercial leucaena varieties have been released for forage production in Australia over the last 50 years, and seed of five remain on the market (Table 2.1.).

‘Common’ leucaena (species *Leucaena leucocephala* subspecies *leucocephala*) entered Australia from Papua New Guinea and the Pacific Islands more than 120 years ago and has naturalised in small disturbed areas along tropical and subtropical coasts from northern NSW to north-western WA. ‘Common’ leucaena is not very productive, sets masses of seed and is susceptible to psyllid damage in coastal climates. It is classified as an environmental weed and so should be eradicated wherever it is found.

Commercial cultivars

All commercial leucaena cultivars are either pure lines of, or hybrids with, the species *Leucaena leucocephala* subspecies *glabrata*, and are vigorous and productive.

Leucaena produces best on land that could be classed as cropping country—deep, fertile soils without waterlogging.

cv. Peru. Argentinean botanists first collected seed of this variety from Peru. It was tested and released as a cultivar in Australia by the CSIRO in 1962, and may be still commercially available. Peru has a shrubby growth form with good basal branching, but it is very seedy and highly susceptible to the psyllid insect pest.

cv. Cunningham. CSIRO researchers crossed cv. Peru with another variety from Guatemala, and released it as cv. Cunningham in 1976. Cunningham is a good grazing plant being multi-branched and bushy. It is taller than Peru, and produces more forage. It is susceptible to frost and psyllid damage and is also a prolific seed producer.

cv. Tarramba. Tarramba was bred by the University of Hawaii and was released in Australia under Plant Breeders' Rights by The University of Queensland, the University of Hawaii, the Queensland DPI&F and the CSIRO in 1994. Tarramba is more arboreal (tree-like) and needs more frequent height management than Peru or Cunningham, but it is more vigorous, has better tolerance of cool conditions and keeps growing under psyllid attack. It is also a less prolific seed producer. Vigorous seedling growth gives rapid establishment and reduces risk of failure due to weed competition or insect attack. Frost susceptibility is similar to that of Cunningham and Peru.

cv. Wondergraze. Wondergraze was bred by the University of Hawaii and was released in Australia under Plant Breeders' Rights to Leucseeds Pty Ltd in 2010. Wondergraze is an intraspecific hybrid between psyllid-tolerant variety K584 and cv. Tarramba. Wondergraze possesses the best attributes of the shorter stature and branchy leafy habit of Cunningham and Peru along with Tarramba's excellent seedling vigour and better survival when under psyllid attack. Seed production of Wondergraze is greater than Tarramba, but less than Cunningham and Peru.

cv. Redlands. Redlands was bred by the University of Queensland and was released in Australia in 2014 under Plant Breeders Rights to The University of Queensland and Meat and Livestock Australia. It is based on an interspecific hybrid between psyllid-resist*ant Leucaena pallida* and *L. leucocephala* ssp. *glabrata* back-crossed to cv. Wondergraze. Redlands is highly psyllid-tolerant, has a branchy habit and high levels of forage production. It is recommended for humid coastal psyllid-prone areas with over 800mm annual rainfall.

Selecting your cultivar

Characteristics of the commercial cultivars are shown in Table 2.1.

Consider your climate and available management capacity when selecting which cultivar to plant.

Your climate. In frost-prone southern areas, Tarramba's cool tolerance can give an advantage with more rapid recovery in spring from frost damage in winter and will make late summer/autumn plantings more reliable. Regular frosting does provide good height control despite loss of frosted forage during cold periods.
In humid psyllid-prone environments, Redlands' superior psyllid tolerance makes it the best cultivar.

Management requirements. Vigorous growth in summer can allow leucaena to quickly grow beyond reach of grazing animals, especially with Tarramba. Even when grown in double rows, Tarramba requires additional height management depending on the environment and grazing intensity.

Table 2.1: Characteristics of commercial cultivars of leucaena

Attribute	Peru	Cunningham	Tarramba	Wondergraze	Redlands
Species	*L. leucocephala* ssp. *glabrata*	*L. leucocephala* ssp. *glabrata*	*L. leucocephala* ssp. *glabrata*	*L. leucocephala* ssp. *glabrata*	*L. pallida* x *L. leucocephala* ssp. *glabrata*
Forage yield	moderate	high	high	high	high/very high
Forage quality	very high	very high	very high	very high	high
Forage palatability	very high	very high	very high	very high	high
Psyllid tolerance	low	low	low/moderate	low/moderate	high
Growth after psyllid attack	slow	slow	moderate	moderate	rapid
Frost resistance	poor	poor	poor	poor	poor
Growth after frost damage	slow	slow	moderate	moderate	moderate
Establishment	slow	slow	moderate	moderate	moderate
Form	branching	branching	erect / arboreal	branching	branching
Cutting management	occasional	occasional	periodic	occasional	occasional
Intellectual property rights	public domain	public domain	Plant Breeder's Rights (PBR)	PBR	PBR

Developing Redlands

Cultivar Redlands was based upon five elite *L. pallida* x *L. leucocephala* ssp. *glabrata* (KX2) F_1 hybrids bred by the University of Hawaii. These parents were open-pollinated and F_2 seed was planted and subjected to intense selection (5–10% retention) under the criteria of psyllid tolerance, yield, tree form (high degree of basal branching) and self-sterility. After another cycle of open-pollination and recurrent mass selection, elite F_3 trees were back-crossed (BC) (hand-pollinated) to *L. leucocephala* ssp. *glabrata* cv. Wondergraze. Elite psyllid-tolerant BC1 progeny were backcrossed again to produce breeding lines that were effectively 87.5% cv. Wondergraze and 12.5% *L. pallida*. The best BC2 breeding lines were then self-pollinated three times and subjected to further selection namely forage quality (*in vitro* digestibility and crude protein content). Finally, palatability was determined under direct grazing trials and demonstrated that, while cattle preferred cv. Cunningham and cv. Wondergraze ahead of cv. Redlands, all varieties were readily eaten.

Hand pollination to produce backcrossed seed in the cv. Redlands breeding program: top left – emasculated flower; top right – green pollen grains from cv. Wondergraze; bottom – immature BC1 pods.

Future leucaena improvement – sterile cultivars?

Plant breeding programs supported by the MLA Donor Company through the University of Queensland and the Department of Primary Industries and Regional Development (Western Australia) aim to develop a sterile cultivar. Strategies are focusing on developing sterility (male or female) in commercial cultivars via back crossing, mutagenesis or gene editing to prevent flowering.

Besides reducing or eliminating the weed potential of *Leucaena* spp. cultivars, sterility may confer a significant forage yield advantage as plant resources are not diverted from vegetative growth to seed production.

Sterile leucaena cultivars may require vegetative propagation and broadacre seedling transplanting techniques.

Tarramba is cold tolerant but tall, it needs cutting periodically – especially in frost-free locations.

Height management might include crash grazing with large cattle (such as lactating cows with calves), frost damage or mechanical treatment, after which vigorous shoot growth will form a bushy hedge.

Seed quality and price

Plant seed of high quality and request germination and purity information when purchasing. While properly harvested and stored leucaena seed is normally of high quality because of its hard seed coat, bruchid beetles can infest 90% of unprotected seed crops and destroy ripening leucaena seed before it is harvested.

Adult bruchid beetles bore small round holes in seed and pods when they emerge (above). Bruchid beetles lay eggs on leucaena pods; larvae feed on seed endosperm before emerging.

Seed crops can be sprayed in the paddock and must be fumigated post-harvest to be bruchid-free. Seed should also be free of weed seeds, have a recent harvest date and have been stored under dry, cool conditions.

After scarification to break seed dormancy, all seed sold should be tested for germination (%). The price of seed varies considerably between varieties so check with seed suppliers for current prices.

Seed quality

Look for:

- seed size
- low bruchid damage (small holes in seed)
- no/low weed seed contamination (purity)
- recent harvest date and good storage conditions
- scarification
- high viability (germination test)

2.4 Seed treatment

Seed scarification

Seed of most legumes needs to be scarified to break dormancy and allow germination. Seed dormancy is a survival mechanism; it increases the chances of some seedlings surviving by preventing all seed from germinating at once. More than 90% of fresh leucaena seed may be dormant and can survive for more than five years in the soil.

Leucaena's seed dormancy is due to its hard, water-proof seed coat the strength of which can depend on the age of the seed, the variety and the environmental conditions under which it was grown. The hard coat must be abraded or breached to allow water to reach the embryo and start germination.

Scarifying seed ensures fast and even germination; under typical planting conditions, this is desirable and easier to manage than a patchy, staggered strike.

Methods of scarifying seed

Several methods have been used to break the waterproof seed coat of leucaena.

The hard coat of the seed has been ruptured by immersing seed in hot water (boiling for five seconds or 80°C for four minutes) – but this method can be unreliable.

Mechanical scarification, in which the seed is physically damaged, is the most reliable way to break dormancy. With proper calibration, mechanical scarification gives a more uniform strike, faster germination and emergence, and greater seedling vigour.

Most seed producers now sell mechanically-scarified seed; some seed merchants will mechanically scarify home-grown seed for a small fee.

Handling scarified seed

Scarified seed has a shorter shelf-life because moisture from the atmosphere can enter the germplasm. Seed is usually scarified immediately before planting; if this is not possible scarified seed should be used within four months of purchase. Some seed producers slow the loss of viability of their seed by storing in an air-conditioned room with a mild temperature (below 20°C) and low humidity (under 30% relative humidity).

Some growers have soaked scarified seed in water for a few hours just before planting to further speed up germination and emergence. This is not recommended as the soft seed can easily be destroyed during planting with mechanical seeders, and waterlogged seed may rot if it cannot be planted immediately.

Rhizobium inoculation

Most legumes form a symbiotic (mutually beneficial) relationship with soil *Rhizobium* bacteria – the plant provides the bacteria with energy and the bacteria fix atmospheric nitrogen (N) which the plant uses for protein production. These bacteria infect roots through the root hairs and form small root nodules.

As the *Rhizobium* bacteria use molybdenum (Mo) in the fixation process, and the plant uses phosphorus (P) to grow and sulphur (S) to make protein, leucaena needs an adequate supply of these elements to ensure high levels of N fixation. Single superphosphate fortified with Mo will provide the Mo, P and S to a soil deficient in these essential nutrients.

Healthy leucaena pastures can fix 75–150 kg N/ha each year (equivalent to 160–325 kg urea/ha), and this is cycled to the companion grasses.

Types of inoculum

Native *Rhizobium* usually present in the soil may form nodules with leucaena but N fixation is generally poor. Effective nodules have an orange-pink-red colour inside when cut; ineffective nodules exhibit a pale pasty green colour.

Healthy and effective nodules are pink when cut.

It can be difficult to find nodules on leucaena roots in the field as they usually break off as the root is being dug out.

While leucaena can form nodules naturally, it is recommended that seed is inoculated with specific *Rhizobium* strains. Commercial inoculum is made up of moist black peat and *Rhizobium* bacteria. Some brands contain pre-mixed adhesives such as Celstik®.

Commercial inoculant for leucaena

Packets of inoculum should be stored in a domestic refrigerator; each packet has an expiry date as old packets lose viability and will not provide adequate, if any, nodulation.

Inoculum quality is controlled by the Australian Legume Inoculants Research Unit; inoculum can generally be purchased from the seed merchant or commercial inoculum supplier.

Applying the inoculum

Instructions are included with the inoculum packet. It can be applied in the following ways:

Slurry inoculation of seed

Mix inoculum powder at the recommended rate of one 250g packet of inoculum per 100kg of seed in one litre (L) of clean water until thoroughly dissolved.

Extra sticker, such as milk or 5g methyl cellulose, can be added to hold the inoculum to the seed. Within 12 hours, the prepared slurry should be mixed through the scarified seed in a clean cement mixer or by hand in a suitable bucket. The seed only requires a light coating of inoculum and must be dry before planting. The inoculated seed should be dried in a cool shady place (not in the sun) on a clean floor (or shade cloth or tarp).

Inoculant and seed can be mixed in a cement mixer.

Water injection

Rhizobium can be applied at planting by water injection to the soil directly around the seed by diluting the inoculum in water. Typically, 1L of water/25m of twin row is applied to saturate 3–5cm of soil around the seed, ensuring good soil-seed contact and rapid germination. Using water injection separates the *Rhizobium* from potentially harmful chemical seed treatments.

Lime pelleting

Lime pelleting is rarely necessary in fertile alkaline soils but can prevent direct contact between the bacteria and acidic fertilisers such as superphosphate. However, fertiliser is best applied through the fertiliser box on the drill, and banded just below and to the side of the seed.

To pellet 100kg seed, dissolve 1.5% methyl cellulose powder solution in 1L of water, mix in 250g of peat inoculum and evenly coat the seed in a cement mixer. Add 12.5kg of very fine lime (use microfine, omyacarb or plasterer's whiting— **not quicklime or builders' lime**) and mix for 1–3 minutes.

The seed should be evenly covered in lime and the pellet should be hard enough to roll lightly between the fingers without disintegrating. To make a stronger outer coat, the pelleted seed can be sprayed with a 1:1 mixture of PVA wood glue and water while rolling in the drum. Dry as for slurry inoculation.

Sow pelleted seed within 24 hours, or store below 15°C for up to seven days.

Post-planting inoculation

Rhizobium inoculum has been applied to established seedlings. The peat inoculum is mixed into water and then diluted, e.g. to 100L, and applied in a jet at the soil or litter surface to the base of the plant. The spray rig must be clean as any pesticide residues may kill the bacteria – as will direct sunlight, high temperatures and drying out. This application is best done in the late afternoon during or just before rain or irrigation to help the inoculum percolate down to the plant roots.

Another approach is to inject the diluted inoculum below and behind a scuffler tine immediately beside the seedlings during mechanical weed control early in establishment.

Post-planting inoculation is risky and more expensive than applying *Rhizobium* to seed at the time of planting.

Seed should be treated with an insecticide that is not toxic to *Rhizobium*. Chlorpyrifos, in powder form, provides effective control of insect pests and reduces the viability of *Rhizobium* only slightly, but liquid-based formulations of chlorpyrifos using xylene are particularly toxic to *Rhizobium*. The use of new insecticides e.g. fipronil on inoculated seed needs further evaluation, however healthy nodulation following use of fipronil has been observed in the field.

Direct contact with fertiliser may also harm the *Rhizobium*. Fertiliser must be placed well below and to the side of the inoculated seed or lime pelleting used to protect the inoculum if seed is placed in contact with fertiliser.

Inoculation with Rhizobium bacteria

- *Rhizobium* bacteria use atmospheric N to make protein which becomes available to the plant. They can fix over 75 kg N/ha/year, equivalent to more than 150 kg urea/ha/year.
- Leucaena needs this N to sustain long-term productivity of the pasture.
- Leucaena needs the correct strain of Rhizobium – CB3060 or CB3126.
- These strains are commercially available from seed suppliers in sealed packs.
- Refrigerate the pack and check its use-by date.

2.5 Land preparation

Leucaena seedlings have slow shoot growth, initially putting most energy into root development. This slow growth makes them particularly susceptible to competition for water and nutrients from other plants and to insect and wildlife predation.

Storing soil moisture

The paddock should be fallowed, using repeated cultivation or herbicide application to kill weeds and store soil moisture. Establishment is most reliable with a full profile of soil moisture as seedlings can access deep moisture as their root systems develop, reducing dependence on follow-up rain. Many growers aim to store at least 1m of soil moisture (equivalent to 300–500mm rainfall) before planting.

Check depth of moist soil with a probe.

Prolonged fallowing can lead to 'long fallow disorder', which causes phosphorus deficiency in the leucaena seedlings. Clean fallowing for longer than 12 months can reduce populations of VAM fungi, which the leucaena seedlings need to improve uptake of phosphorus.

This condition can seriously slow leucaena establishment with the weakened seedlings more susceptible to weed competition and predation. As leucaena is very sensitive to phosphorus deficiency, starter phosphorus fertiliser at planting can help to compensate for the low VAM activity.

Once the pasture is established, organic matter cycling in the soil sustains a healthy population of VAM fungi.

Lighter soils in northern Australia

Northern Australia is dominated by lightly textured soils with limited water storage capacity and fewer opportunities for planting.

Risks associated with sowing into lighter soils in northern climates include: greater evaporation and rapid depletion of soil moisture; soil surface sealing and soil wash burying seedlings.

Sowing deeper than 25mm to access soil moisture can lead to slow and poor emergence.

Best establishment occurs with planting at depths of 20–25mm into moist soil when rain is expected within 5–7 days, as early as possible in the wet season and not after the end of February.

Fine seedbeds

A relatively uniform, fine seedbed will provide the good contact between soil and seed needed for successful germination, and will improve the efficiency of soil-applied pre-emergent herbicides such as imazethapyr.

Planting into old grass pasture will require a significant effort to break up clods and grass sods while old cropping land may need deep ripping to break up compacted layers in the subsoil and so increase the rooting depth of leucaena.

Land preparation central and southern Queensland

- prepare land to maximise stored soil moisture, with fallowing to accumulate a full profile.
- deep rip (30–50cm) along rows if needed.
- analyse soils to identify nutrient deficiencies and fertiliser requirements.
- long fallows may deplete beneficial soil VAM fungi so pre-apply 'starter' P fertiliser under proposed hedgerows.
- prepare a fine uniform seed bed for :
  - good soil–seed contact for germination
  - fine tilth for residual pre-emergent herbicides
  - reduced weed competition.

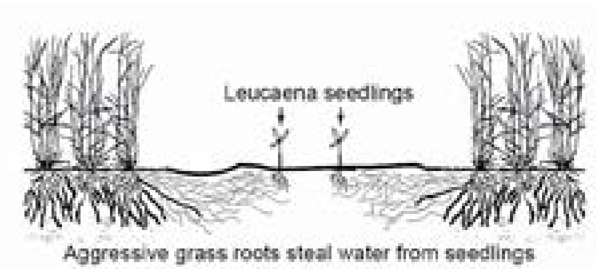
Northern Queensland

- no need to fully cultivate the paddock unless establishing new inter-row pasture grass.
- cultivate strips 4–6m wide through existing pasture on alluvial, duplex and coastal soils.
- deep rip (30–50cm) rocky basalt soils and then fallow.
- analyse soils to identify nutrient deficiencies and fertiliser requirements.
- apply fertiliser in a 1–2m wide band over the plant row at final cultivation.
- prepare the seedbed ready for planting by the onset of the wet season.

Competition from grass and weeds

Complete fallow or grass strips?

Leucaena can be established into strips cultivated through an existing pasture but, as the grass will grow back quickly and compete with leucaena seedlings, strips should be wide (4–5 m) and kept weed free.



Cultivate strips in pasture at least 4–5 m wide and keep them weed free.

Full paddock preparation (cultivated or sprayed out) gives the most reliable establishment but retaining narrow grass strips in the inter-row can prevent soil erosion on sloping land.

Weed-free cultivation ensures maximum soil moisture to the young leucaena plants and promotes their rapid growth.

As it is difficult to establish grass into the downs soils of central Queensland, narrow grass strips act as grass seeding nurseries. However, leaving grass strips may reduce the total soil moisture available to leucaena by 70–80% compared with a complete fallow.

Cultivated strips on either side of the leucaena rows must be at least 2m wide (minimum total width 4–5m) and should be kept bare until the leucaena is more than 1.5–2m tall – which may take over 6 months, depending on rainfall.

Cultivated strips must be at least 4-5m wide and cultivated regularly to prevent grass roots encroaching.

Strips of tough grasses such as buffel can be sprayed periodically with a low rate of glyphosate to reduce water use without killing the grass completely. But spray must not drift onto the glyphosate-sensitive leucaena.

Complete fallow vs grass strips

Full paddock preparation

- higher cost of soil preparation, more moisture stored, more rapid and reliable establishment.
- requires sowing of grass seed.

Grass strips

- lower cost of land preparation, less chance of erosion, can maintain grass on downs soil.

but

- grass competes with leucaena for water and can slow time to full establishment, especially in drier inland districts.
- only suited when grass present is a desirable species and not run-down.

Zero till (ZT)

While a fully cultivated seedbed kills established and emerging weeds and enables good soil-seed contact, each cultivation results in significant loss of soil water. Fallowing using herbicides only (zero till; ZT) will preserve scarce water and reduce erosion losses.

Leucaena can be planted directly into ZT pasture or crop stubble (e.g. wheat) if early rainfall recharges the soil profile, but is only recommended on friable (non-crusting) soils such as self-mulching clays. Late planting in March avoids heat-wave conditions.

Complete weed control during establishment is vital and can be maintained by application of the residual herbicide imazethapyr– with or without other knock-down herbicides. Imazethapyr is more effective with less stubble cover.

When herbicide is applied over the leucaena row at planting or in a later pre-emergent operation, the sprayed strips should be at least 4–5m wide (see Section 2.8).

Leucaena planted directly into zero-tilled wheat stubble

2.6 Planting

Planters

Modified combine planters can place seed accurately but precision row planters provide the best seed metering. Precision planters can be single or twin row, and may use a coulter in front to cut or displace stubble, followed by a tine or disc opener mounted on a parallelogram. This allows the seed to be accurately placed into moist soil at the minimum depth which ensures the seed remains wet for seven days.

Twin row planter with press wheels

Twin press wheels are used to press both sides (rather than over) for good soil-seed contact.

Single press wheels over the seed tend to cause crusting and sealing of the surface. The ridge formed by twin press wheels can be smoothed off (often by a wire brush or chain) to maintain accurate planting depth.

One seed should be placed every 4–7cm. Planting too deep stops the fragile emerging seedlings from reaching the surface. Shallow plantings in partially wet soil often result in poor and erratic germination as germinating seed will die in dry soil.

Some soils form a hard crust after rainfall. This can prevent seedlings emerging and so cause establishment failure. Yetter wheels will break the crust allowing leucaena seedlings to emerge and remove small weed seedlings. Losses of leucaena seedlings are minimal.

A fertiliser box with its own delivery tube and tine can deliver 'starter' fertiliser. Water injection at planting can apply *Rhizobium* inoculum or liquid 'starter' fertiliser.

Row spacing

Row spacings for dryland planting in sub-humid areas are single or twin rows (50–100cm apart) with row centres 7–10m apart; this will maximise animal productivity but will need intensive management.

Yetter wheels over the rows break any surface crust and knock out small weeds without greatly disturbing leucaena seedlings.

Narrow row spacing (less than 7m), and associated shading and high grazing pressure, make it difficult to maintain a strong grass sward between rows, and is not recommended.

Wide row spacing (>10m) reduces the amount of leucaena available for grazing per hectare especially with competitive grasses, such as buffel, which capture most of the rainfall. This wide row spacing is not recommended unless inter-row forage cropping with wide machinery is planned. Wider row spacing (10–15m) may allow leucaena plant height to be more easily controlled.

Typical row spacings for dryland planting in the subhumid zone are 6–10m centres for twin rows (usually 50–100cm apart).

The advantages of twin rows are:

- a more even plant stand as gaps in one row are compensated by plants in the adjacent row
- lack of grass within the twin rows increases water availability to leucaena, and twin rows increase the amount of leucaena available for grazing
- competition between the rows limits the height of the leucaena and improves the accessibility of forage to cattle.

Planting time

The most critical time for leucaena establishment is at planting and the few weeks after emergence.

November to January is the preferred period for planting in southern and central Queensland as there is no risk of a late frost, and rainfall is more reliable in the early growing season; there is also a better chance of follow-up rain in February and March.

Soil temperatures should exceed 18°C but young seedlings can be burnt if they emerge in extremely hot conditions (January and February) in lighter textured soils.

Time of planting is also critical in northern Queensland because of its highly seasonal rainfall. Plant as soon as possible after rain but be mindful of potential follow-up rainfall. The aim is to have well established plants for the coming dry season.

The best planting time in north Queensland would be January–February. March–April planting under irrigation is feasible in frost-free tropical locations.

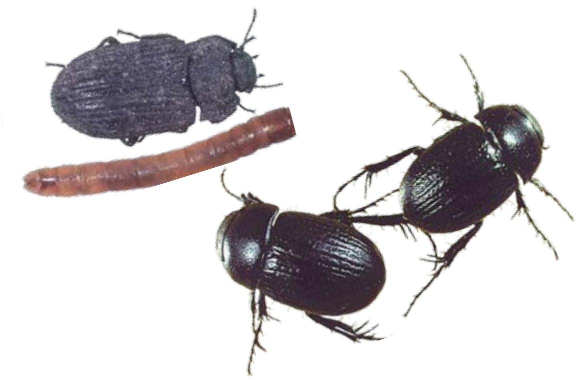
'Starter' fertiliser

Fertiliser is seldom applied to fertile deep alluvial soils but deficiencies of soil phosphorus and sometimes sulphur may be identified by soil tests. These require application of a 'starter' fertiliser, such as single superphosphate, 'starter' with zinc or MAP, to promote rapid leucaena establishment.

Apply about 40kg of P/ha to a 2m wide strip across the leucaena rows. Band the fertiliser 5–7cm below and beside the seed row.

2.7 Soil insect control

Insect pests above and below the soil surface can devastate populations of emerging leucaena seedlings.



False wireworm beetles (top left) and scarab beetles (right) eat young leucaena seedlings at ground level while false wireworm larvae (top left) eat the germinating shoots below ground.

Most above-ground insect pests can be controlled with chlorpyrifos applied in baits to the soil surface along the leucaena row.

Beetle baits (Table 2.2) with a vegetable oil attractant should be applied at the rate of 2.5 kg/ha with a fertiliser spreader as soon as the first leucaena seedlings emerge and for the next one to three weeks until they produce new 'fern' leaves. During this time, baits need to be replaced after heavy rain.

Subsoil insecticide treatment is also needed to protect emerging seedlings from below-ground insects such as earwigs and false wireworm larvae.

Table 2.2: Beetle bait recipe

Ingredient	Amount
Cracked grain (sorghum or barley)	2.5kg
Vegetable oil	125mL
Chlorpyrifos (500 g/L emulsifiable concentrate (EC) liquid formulation)	100mL

The seed can be treated with chlorpyrifos dry powder formulation while inoculating. Systemic insecticides, such as fibronil, absorbed into the emerging leucaena seedling, have been tested to treat the seed directly before planting.

These insecticides are registered for use on commonly grown crops but not on leucaena seed; it is not known whether they will damage the *Rhizobium*. However effective nodulation has been observed.

Scarab and false wireworm beetles live in plant debris that accumulates on headlands and contour banks, emerging in the late afternoon to feed on leucaena. Removing plant debris well before planting will reduce beetle populations.

In north Queensland, grasshopper invasion can pose a significant risk to freshly emerging leucaena seedlings as young plants will not recover. Closely monitor emerging leucaena for grasshoppers and control them if required. Aerial application of fipronil has given good residual control.

Control insect pests

Insect control is vital for the first three weeks

Below-ground pests – earwigs, false wireworm larvae

- treat seed with chlorpyrifos dry powder.

Above-ground pests – scarabs, earwigs, crickets, grasshoppers, locusts, false wireworm beetles and wingless cockroaches

- use beetle bait (chlorpyrifos EC)
- remove plant debris from paddock before planting.

2.8 Weed control

Leucaena seedlings cannot tolerate competition.

All weeds must be controlled in the row and for at least 2m on either side of the hedgerow. It is easiest and cheapest to kill weeds as soon as they germinate (under 1–2cm high) and to maintain complete control for 6–12 months.

Leucaena growers should have their weed control strategy ready and prepared before planting.

Mechanical options

Weeds in leucaena can be controlled using mechanical cultivation.

Over-the-row mechanical options include a variety of tillers, scufflers and rolling cultivators (such as Yetter wheels).

Inter-row cultivation using tined or off-set disc implements effectively controls grass and broadleaf weeds. Leucaena seedlings respond to scuffling, which breaks their lateral (side) roots, by developing a deeper tap root that allows them to exploit subsoil moisture throughout their life.

Chemical options

Several combinations of herbicides can be used to control weeds in establishing leucaena.

Table 2.3: Herbicides used in leucaena establishment

Active Ingredient (a.i.)	Registered brand names
Imazethapyr	Spinnaker; Impale; Amaze
Bentazone	Basagran; Dictate
Trifluralin	Trifluralin; Treflan
Fluazifop–P	Fusilade; Forte
Haloxyfop	Verdict
Glyphosate	Roundup; many others

The inclusion of trade or company names in this publication does not imply endorsement of any product or company by MLA or any contributor to this publication.

At present, only two selective herbicides (imazethapyr and fluazifop-P) are officially registered for use on leucaena although other herbicides may be registered for other legume crops. Some chemical control options that have been successful in trial plantings include:

Pre-emergent

- spraying 140 g/L imazethapyr in 100 L water/ha pre-emergent over the entire area or in a band along the planting rows at planting
- spraying weed seedlings with glyphosate before leucaena emerges.
- Trifluralin (480 g/L) applied at 1.2 L/ha light soil, 1.7 L/ha medium soil and 2.3 L/ha heavy soil in 200–300 L water/ha and immediately incorporated to 50–75mm depth effectively controls grass weeds and pigweed for 3–6 months.

Post-emergent

- Band spraying grass weeds within-row using haloxyfop or fluazifop-P has controlled both grass and most broad-leaf weeds growing within rows with minimal damage to leucaena. Adding bentazone without oil to fluazifop-P controlled both grass and most broad-leaf weeds
- Herbicide control of broad-leaf weeds within leucaena rows is often ineffective when the weeds are past the 3–5 leaf stage.

Trifluralin, bentazone and haloxyfop are not registered for use on leucaena with the Australian Pesticides and Veterinary Medicines Authority. Use at your own risk.

Glyphosate spray and drift will kill young leucaena seedlings. Plants over 1m tall are less affected but can still be badly damaged.

Any inter-row spraying with glyphosate is hazardous. If attempted, use an efficient shielded spray rig and coarse spray nozzles to reduce fine droplets, high water rates (at least 100L/ha) at low pressure, slow vehicle speed and still weather conditions to minimise potential spray drift.

Clean cultivation between rows of contoured leucaena

Imazethapyr 700 WDG

Imazethapyr 700 WDG controls most broadleaf and some grass weeds at germination and seedling stage. The best weed control occurs when imazethapyr is applied to the seedbed before weeds germinate and emerge. Imazethapyr is slightly phytotoxic on young leucaena and should be used with care after leucaena seedlings have emerged.

The entire area can be sprayed, or preferably apply in a band along the sowing rows at planting.

After application, imazethapyr needs at least 25mm of rain on clay soils for incorporation to a depth of 5cm and uptake by germinating weeds.

Imazethapyr acts by providing a thin 'blanket' of residual herbicide on or very near the soil surface, and can prevent weeds from establishing for up to 15 months under low rainfall conditions. If this protective blanket is disturbed, weed control will fail at the point of disturbance. Excessive trash on the soil surface results in variable soil incorporation and causes poor weed control.

Imazethapyr was developed specifically for use on legume crops and so will not control leguminous weeds such as maloga bean, chain pea, sesbania (horse bean) or forage legumes such as desmanthus, butterfly pea, Wynn cassia and stylos, which can be serious weed pests in young leucaena.

Remember the potential long residual action of imazethapyr when planning to plant improved grasses in the inter-row. . Either band imazethapyr over the leucaena rows or wait until grass seedlings begin to recolonise before planting companion grasses if the complete inter-row has been sprayed. New leucaena growers are encouraged to obtain application tips from advisors or experienced producers to maximise effectiveness in their situation.

Spinnaker applied to a 3m wide strip. Note the patch where no herbicide was applied and weed control failed (Richardson Ag Solutions).

Controlling legume weeds

Legume weeds can be controlled using cultivation (e.g. Yetter wheels) or manual chipping if present as isolated plants. Heavy infestations of fast growing annual weeds can be controlled with knockdown herbicides [e.g. glyphosate, metsulfuron-methyl), 2,4-D, picloram + triclopyr) carefully applied by a wick wiper. The wick wiper physically paints herbicide on the taller weed while the shorter leucaena seedlings pass underneath the wicks (soaked pads). A combination of glyphosate and metsulfuron-methyl has effectively controlled sesbania when applied at 5–10 km/h. The chemical is fed to the wicks via a low pressure 12 V pump regulated to prevent herbicide dripping on the leucaena seedlings. Scraping the weed stems with a sharpened leading edge of the wick wiper frame can aid chemical uptake and improve weed kill.

Caution:
Glyphosate spray or drift will kill young leucaena seedlings.

2.9 Companion grasses

Grasses play an important role in the sustainability of leucaena pasture systems. Leucaena fixes large amounts of nitrogen through the *Rhizobium* in its root nodules. Some nitrogen ends up as protein in the grazing animal's body but most returns to the soil, either through leaf-fall or animal excreta. Nitrogen-hungry grasses use the extra nitrogen to produce good quality feed (and fibre).

Without a grass to use up the nitrogen, unproductive weeds often invade the inter-row or unwanted leucaena seedlings may germinate. In lighter textured soils, excess nitrogen can be leached down and result in gradual soil acidification.

A vigorous grass sward protects the ground and increases rainfall infiltration. In clean-cultivated plantings, grass is normally sown when leucaena reaches 1.5–2m in height which may be in autumn (following a light grazing) or the following spring after planting rains. However, in dry years, it has often been difficult to get good grass establishment because the soil moisture has been depleted.


A strong grass sward between leucaena rows protects the soil and prevents weed and leucaena seedling emergence.

Please don't be confused!

Over the years, there have been periodic reclassifications of many grass species by taxonomists, and this can cause confusion between producers, seed merchants and even pasture agronomists.

This publication uses the common English names that are well recognised by most producers, along with the current scientific name.

Examples of reclassification include:

- Guinea grass – *Megathyrsus maximus* is synonymous with *Urochloa maxima* syn. *Panicum maximum*
- Buffel grass – *Pennisetum ciliare* syn. *Cenchrus ciliaris*
- Signal grass – *Urochloa decumbens* syn. *Brachiaria decumbens.*

Which grass?

Choose the grasses best adapted to your soils and rainfall.

For the heavy clay downs soils of central Queensland, the best-adapted grasses are:

Bambatsi (*Panicum coloratum* var. *makarikariense*) — can be difficult to establish and is slow to develop in its first year. But once established it is tolerant of drought and waterlogging, and will grow in the cooler months.

Floren bluegrass (*Dichanthium aristatum*) — well adapted to heavy clay soils, should combine well with leucaena but seed is expensive.

Queensland bluegrass (*Dichanthium sericeum*) — well adapted and native to the downs soils. Retaining strips of bluegrass will help later spread. It is palatable but not deep-rooted. Plants are easily uprooted and do not tolerate heavy grazing.

For the lighter, self-mulching brigalow clay soils:

Buffel grass (*Pennisetum ciliare*) — is the main species planted with leucaena on brigalow soils in central and southern Queensland. It spreads rapidly, is drought tolerant and can handle heavy grazing pressure. But it is extremely competitive for moisture and may limit the productivity of established leucaena in dry years. Weakening the buffel grass immediately alongside the leucaena rows by cultivation or herbicide application may increase the yield of leucaena.


Buffel is drought-tolerant and can withstand heavy grazing but competes with leucaena for shallow soil moisture.

For the fertile and friable scrub soils, there are many well adapted grass species such as:

Green panic and Gatton panic (*Panicum maximum*) — very palatable and suited to many soils. Panic pastures improve as nitrogen levels build up in the soil under leucaena. They are tolerant of shading and will grow in the leucaena hedgerows. Gatton panic is more drought hardy and has broader and longer leaves than Green panic.

Rhodes grass (*Chloris gayana*) — Rhodes grasses are subtropical species and can provide some growth in cooler conditions.

Rhodes grass and the panics are less competitive than buffel for moisture and so may promote leucaena productivity.

For basalt, red duplex and fertile frontage soils

On the higher rainfall (800+mm) coast or under irrigation, several suitable grass species can tolerate high stocking rates in frost-free environments:

Signal grass (*Urochloa decumbens*) cv. Basilisk — a creeping species for frost-free areas with more than 1,000mm rainfall.

Humidicola (*Urochloa humidicola*) cv. Tully — a very aggressive creeping grass, especially for wet soil conditions. Hard leaf is not so palatable as pangola. Good under irrigation or in the wet tropics.

Urochloa spp. hybrids cv. Mulato – very vigorous, productive and palatable stoloniferous grass for the wet tropics.

Pangola grass (*Digitaria eriantha*) — very productive and palatable creeping grass, can withstand heavy grazing but has to be planted from runners. Can be susceptible to virus attack in the wet tropics.

Setaria (*Setaria sphacelata*) cvv. Solander, Splenda, Narok, Nandi, Kazungula – a productive tussock grass suited to the cool elevated tropics and wet subtropics. Requires heavy rotational grazing to maintain forage quality.

Digit grass (*Digitaria milanjiana*) cv. Jarra, Strickland — well adapted to the lighter soils (sands to loams) in the high rainfall areas. Taller than pangola but can be planted from seed; resistant to pangola virus.

Rhodes grasses (*Chloris gayana*) — perform well under irrigation in more subtropical areas but can be damaged by very high stocking rates.

Creeping bluegrass (*Bothriochloa insculpta*) cv. Bisset — creeping grass for clay soils of medium fertility. Fluffy seed and slow to establish.

Establishing grass

Grass seeds are generally small so need to be planted on the surface, or just under a fine and weed-free seedbed. Seed of some grasses can be spread through a fertiliser spreader but fluffy seeds such as buffel and bluegrass may need special planters, such as drum or pneumatic seeders. Small fine seeds are best spread on the surface of cultivated soil and rolled in whereas larger seed needs to be lightly covered and then rolled.

Winter-active legumes

Winter-active legumes such as clovers (*Trifolium* spp.), medics (*Medicago* spp.) and vetches (*Vicia* spp.) can be planted in autumn with grasses in subtropical regions which receive enough winter rainfall. They will provide high-quality feed if adequate soil moisture is available and when the leucaena has been frosted or when the leucaena and warm-season grasses are not growing because of low temperatures.

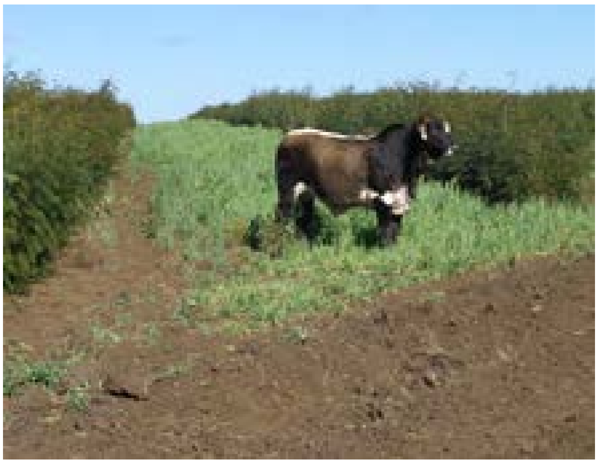
These species persist through reserves of hard seed in the soil. Vigorous growth of clovers and medics can cause bloat in cattle—unlike bloat-free leucaena.

Lucerne will compete with leucaena for subsoil moisture due to year-round growth and is not recommended as a companion pasture plant.

Opportunity cropping

Crops and forages can be planted in the inter-row once the leucaena is fully established and with wider spacings to accommodate equipment. Forage sorghum is a good summer-growing option. Winter forages such as oats and rye grass can be cropped annually when soil moisture allows. These are especially attractive to irrigators seeking to maximise stocking rates by improving year-round production of high quality forage.

Note that without extra water from irrigation, inter-row cropping with forage sorghum or winter cereals will reduce water available to grow leucaena.



Intensifying land use by intercropping oats in areas with sufficient winter rainfall or irrigation

No-grass (leucaena-only) pastures

Continued cultivation of the inter-row to keep out grasses and weeds may maximise water use efficiency and growth of the leucaena (especially for irrigators), with cattle getting access to grass in adjacent paddocks.

But reduced ground cover can increase soil erosion on sloping land, weeds can invade, or leucaena seedlings establish if cultivation is not effective. There is risk of soil acidification on lighter soils and cattle eating high leucaena diets can waste dietary protein.

Leucaena-only management is not recommended in the Code of Practice.

2.10 Early grazing management

Young leucaena plants must be allowed to grow vigorously and unchecked as vigorous early growth leads to strong mature plants. But they must not be allowed to grow to excessive height.

Grazing too early:

- weakens developing seedlings
- prolongs time to full establishment
- slows recovery after grazing
- can reduce productivity for the entire life of the leucaena pasture.

Grazing too heavily leaves the plant frame small.

Once leucaena starts to flower and produce pods, leucaena stem growth, leaf production and leaf quality are markedly reduced as the plants put greater energy into seed production. This can happen at any time, especially with Cunningham and Peru, and will peak as the days shorten coming into winter.

Light grazing when flowers first appear will allow the plant to keep producing leaf, promote basal branching and reduce the environmental weed potential from excessive seeding.

Early grazing rules

- Do not graze until plants are more than 1.5m tall (6–12 months).
- Graze lightly to stimulate branching, especially with Tarramba.
- Allow leucaena to recover.
- Start normal grazing when plants are about 2m tall (15–24 months).

The 'show pony' effect

Leucaena often looks its best in the first two years after establishment, especially on old cultivation land; after this, growth can slow.

This initial period of rapid growth – the 'show pony' effect – occurs as the deep roots of leucaena tap unused water and nutrients in the subsoil layers (1.5 to 5m depth) below the normal rooting zone of crops and pastures.

The leucaena growth slows once these resources are exhausted; light rainfall stays in the upper soil layers where there is strong competition from the shallow-rooted grasses.

Leucaena growth can be boosted by fertiliser application and heavy rainfall which replenishes moisture in the deeper soil layers.

Grazing lightly with smaller stock at the end of the first year of leucaena growth and before frost kills the leaf.

3. Managing the leucaena plant

Chapter 3. Managing the leucaena plant

3. Managing the leucaena plant

3.1. Mineral nutrition

If cattle are to achieve their maximum weight gains from leucaena, the plants must also be growing to their full potential.

Most leucaena is planted on fertile soils without fertiliser and it is generally assumed that it will look after itself; but this is not the case.

Soil fertility depletion

Soil types suitable for leucaena can have different levels of fertility. Alluvial and clay soils contain higher levels of plant nutrients than those of sandier texture. Some red basalt soils chemically bind sulphur (S) so that it is not available to plants.

Previous paddock management may determine soil nutrient availability when establishing leucaena.

Large areas of marginal farming cultivation have been converted to leucaena pastures. This country was often not fertilised and nutrients have been depleted under cropping. If fertiliser is not applied when planting leucaena, P and S can soon become deficient.

Under intensive grazing of leucaena pastures, large amounts of soil nutrients are removed in animal weight gain or relocated from the paddock in excreta, further accelerating the onset of plant nutrient deficiencies (Table 3.1).

Table 3.1. Amount of plant nutrients removed or relocated from leucaena paddocks in animal live weight gain and excreta

Nutrient	Amount of nutrient removed from paddock (kg/ha)			
	5 yr	10 yr	20 yr	30 yr
Phosphorus	38	76	152	228
Potassium	8.5	17	34	51
Sulphur	10	20	40	60
Calcium	48	96	192	288
Magnesium	3	6	12	18

Nutrient deficiencies of P and sometimes S were observed on six out of eight properties in one study. The deficient leucaena had lower forage yield and lower protein content due to suppressed N fixation by *Rhizobium* bacteria.

Some leucaena pastures planted on old cultivation that had been cropped for more than 20 years were nutrient deficient three to five years after establishment. The symptoms and lost production were not obvious to the producers involved.

Plant nutrient status should be monitored every three to five years by testing the soil and leucaena leaf for P, K, S, calcium and magnesium.

Pale young leucaena leaves indicate sulphur deficiency on a basalt soil in north Queensland.

Soil testing

When planning a leucaena development, soil fertility should be tested before planting. Soil testing is typically limited to the surface 0–10cm layer of the soil from which leucaena seedlings will extract the plant nutrients required to support their early growth. But deeper testing might expose other limitations.

Identifying these deficiencies can decide the formulation and application of 'starter' fertiliser to promote early leucaena growth and effective nodulation with *Rhizobium* bacteria for N fixation.

Specific critical soil nutrient levels have not been developed for leucaena, but those developed for lucerne are a good guide. Analytical laboratories usually provide benchmark comparisons to determine the soil nutrient status.

Monitoring nutrition of established pastures by leaf testing

Testing soil to determine the nutrient status of established leucaena pastures is not recommended; small soil samples from 10cm or 30cm depth are not representative of the large volume of soil exploited by the extensive root system of leucaena.

Although leucaena roots can reach five metres out from the hedgerow and to four metres depth, most are concentrated in the top one metre of the soil profile. Soil nutrients in grazed pastures are unevenly distributed due to dung and urine patches.

Leaf tissue testing is the preferred method of determining plant nutrient status of established plants. The nutrient concentrations of specific leaves are compared with the benchmark figures required for optimal plant growth (Table 3.2). Fertiliser applications should be based on this and soil nutrient sampling.

How to sample leaf tissue

Index tissue – The youngest fully expanded leaf is the index tissue collected for plant nutrition testing. These are the youngest leaves (i.e. located closest to the stem tip) that have reached full size (similar to leaves lower down the stem). Often this is the 4^{th} or 5^{th} leaf from the stem tip. If in doubt, always take the next oldest leaf.

Leaf sampling protocol – Youngest fully expanded leaves should be collected from at least 30–40 different plants that represent the average performance of the paddock, or from the patch of poor performing leucaena.

Collecting another sample from an area of leucaena that appears to be healthy and growing vigorously can be used for direct comparison with the unthrifty plants.

- Avoid sampling leaves from trees along the edges of the paddock. Move in at least four rows.
- Leaf samples should be either air-dried (in a place free from dust or soil contamination) or oven-dried (fan forced oven) at temperatures below 60°C with the oven door left ajar. Dried samples can then be provided to laboratories for analysis.

Sampling conditions – collect the youngest fully expanded leaves only from actively growing leucaena that is free from any growth impediments. Samples should be collected:

- during November-April to avoid cold temperatures that limit plant growth
- following a significant amount of rain (or when adequate soil moisture is present) so that water stress is not limiting nutrient uptake and plant growth
- in periods free from psyllid attack
- when the plant is in a state of active vegetative growth, avoiding periods of heavy flowering, seed set or pod production.

Critical concentrations of plant nutrients

Leaf tissue concentrations of essential plant nutrients provide a reference point; lower levels will result in poorer yield (Table 3.2). Critical concentrations for macronutrients are expressed as % dry matter and micronutrients as mg/kg dry matter.

Comparing the concentration of nutrients in your leaf samples with the critical concentrations will identify if any nutrients are marginal or deficient.

Scheduling leucaena leaf tissue sampling

Monitoring plant nutrition should be part of routine leucaena pasture management.

Leaf tissue should be sampled within three to five years of establishment, followed by repeat sampling every two to three years to determine when maintenance fertiliser application is required. The frequency of ongoing monitoring can be determined by leucaena plant nutrient status and grazing management.

Table 3.2: Critical nutrient concentrations in youngest fully expanded leaves of actively growing leucaena

Macronutrients (%)	Deficient	Marginal	Adequate	High	Toxic
Nitrogen (N)	<3.5	3.5–4.0	4.0–4.5	>4.5	
Phosphorus (P)	<0.18	0.18–0.20	0.20–0.28	>0.28	
Potassium (K)	<0.8	0.8–1.0	1.0–2.0	>2.0	
Sulphur (S)	<0.20	0.20–0.24	0.24–0.30	>0.30	
Calcium (Ca)	<0.30	0.30–0.40	0.40–1.50	>1.50	
Magnesium (Mg)	<0.18	0.18–0.20	0.20–0.30	>0.30	
Ca:Mg ratio			>2		
Micronutrients (mg/kg)					
Aluminium (Al)			1–100	>100	
Boron (B)		<20	>20	<40	
Copper (Cu)		<2	2–10	>10	
Iron (Fe)	<20	20–40	40–100	>100	
Manganese (Mn)			20–100	100–325	>325
Sodium (Na)			>20		
Zinc (Zn)	<8	8–12	12–24	>25	

If some nutrients are deficient (or marginal), apply fertiliser and repeat sampling the next year after a good wet season to check the results. Do not sample in drought conditions. Plants need rainfall to take up the applied nutrients.

Remedying nutrient deficiencies

From the results of the leaf analysis, an agronomist can formulate fertiliser applications to address any macro or micro nutrient imbalances.

The major nutrient deficiencies likely are P and/or S. Both elements are in single superphosphate (9% P plus 10% S). Although many legumes also need molybdenum (Mo) for good N fixation, critical concentrations have not been developed for leucaena. Trace nutrients can be supplied in fortified superphosphate, for example superphosphate Z (with zinc).

The type and rate of fertiliser can be formulated from the leaf tissue analysis and soil sampling. Test strips of fertiliser can be applied to the paddock and plant growth monitored to confirm any response.

Maintenance fertiliser applications

Healthy leucaena pastures require maintenance applications of fertiliser to replace moved and removed nutrients and to sustain high levels of production. Maintenance fertiliser can be applied every three to five years.

Fertilising the grass

Although leucaena does fix significant quantities of N each year (typically 100–200 kg/ha/yr), only a small proportion (10–20%) is cycled to the companion grass.

All tropical grasses need high and sustained nitrogen supply, the amount needed will depend on rainfall and target production level. Applying N fertiliser could optimise grass performance in high rainfall areas (more than 900mm annual rainfall), or for irrigated pastures where more intensive production and higher stocking rates are required.

Grasses may also respond to phosphorus and potassium fertiliser on less fertile soils.

Methods of fertiliser application

Broadcast spreading – will apply fertiliser to both the leucaena and the grass pasture. Surface applied fertiliser will not be effective until adequate rainfall dissolves the nutrients and carries them into the soil profile where they can be accessed by plant roots.

Incorporation – uses mechanical cultivation to mix the fertiliser into surface soil. This can bring the fertiliser into direct contact with plant roots, accelerating growth response following rainfall.

Broadcasting fertiliser to the leucaena rows

Incorporating fertiliser also reduces nutrient losses by volatilisation and dissolution/erosion in runoff water.

Band application – targets the delivery of nutrients to the leucaena roots by applying fertiliser in a concentrated band (usually at depth in the soil) adjacent to the hedgerows. Banding fertiliser can increase nutrient availability in soils that chemically bind phosphorus or sulphur in forms that are not accessible to the plant. Band application also reduces nutrient losses.

Lime requirements

Lime application is only required to address acidity in soils with pH<5.5, and these are generally unsuitable for leucaena.

As lime has limited mobility within the soil, surface-applied lime is best incorporated by cultivation.

3.2. Height management

To optimise beef production and minimise environmental concerns, leucaena hedgerows should be maintained with a dense leaf canopy within browse height.

Excessive growth of woody stems can reduce the amount of leaf growth. Leucaena plants should be prevented from seeding as flowering and seed production also reduce leaf growth.

Light early grazing when leucaena reaches 1.5m in height (usually 6–12 months after planting) will encourage prolific branching and maximise future leaf production. In subsequent years, high grazing pressure, achieved by high-intensity short-duration rotational grazing, with strategic cutting as necessary, will manage hedgerows at a desirable height of 2–3m. Frost damage can also control plant height.

For the best productivity, leucaena should be kept within browse height.

Controlling height of leucaena

A leucaena canopy above browse height may shade grasses excessively, especially in narrow row spacings, and so weaken the grass.

The height of leucaena hedgerows can be controlled by:

- planting in twin rows to reduce the size of individual plants
- high-intensity short-duration rotational grazing
- increasing the number and size of grazing animals. Large animals such as bulls can break down stems 4–5m high after fattening steers have eaten all leaf within reach. Lactating cows, with their high nutritional need, pull down high stems to reach leaf at the tips.
- slashing or cutting when too many plants are beyond reach of stock or after seed harvesting. Large trees will need to be cut back with a heavy-duty slasher.
  Slashing which lacerates and splits stems will promote more budding and regrowth branches than a clean cut.

Slashing leucaena to control height. Lacerated and split stems regrow well from multiple bud sites.

Large animals, especially lactating cows, will pull down stems four metres tall.

How high and when to cut

Regrowth of leucaena is maximised after cutting when:

- cutting heights of 0.5–1m maintain numerous residual active buds and sprouts.
- there is residual leaf for photosynthesis.
- residual stems and root systems are strong.
- there is ample soil moisture.

Leucaena regrowth after cutting

Cut leucaena to manage grazing height only when there is adequate soil moisture and a high enough temperature for rapid regrowth. Trees may die if cut when the soil is waterlogged or be severely weakened if cut during drought.

Height management

- Practice intensive rotational grazing.
- Use large animals to break down tall stems.
- Slash if many stems too tall for cattle.
- Slash at a height of 0.5–1m.
- Cut only when soil moisture is adequate for rapid regrowth.

Contact The Leucaena Network for available slashing contractors in your area.

3.3. Psyllid insects

Damage by psyllids

The leucaena psyllid (*Heteropsylla cubana*) damages plants when both nymphs and adults feed by sucking sap from the developing shoots and young foliage. Heavy infestations defoliate the plant and stop growth.

Psyllid attack on growing tips of leucaena prevents new growth.

Older leaves are less directly damaged but can be covered in sooty mould.

Where psyllids have been active, there may be no new leaf growth for up to 30cm from the stem tip, representing a loss of several weeks or even months of growth.

Quantifying the damage caused by the psyllid is difficult, but most commercial planting of leucaena has been restricted to areas with 600–800mm rainfall because of potential psyllid damage. Even in these subhumid inland regions, uncontrolled psyllids can reduce production by 20–50% and in humid coastal regions by 50–80%.

Options for combating psyllids

Only plant susceptible leucaena varieties in subhumid environments (less than 800mm rainfall) where psyllid attack is less frequent and severe.

Cultivars Tarramba and Wondergraze have superior psyllid tolerance than Cunningham and Peru, and respond better under occasional psyllid attack.

Use more tolerant varieties – Use only the psyllid-tolerant cv. Redlands when planting leucaena in humid (>800+mm annual rainfall) coastal environments.

Note that cv. Redlands is described as psyllid tolerant. It is not resistant and can still be damaged by severe psyllid attack.

Do nothing – Although some forage production is lost for a time, environmental conditions change and the psyllids disappear. Drought and frosts lead to leaf drop and reduction in psyllid populations. Very heavy rain (or overhead irrigation) and hot, dry winds will also reduce psyllid populations.

Fertilise rundown leucaena – Leucaena plants under nutrient stress are more prone to psyllid attack and suffer a greater degree of damage. Applying fertiliser improves plant health and minimises susceptibility to insect attack.

Spraying insecticide – The psyllid is readily killed by low doses of several insecticides. Dimethoate, a systemic insecticide, is registered for use on leucaena, and provides effective control for up to 3–4 weeks.

Producers must strictly observe the correct withholding period before grazing to ensure pesticide residues are not present in the foliage eaten by stock.

Insecticide use is warranted to protect establishing leucaena and high-value seed crops.

Grazing management – Some producers graze their leucaena heavily as soon as the psyllid populations build up in an attempt to remove their feed source and break the population cycle. However, psyllids will generally remain in high numbers as the plants regrow.

Biological control – In any environment, there will be some predators that feed on one or more stages of the life cycle of the psyllid; Natural predators effectively control psyllids in its native habitat in Central America.

In Australia, the larvae of the common ladybird beetles are good predators but are unable to keep psyllid populations under control in commercial leucaena pastures.

Plant breeding – An MLA-supported breeding and selection project with the University of Queensland has developed the psyllid-tolerant cultivar Redlands from the hybrid between two leucaena species *L. leucocephala* and *L. pallida.*

This breeding program is described in detail in Chapter 2.

The psyllid insect

The leucaena psyllid (*Heteropsylla cubana*) is a small yellow-green insect 1–2mm long. It is native to Central America and the Caribbean where it has presumably co-existed with leucaena for thousands of years.

Although it has been reported to occur on a few other leguminous shrubs and trees, these are not damaged to any great extent and it is probable that the psyllid can only complete its life cycle on plants in the genus *Leucaena*.

The psyllid first became a problem on experimental plantings in Florida in 1983. From there, it spread rapidly throughout the tropics and subtropics and is now present in all areas where leucaena is grown.

In Australia, following the first recording at Bowen in north Queensland in April 1986, the insects spread 800km to Gympie within three months, and by mid-October had reached Brisbane.

The extremely rapid rate of spread suggests that air currents (including high-level winds and cyclone activity) are largely responsible for their dispersal. It is not uncommon to find psyllids on isolated stands of leucaena.

Life cycle

Female psyllids lay up to 400 eggs on very young shoots where they are lodged between the folds of the developing leaflets. Eggs hatch in 2–4 days, and through five nymphal stages, become adults 10–16 days later, depending on climatic conditions. The nymphs rapidly become mobile and congregate in large numbers on the growing points of young shoots. Populations can build up extremely rapidly, producing many generations in a year.

In the field, psyllid populations normally fluctuate widely over time. Peak numbers of nymphs tend to occur soon after rain but are affected by humidity and plant nutrient status, leucaena stand density, and exposure to wind. Management that maximises forage production (i.e. abundant young leafy growth) greatly increases psyllid numbers.

In Queensland, psyllid numbers are highest during the wet season whereas in South-East Asia they are most abundant at the end of the monsoon season and early dry season. The build-up of psyllid populations is reduced by periods of sustained intense rain (or irrigation) or one or two days of hot, dry (35+°C) temperatures. Frost will kill psyllids (but also the leucaena).

3.4 Other insect pests

Long soft scale

The long soft scale insect (*Coccus longulus*) is a periodic pest of leucaena in central Queensland. Adult scale insects are 4–6 mm long and congregate on the stems and leaf petioles on leucaena plants.

Heavy infestation of soft scale on leucaena

Heavy infestation retards plant growth as the insects suck sap; photosynthesis is reduced by sooty mould that grows in the honey dew excreted by the scale insects and deposited on the lower leaves. Trees suffering scale insect attack typically have black stems covered in sooty mould.

The life cycle of this insect is typically 2–3 months. Females give birth to live young called 'crawlers' that disperse and infest younger plant stems. Four to six generations can be completed in one year.

Cutting/mulching leucaena for height control kills established infestations and breaks the pest's lifecycle. As with psyllids and other insect pests, scale insects often attack rundown leucaena and overcoming plant nutrient deficiencies will enhance plant tolerance.

No chemicals are currently registered for controlling soft scale on leucaena. For other crops, long soft scale can be controlled by applying white oil (for citrus at 2L/100L water) and methidathion EC 400 g/L (for trees/shrubs, macadamias, custard apples at 125mL/100L water). Best control is achieved by spraying at the insect's 'crawler' stage. Scale insects are sedentary (they do not move) so good coverage with sprays is required to give adequate control. White oil has been found to be phytotoxic on young leucaena growth in glasshouse trials. Both these chemicals should be tested with caution.

Certain ants will climb leucaena plants seeking the sticky exudate of scale insects. They protect the scale from predators and spread the sooty mould. Controlling ants can reduce scale infestation.

A common ant bait used in citrus orchards to reduce scale infestations can be made as follows:

- mix 25kg polenta + 2.5kg Cerevite in a cement mixer
- separately mix 150mL food colour + 50mL fipronil SC 200 g/L + 800mL water
- spray 500mL of corn oil evenly into the corn mix in the cement mixer
- spray the coloured fipronil solution as a fine mist onto the grain while mixing.

Apply ant bait at 2.5 kg/ha by fertiliser spreader.

Note: These chemicals and baits are not registered with the APVMA for use on leucaena. Use at your own risk and be aware of withholding periods before grazing treated plants.

Stem borers

Stem borers can attack severely rundown leucaena – older stands that have never been fertilised, annually frosted with regular heavy grazing of the young regrowth. Borer damage is opportunistic and is rarely seen in vigorous healthy leucaena stands.

Stem borers can attack run-down leucaena.

Identifying and applying the nutrients deficient in the leucaena stand, and allowing more time for recovery of heavily frosted leucaena, are the best remedies for stem borer attack, Temporarily removing grass competition (e.g. by cultivation or selective herbicide) for soil water can speed the recovery of rundown leucaena.

Thrips

Thrips have been a periodic pest on leucaena grown in the Ord Irrigation Area of north-west Western Australia. They damage plant growing points during pasture establishment and regrowth after grazing. They have not been observed as a pest of leucaena in the eastern states.

3.5. Irrigating leucaena

Irrigation can have a large impact on the productivity of leucaena systems. It promotes higher productivity, allows increased stocking rates, improved reliability, flexibility in marketing finished cattle and more accurate budgeting of costs and returns.

A number of producers have established irrigated systems in Queensland, predominantly using centre-pivot and flood irrigation.

Some of the technologies discussed earlier for dryland leucaena do not necessarily apply to irrigated leucaena; different establishment and management issues may be appropriate but knowledge is still far from complete.

Planning an irrigation development

Irrigation is expensive and must ultimately be profitable; irrigated leucaena pasture systems must be planned carefully.

Production objectives need to be clearly defined, and may include:

- maximising forage production and balancing leucaena and grass forage available
- maximising animal output and profitability from the land and water resources available
- targeting particular high-value markets such as feeder steers for feed lots, or finishing for slaughter.

The layout of paddocks must consider efficient water delivery and animal management; cattle may need access to adjacent ‘dry’ pastures when irrigated paddocks are waterlogged, and extra grass forage may be needed to complement the high leucaena production. It is recommended to locate stock watering points outside irrigated paddocks to aid mustering.

Irrigation water quality is important; leucaena can tolerate overhead irrigation with water of salinity (electrical conductivity) 2–3 decisiemens dS/m without suffering foliar damage. However, if the water contains salts, an adequate leaching fraction is required to ensure soil salinity does not build up over time. Leucaena is moderately salt tolerant, but plant yield decreases when soil salinity (of a saturated soil paste) exceeds 4.5 dS/m.

Establishing irrigated leucaena

Cultivar selection is important. Branchy cultivars such as Cunningham and Wondergraze are better for ease of height control rather than arboreal Tarramba; cv. Redlands is recommended for high psyllid environments.

In northern Queensland, planting early in the dry season (April), frost and temperature permitting, will allow stricter control of the amount of water applied; this will avoid seedlings getting waterlogged if heavy rain follows irrigation. On loamy soils, planting in cool seasons prevents the seedlings getting burnt by high soil surface temperatures in summer.

Row spacing will depend on whether grass production is required to supply additional energy and fibre to support higher stocking rates within the irrigated paddock.

A strong grass sward that contributes to the diet uses fixed nitrogen and reduces the incidence of cattle bogging in wet conditions. Row spacings over 5m, similar to dryland leucaena, have been used to promote stronger grass growth.

Narrow row spacing (less than 4m) inhibits the establishment of a productive inter-row grass. Supplementary roughage (hay) and energy (grain or molasses) may need to be fed or adjacent grass pastures grazed in conjunction with the irrigated leucaena.

Higher seeding rates (up to 4 kg/ha) are used to achieve dense plant populations within spaced double leucaena rows. Stands with mature plants spaced approximately 15cm apart produce many fine stems and a high proportion of leaf. Seed can be planted at a shallower depth for rapid germination as irrigation can keep the surface soil moist.

Soil, insect and weed management are still of prime importance during establishment.

Effective weed control improves water use efficiency. The same herbicides used for dryland leucaena are effective for irrigation systems although pre-emergent herbicides may be less effective if overhead irrigation leaches the active ingredients from the soil profile. Mechanical methods of weed control can also be used, although not on flood-irrigated heavy clay soils.

Inter-row grass species such as bambatsi, Callide and Finecut Rhodes, Gatton panic and creeping blue grass have been used successfully in Queensland. The selected species must be able to tolerate heavy grazing and soil compaction under high stocking rates. Grass establishment practices are similar to those for dryland leucaena.

As large amounts of soil nutrients are removed in animal live weight, soil fertility (P, S, K, Zn or Mo) should be monitored every two years. Regular application of fertiliser should be economically viable due to the higher level of productivity. At wider row spacings, the inter-row grass can be fertilised (e.g. with N and P) to optimise growth and water use efficiency.

In subtropical areas, winter forage crops (oats, rye grass and medic) are occasionally sown in the interrow to provide forage while leucaena growth is constrained by frost and low temperature.

Pivot irrigation of leucaena at Gogango

Water management

Irrigation management should aim to maximise economic returns per megalitre (ML) of water through strategic water application. Irrigators report using 3–4 ML/ha/year over 3–5 applications.

Spray systems give better and more even water application than flood irrigation and reduce the need for land levelling.

Both pivots and guns, and even hand-sets, have been used to deliver water during establishment. Drip irrigation systems have been used short-term to establish leucaena and boost early production, and longer-term for high value seed crops.

In Queensland, furrows for flood irrigation vary in length from 500 to 2,000m, with a maximum of 1,000m now recommended. Furrows can be damaged by cattle tracks which divert water and cause uneven watering, while grass in the furrows slows the flow of water. Furrows or bays require maintenance every one to two years to deliver uniform water flow and optimise irrigation efficiency. Irrigating alternating furrows has proved just as effective as irrigating every furrow while halving water use.

Flood irrigation at Home Hill

Leucaena is sensitive to waterlogging and will often die out where surface water fails to drain rapidly. Flood-irrigated paddocks need laser-levelling and may require more than one levelling operation as settling commonly occurs where fill is deposited.

Planting an annual crop between the first and second levelling operations will give best results. Length of irrigation run must match soil type so that blocks can be wet up over a 12–24 hour period. Tail drains and furrows should be regularly maintained to distribute water evenly and to remove excess water rapidly out of the paddock.

Irrigation water is normally applied immediately after a paddock has been grazed. The pasture is then spelled for 6–8 weeks to recover before being grazed again. In central and southern Queensland, heavy irrigation of inter-row winter forages reduces evaporative water loss and water not used by the crop replenishes subsoil moisture ready for leucaena growth in spring and early summer.

Grazing management

In north Queensland, irrigated leucaena pastures are spelled during the wet season (December-March) to avoid soil compaction and pasture damage. Animal performance also declines under the high temperature and humidity between the hedgerows and with muddy conditions reducing grazing time and feed intake.

Stock are rotationally grazed, with grazing periods ranging from 10–28 days to maintain the vigour and productivity of the grass. In Queensland, stocking rates can be 5 hd/ha.

Feeding supplementary roughage and energy (grain, molasses, hay, silage or adjacent grass pasture) may be required to make efficient use of the leucaena protein source if insufficient grass is grown in the pasture.

Steers fed roughage grass hay as supplement to irrigated leucaena

Height management

Vigorous leucaena under irrigation may need more regular slashing, even when using rotational grazing systems and high stocking rates for short periods. Wet season spelling in north Queensland allows leucaena to grow too tall.

Slashing stems of plants growing on waterlogged soil, due to over-watering, in the Ord River irrigation scheme in Western Australia, resulted in root rots leading to plant death. 'Leucaena dieback' caused by a crown rot (*Pirex subvinosus*) became common in stands of irrigated leucaena in the late 1990s, and spread from localised infection points at the rate of about a metre a year. *Pirex* may not become a management issue for irrigated leucaena in Queensland, as less water is applied.

3.6. Producer experience – irrigating leucaena in the Burdekin

Don, Laurel, Peter and Scott Heatley

Don, Laurel, Peter and Scott Heatley run 8,000 head in an integrated breeding and fattening operation across 27,000ha in north Queensland. They have developed 500ha of leucaena under flood irrigation on 'Byrne Valley', 44km south of Home Hill.

Don says, "Initially we were hesitant about planting leucaena as we were cattle producers not farmers". However, after inspecting irrigated leucaena pastures in the Ord River Irrigation Area at Kununurra, he was convinced that irrigated leucaena was the intensive fattening system that his operation needed.

Establishment. Their first leucaena paddock, a converted rice paddy, was planted in 1998. Soils are sandy loams on the river levee and heavy cracking clays on the flood plain. Most paddocks are about 80ha (2000m long x 400m wide) and were laser-levelled with a fall of 0.1%. A deep V-shaped furrow maintains fast irrigation water flow with cv. Cunningham leucaena planted in twin rows on the raised beds 4m apart.

Leucaena is planted during the early dry season (late April/early May) under irrigation. Wet season plantings have failed because, under heavy rainfall, soil crusting prevented seedling emergence. Weeds are controlled with selective herbicide applications (usually twice) as cultivation is not possible on the wet clay soils. Rhodes grass has colonised the inter-rows.

Irrigation. Originally every inter-row was flood irrigated from two pumps lifting water (150 L/s) from the adjacent Burdekin River. Now irrigation water is applied to every second inter-row as a fast flush on an alternating basis. This has improved water use efficiency (halved water and power usage) whilst maintaining forage production.

Leucaena paddocks are irrigated immediately after grazing and each paddock typically receives 4–5 applications per year delivering a total of 4–5 ML/ha/yr depending upon rainfall. Furrows are delved every four years to maintain consistent fast water flow.

Management. Maintenance fertiliser (44 kg/ha P and 55 kg/ha S) is applied every 4–5 years. Psyllids cause significant damage periodically and future plantings will use psyllid-tolerant cv. Redlands. Despite intensive rotational grazing, hedgerows have to be cut back every 4–5 years.

Cattle are removed from the leucaena paddocks during the wet season to avoid pasture damage and graze adjacent improved stylo/grass pastures.

Paddocks are rotationally grazed during the dry season only (April-November) at an effective stocking rate of >20 livestock unit (AE/ha. The leucaena is spelled for 5–6 weeks before being grazed again.

The Heatleys produce Rhodes grass hay which is fed ad lib as a source of roughage with cattle eating about 5 kg/hd/day. Molasses is fed (2 kg/hd/d) as an energy supplement.

Production and marketing. Growth rates are 0.9–1.4 kg/day totalling a live weight gain of 1000 kg/ha/yr from the leucaena pastures.

Steers are sold direct to meat processors supplying export markets in Japan, Korea and USA at 630–670kg live weight (340–360kg carcase weight) at 24–26 months of age. This leucaena feeding system has halved the age to turn-off compared with grass-only pastures.

The quality of the finished cattle has improved giving the Heatleys flexibility to target premium markets. The irrigated pastures have enabled finished cattle to be sold throughout the dry season when supply is short and prices high. Irrigation has also reduced the impact of seasonal conditions on production, guaranteeing income and profit security.

Lessons learnt. Despite many challenges, the Heatleys have developed a method of establishing leucaena under flood irrigation. Lessons learnt include:

- deep rip ground under beds before planting
- do not plant in the wet season
- do not plant seed too deep
- keep grass competition away from young leucaena
- maintain a consistent irrigation schedule (do not rely on rainfall)
- maximise leucaena production within the irrigated area; provide roughage (grass or hay) and energy supplements outside the paddock
- always locate stock water for cattle outside leucaena paddocks.

Future plans. The Heatleys plan to develop another 800ha of irrigated pasture, planting cv. Redlands and reducing inter-row spacing to 2m to maximise leucaena production and control shrub height. Water will be delivered by an underground pipe network rather than through fluming.

4. Grazing management

Chapter 4. Grazing management

4. Grazing management

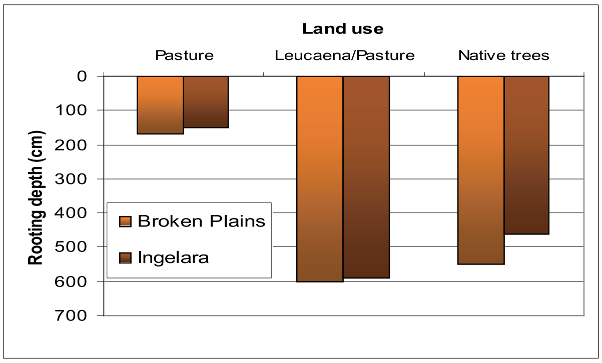
4.1 Forage growth

The aim is to grow as much leucaena leaf as possible, and then to use it efficiently. A general target is to have at least 30–60% of the pasture as leucaena. Following the guidelines for successful establishment will affect productivity for many decades.

The greatest influence on plant growth is rainfall. While producers cannot control rainfall, they can maximise the amount of leucaena grown per mm of rainfall. Options include:

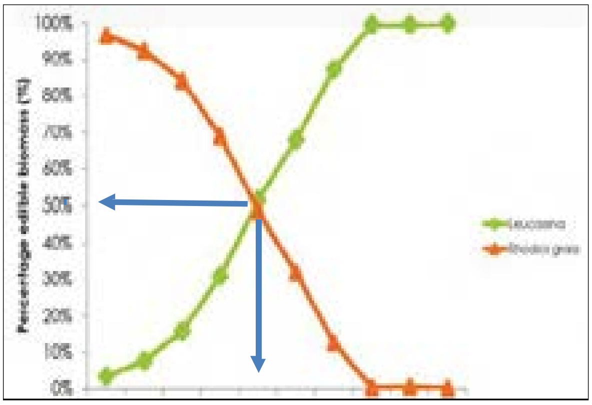
- **Choice of site.** Plant leucaena only on soil of suitable fertility and deep enough to store adequate moisture. This will keep leucaena growing even when dry conditions stop grass growth.
- **Closer rows.** Although leucaena can tap water from deeper in the soil profile than can grass, most of its roots are in the same 1.5m depth rooting zone (Figure 4.1).

Figure 4.1: Rooting depth of pasture grasses, leucaena and native trees at two sites in central Queensland



Grass in inter-rows competes directly with the leucaena for soil moisture. The dense root systems of buffel grass can capture 80–90% of rainfall and can reduce leucaena growth by 60–70%. Competition from grass can be reduced by planting double rows at 5–6m centres rather than at 8–10m (Figure 4.2).

Figure 4.2: Row spacing affects the balance of leucaena and grass.



Row spacing
Wide >20m ———————————— narrow <2m

- **Role of grass.** Grass is needed for good animal nutrition and to use the nitrogen available from the legume. Grass forage production allows year-round grazing of leucaena pastures, even if leucaena is frosted during winter. Good grass cover minimises runoff and prevents seedlings of leucaena and weeds establishing between the rows.

Grass is essential for a sustainable grazing system but it competes with leucaena for water.

Row spacing affects the proportions of leucaena and grass forage available. Wide spacing (15m) (left) decreases the proportion of leucaena, narrow spacing (5–6m) (right) increases it.

Grass competition can be reduced by spraying or ploughing out strips of grass adjacent to the leucaena rows.

- **Fertiliser use.** Promote leucaena growth by applying phosphorus and/or sulphur fertiliser if needed.
- **Time to regrow.** Leucaena responds well to rotational grazing systems when it is allowed to recover after grazing — or after winter frosting. If leucaena is grazed to a leafless woody frame, leaf regrowth is slowed.

How much leucaena do I need?

What area should be planted? The availability of suitable soil limits the total area that can be planted on an individual property. The time available to adequately prepare, plant and control weeds influences how much leucaena can be established in any given year.

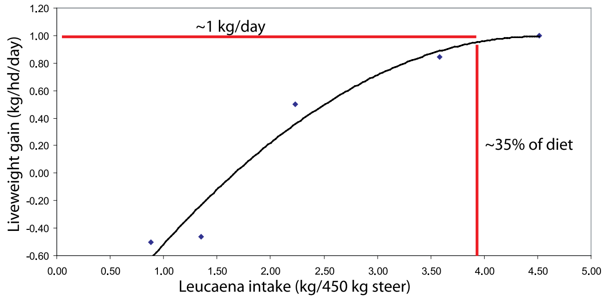
Typically, aim to establish 50–100ha per year with a target of 200–1000ha depending on area of suitable land available. Small areas can be devastated by hungry wildlife (marsupials, birds, hares, rabbits) during establishment, and are not recommended.

What is the best proportion of grass and leucaena in the paddock? The proportion of leucaena in the pasture will vary with spacing of the leucaena rows (wider rows = less leucaena), soil depth and fertility, and adoption of best establishment and management practices.

The proportion of leucaena in the pasture is determined by row spacing, soil depth and fertility, and good establishment and management.

Animal weight gain is closely related to the amount of leucaena consumed – theoretically 40% leucaena in diet for 1kg/hd/day LWG (Figure 4.3). However, voluntary intake of leucaena varies from 5–100% depending on availability and season. Cattle normally graze more grass at the start of the season when it is young and nutritious, but prefer leucaena as the grass matures.

Figure 4.3: Relationship of live weight gain with intake of leucaena



Under heavy grazing, there may be less than 10% of leucaena leaf and small stem available.

If there is limited grass available due to drought, cattle may consume over 90% leucaena in their diet when it is first introduced. Excess consumption of leucaena is wasteful if the area of leucaena is limited. Frost will also partially or completely reduce the amount of leucaena leaf available, depending on severity.

More leucaena leaf than grass may be available under drought conditions, and cattle can do well.

Graziers should aim to have 40—-60% of forage dry matter on offer in the paddock as leucaena, and then manage stocking rate to ensure adequate leucaena when most needed in late summer and autumn.

4.2 Grazing leucaena

Carrying capacity

The number of cattle that can be finished from a paddock of leucaena is based on:

- The amount of edible feed in the paddock (edible leucaena and grass). This depends of the success of establishment of both leucaena and grass, the fertility and depth of the soil, whether fertiliser was applied, and the amount of rainfall received over the growing season.
- The percentage of feed available that can be eaten without damaging the pasture. This might be 30% of the grass but 90% of the leaf and edible stem of the leucaena.

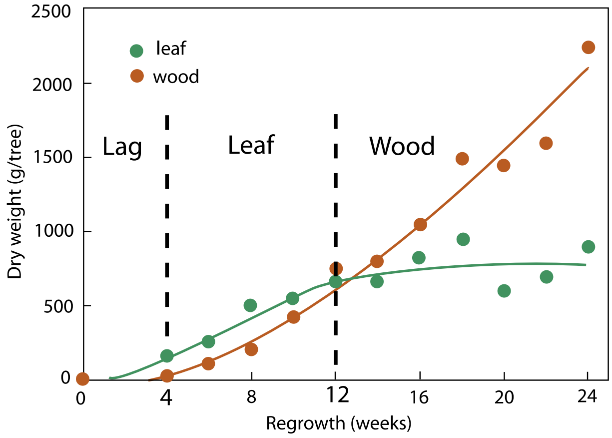
There are few good estimates of the amount of edible pasture produced in leucaena-grass systems. Predictions based on rainfall use efficiency which estimate forage and animal productivity are shown in Table 4.1. This is being achieved by some producers, for example by Stuart and Sharee Ogg at Carnarvon, but will vary from property to property. Case studies from central and southern Queensland indicate a lower carrying capacity and therefore lower production per hectare (Table 4.2).

Regrowth after grazing

Regrowth after heavy grazing and rain can be described as having three phases (Figure 4.4).

- Phase 1 (lag phase) lasts about 4 weeks during which regrowth is slow due to low leaf area.
- Phase 2 (leaf phase) is a 4–10 week period of maximum growth of leaf and young green stem with little growth of wood.
- Phase 3 (wood phase) occurs when leaf yield increases slightly but woody biomass increases dramatically as the trees grow taller.

Figure 4.4: Leaf and stem regrowth of leucaena after cutting



Grazing management should aim to leave 10% leaf area and then to allow sufficient time for regrowth to maximise the yield of edible forage. In the example shown in Figure 4.4, optimal edible foliage is achieved 8–12 weeks after regrowth starts assuming adequate soil moisture and temperature. This is a good time to put cattle back on the leucaena.

Table 4.1: Potential forage production, stocking rate and animal production from leucaena-grass pastures in Queensland, based on rainfall use efficiency (RUE).

Species/item	RUE (kg/ha/mm	Forage yield (kg/ha/yr)	% utilisation	Edible yield (kg/ha/yr)
Annual rainfall 700mm % leucaena in diet 67%				
Leucaena	4	2,800	90	2,520
Grass	6	4,200	30	1,260
Total	10	7,000		3,780
Estimated carrying capacity of 500kg steers consuming 2.5% of body wt (ha/AE/yr)				1.21
Estimated LWG assuming 270 grazing days at 1 kg/hd/d (kg/ha)				270
Estimated LWG assuming 270 grazing days (kg/ha/yr)				224

Table 4.2: Case studies of carrying capacity (ha/adult equivalent AE), live weight gains (LWG) and gross margins on leucaena properties in central and southern Queensland

Location	Grazing days (days/yr)	Stocking rate (ha/AE)	Average LWG (kg/day)	LWG (kg/hd)	LWG (kg/ha/yr)	Gross margins ($/ha)
Central Qld (open downs)	270	2.3	1.12	302	133	163
Central Qld (brigalow)	270	2.3	1.12	302	133	169
Southern Qld (brigalow)	240	2.8	1.23	294	106	107

Regrowth after grazing

Three distinct phases – 1 lag, 2 leaf and 3 wood:

- Forage growth is slow during lag phase.
- Maximum forage growth occurs during leafy phase, and is ready for grazing when 50–60% of regrowth is edible.
- Regrowth period of 8–12 weeks is optimal, depending on temperature and soil moisture.

Wood production is wasteful and needs height control management with machinery.

At this point, edible forage (leaf and small stem) would make up 50–60% of total regrowth biomass. Longer intervals will give a lower proportion of leaf and higher wood yields (Figure 4.4).

Grazing systems

Continuous grazing

Some producers leave cattle on leucaena continuously; all gates are open and cattle are free to choose where and when they graze. This system is low maintenance but, as it does not maximise productivity from the investment, it is not recommended.

Seasonal and rotational grazing

Most leucaena is grazed on a seasonal or rotational basis. Leucaena responds well to intensive short-duration grazing with adequate time for recovery.

In seasonal grazing, the leucaena is locked up to accumulate leaf for feeding cattle at critical times such as autumn and early winter when steers need to be finished but grass quality is dropping quickly. This system is useful where the area of leucaena is insufficient for a more continuous forage supply.

In rotational grazing, cattle are moved around blocks of leucaena allowing time (at least 8–12 weeks after severe defoliation) for paddocks to fully recover before the next grazing.

Rotational grazing aims to keep cattle grazing prime leucaena pasture year-round. To achieve this, graziers need to monitor pasture yield and composition and adjust animal feed days, rotation times and stocking rates accordingly.

Irrigated leucaena pastures are well suited to rotational grazing as pasture yield can be guaranteed by the timely application of water, simplifying feed-budgeting and stocking rate management.

Which grazing system?

Continuous

- need large areas of leucaena
- simplified management
- but no control of height and seediness.

Seasonal

- best for smaller areas of leucaena
- use leucaena to fill autumn/winter protein gap
- target specific animals.

Rotational

- rests leucaena and grass periodically
- maintains grass yield and vigour
- good control of leucaena utilisation and height.

Cell grazing

A large number of cattle rotationally graze small paddocks (cells) for a short time. They quickly eat most of the available fodder and are then moved on, with the cell rested for 8–12 weeks to recover.

Leucaena-grass pastures are well suited to cell grazing because:

- Intense grazing pressure helps manage the height of leucaena preventing it growing out of the reach of cattle.
- Intense stocking leads to more even grazing pressure, better utilisation of pasture resources, and therefore easier pasture feed budgeting.
- High animal traffic accelerates nutrient cycling, better redistribution of nutrients from dung and urine across the paddock, and improves water infiltration.
- Once established, leucaena tolerates heavy grazing – although the grass must not be over-grazed.
- High productivity (and economic viability) of the leucaena system means that smaller areas can be developed.

but

- Cell grazing needs substantial infrastructure in electric fencing, watering points and speargates for managing cattle movement.
- Cell grazing is labour intensive as pasture condition and utilisation need to be monitored regularly and cattle shifted frequently (even daily).

4.3 Producer experience – southern Queensland

Craig Antonio – 'Borambil', Millmerran

Craig Antonio on 'Borambil', Millmerran has one of the most southerly inland plantings of leucaena. Millmerran lies on the Darling Downs about 300km west of Brisbane at a latitude of 18°S; annual rainfall is 625mm, mostly in summer.

Most of Craig's cultivated country has brigalow clay soil, on which he has planted 400ha of Wondergraze and Tarramba leucaena, and plans a further 1,500ha. He considers that the key factors in successful establishment have been meticulous seedbed preparation and post-planting weed control.

Planting. After any brigalow or grass regrowth has been removed by thorough cultivation, in September he uses a purpose-built planter to sow the leucaena in double rows 8m apart, along with fertiliser (P, S and Zn) banded along the hedgerow. To control the mass of grass seedlings in old cropping land, Craig applies Spinnaker® pre-planting and Verdict™ post-planting – and sometimes uses tillage to control weeds in the inter-row.

Craig sometimes sows oats between the establishing hedgerows during the first winter. He then sows grass in the inter-row in spring following rainfall (October/November).'

Craig checks his leucaena sown after a winter cereal crop

Grazing. The first grazing of the leucaena is in March after the September planting, but it can take up to three years before it is fully established.

Craig uses high stocking rates of 5–10 AE/ha in rotationally grazed leucaena pastures. This controls the height of the leucaena; he says that the cattle preferentially graze leucaena and pull down any tall branches.

Cattle on the leucaena gain 1.6 kg/day for two months and 1.3–1.4 kg/day for seven months to achieve 250 kg LWG/ha/yr. Craig says that this allows him to target his market as he can forecast weight gains even over long dry spells, with shorter fattening periods than on grass-only pasture. Other benefits from the leucaena pastures include better ground cover which reduces runoff and soil loss.

Better stock and profits. Craig has three Angus breeding properties and one finishing property. His markets include feedlot steers at 400–500kg and cull heifers to a kill weight of 500kg with carcases reaching Meat Standards Australia (MSA), and Grassfed or Angus grids if the season allows.

The returns from leucaena-grass pasture is $200-250/ha/yr on old farming country, and $300/ha/yr on regrowth country.

Once the leucaena is established, production is relatively cost free, and it has doubled Craig's carrying capacity and profitability.

Leucaena rows with Callide Rhodes grass at 'Borambil'.

4.4 Making the best use of leucaena

Leucaena as a protein supplement

The main value of leucaena is as a much-needed protein supplement to cattle grazing tropical grass pastures. Rapidly growing cattle need about 13% crude protein in their diets to produce good weight gains, and they cannot get this from grass pastures alone.

When cattle are introduced to leucaena paddocks, their intake of protein immediately increases when they select a high proportion of leucaena — which depends on the leucaena leaf available, seasonal factors and animal behaviour (Table 4.3).

Table 4.3: Percentage leucaena in diet of cattle grazing leucaena and grass on six properties in central Queensland from December to May 2005

Property	Average leucaena in diet (%)	Seasonal range in diet (%)	
		December	May
A	75	98	60
B	51	92	32
C	53	74	24
D	50	79	30
E	44	67	13
F	15	48	5

For cattle accustomed to leucaena, leucaena intake can initially reach almost 100%, and then gradually reduce as there is less leaf available.

Cattle often prefer young nutritious grass early in the season and leucaena later in the season as the grass matures. However, if the leucaena area and associated grass is limited, leucaena is highly palatable and cattle will keep eating it while available. Thus, without a grazing strategy, they tend to eat excessive amounts of leucaena protein early in the growing season — more than they need nutritionally — leaving insufficient leucaena forage for when the grass hays off in autumn. Over the first half of the season cattle consume a high quality diet of both green grass and leucaena, resulting in more dietary protein than they need for growth.

Animal performance can reduce later in the season (autumn) if insufficient leucaena is available as the quality of grass declines.

Managing leucaena intake by restricting access early in the growing season, or by a rotational or cell grazing system, with some grass-only paddocks can improve production efficiency.

Strategic use of leucaena

Leucaena is commonly used to finish cattle for local and export markets. Strategies to make best use of limited leucaena include:

- finishing steers to market specifications (see Producer experience – Stuart and Sharee Ogg)
- backgrounding weaners going into a feedlot (see Producer experience – Paul and Claire Harris) or to live export
- growing and conditioning young bulls for sale – as an alternative to finishing on grain (see Producer experience – Jonathon and Kerry Schmidt)
- as a protein supplement at a specific time of year, usually from autumn through to spring
- 'spike feeding' breeders, usually heifers, before calving.

These strategies assume that there is insufficient leucaena to feed the entire herd year-round and that maximum benefit is obtained by using the limited resource for the most valuable animals.

In all cases of occasional feeding of leucaena, cattle must be protected against mimosine or DHP toxicity.

High protein feed during droughts

Broadscale plantings of leucaena in Queensland have proven to be effective for drought and dry season mitigation.

Producers with substantial areas of leucaena have been able to survive recent severe droughts with their cattle in better condition than those of producers without leucaena. The 5–6m deep roots of leucaena allow it to produce some high-protein leaf during dry periods and so enables cattle to better digest poor quality grass roughage.

Drought, no grass but cattle maintaining body condition on leucaena

4.5 Producer experience – Darling Downs

Jonathan and Kerry Schmidt (Managers), 'Dalby Downs', Kaimkillenbun

Jonathon and Kerry Schmidt manage Burenda Angus & Brangus at 'Dalby Downs' producing 500 bulls each year from a breeder herd of 1,200 head. 'Dalby Downs' is run in conjunction with lease and agistment properties in western Queensland where breeders are run for eight months of the year (November to June)

'Dalby Downs' covers 3,030ha, with 1,095ha of leucaena, mostly cv. Tarramba but with small areas of Cunningham and Wondergraze.

They have 810ha of cultivation for oats for grazing, forage sorghum for silage and barley for hay with an additional 1,135ha of buffel, Rhodes and blue grass on basalt ridges.

Alluvial soils are heavy black cracking clay on flats and red clay soils on stony ridges. Average annual rainfall is 610mm. Low-lying areas are frosted in winter.

Establishing leucaena. Jonathan first planted leucaena on 'Dalby Downs' in 2005. He had difficulty with grass weed control when planting into cultivated strips but much better leucaena establishment with full paddock cultivation, careful seed bed preparation and total weed control. Soil fertility has been improved by the application of feedlot manure, sometimes at 15–16 t/ha.

As low temperatures and frost limit leucaena growth during winter, oats are sown for winter forage. Establishing leucaena on poorer box soil types is challenging as surface crusting affects water infiltration and seedling emergence. Psyllids can cause minor damage in March–April after wet summers.

Managing leucaena. All leucaena is planted in twin rows with Bambatsi, Rhodes and purple pigeon grass in the inter-row. Plant height is controlled by frost and by crash grazing with cows and calves.

Leucaena is usually rotationally grazed – with a silage ration supplied in the paddock to intensify production (increase stocking rate) and to maximise the return per hectare of land. The silage ration, which provides about 30% of the animal's diet, comprises silage, cotton seed meal, hay and grape mark. Oat crops are grazed during winter.

Recent droughts and poor summer rains have resulted in some set stocking and overgrazing of the leucaena, but it recovers quickly with spelling.

Cattle productivity. Once cows have calved, they are joined (AI) while on leucaena/silage. When pregnant they are sent to the agistment properties to graze improved grass pastures from November to June. Weaners are returned to 'Dalby Downs' in March and fed on leucaena/silage and then oats over winter before returning to leucaena/silage. Bulls are run on leucaena/silage and oats from weaning until sale.

Managing toxicity. Cattle were inoculated with the QDAF rumen bug and carrier animals are kept on leucaena; no symptoms of toxicity have been seen.

Although cows graze on leucaena during insemination and early pregnancy, pregnancy rates have been maintained at 91% constantly after a six-week joining period. Bulls grow out on leucaena for eight months of the year (on oats for the remainder) and have no fertility problems.

Productivity and the future. The high productivity of the leucaena pastures has justified the cost of establishment and maintenance.

Feeding leucaena with silage supplement has intensified production with more bulls being produced each year.

The leucaena pastures provide all cattle with a high plane of nutrition and maximise animal growth rates for herd data recording purposes.

4.6 Producer experience – central Queensland

Stuart and Sheree Ogg, 'Ingelara', Rolleston

'Ingelara' is a 7,280ha property near Carnarvon National Park, receiving annual rainfall of 750mm. The native pastures were black speargrass on deep loamy, well-drained creek flats leading into narrow-leaf ironbark ridges.

Establishment. Stuart established 445ha of Cunningham and Peru leucaena, starting some 30 years ago. Leucaena rows of 6–8m apart were generally planted into oat stubble in October-December, with another planting of forage oats between the leucaena rows in the winter of establishment. A further 240ha of forage oats are grown for winter fattening feed.

Weed grasses are controlled with fluazifop-p-butyl (Verdict®) and bentazone (Basagran®) for broad-leaf weeds.

Leucaena ready for grazing

Grazing system. Their grazing system comprises a 4-paddock-200-day cattle rotation, with the cattle moved when the paddock has been optimally grazed.

About 450 cross-bred steers (300–350kg) enter the system in November and gain 200–240 kg/head (1.0–1.2 kg/hd/day) over the 200-day grazing period.

When the leucaena is frosted (90%) around June, cattle are moved to oats at weights from 500–550kg and grazed until they reach slaughter weights of 560–600kg.

Weaner steers are rotated through frosted leucaena paddocks in winter and graze inter-row Callide Rhodes grass until spring.

The leucaena is rested in spring for 6–8 weeks to allow regrowth.

Frosted leucaena recovering in spring

Better stock and profits. Stuart and Sheree see that leucaena has transformed the property from speargrass country into sustainable, prime fattening country, and this has increasing the land value from $3,700/ha to $12,000/ha.

Establishment costs of leucaena in old cultivation land were $200–250/ha.

Fat cattle are now marketed under 24 months and average 300kg dressed weight with MSA grading, thus targeting premium EU and PCAS markets.

Limitations and challenges. Psyllid attack can significantly reduce leucaena production in the occasional humid years.

Any spread of leucaena into creeks and waterways is controlled with herbicide.

Future plans. The Oggs intend to expand the area under leucaena by planting psyllid-tolerant cv. Redlands.

Cross-bred steer fattened on leucaena

4.7 Producer experience – central Queensland

Paul and Clare Harris, Sunland Cattle Co Pty. Ltd.

Paul and Claire Harris own Sunland Cattle Co Pty Ltd., which operates two central Queensland cattle properties, totalling 18,176ha with annual rainfall averaging 640mm. They stock 10,000 full-blood and pure-bred Wagyu, employ embryo transfer and artificial insemination to improve herd genetics.

Paul began planting leucaena in the early 1990s and they now have 6,000ha. This forms an integral part of their beef business.

Establishing leucaena. While Paul initially planted single rows of leucaena in strips of pasture, he now ploughs whole paddocks and plants double rows 1m apart with a 6m inter-row. Seed is treated and beetle baits applied at planting to deter insects.

Spring plantings are preferred to avoid summer heat. Spinnaker® (700 g/kg imazethapyr) is applied in 3m strips to suppress grass growth. As its effect declines, buffel, green panic, Bambatsi panic, Urochloa and Rhodes germinate naturally.

Phosphorus fertiliser will be applied where soil tests indicate deficiency.

Cv. Tarramba was used but because it grows tall, other cultivars will be planted in the future.

Managing leucaena. Plant height has been controlled using a large mulcher but Paul's philosophy is: "When cattle eat the leucaena we make money; when we mulch it, it costs us money".

Heavy duty mulcher for cutting back excess leucaena growth

Cell grazing (high intensity-short duration grazing) will now be used to control excess height and to allow pastures to recover.

Cattle productivity. Leucaena has increased carrying capacity, weight gains and the high marbling score of the Wagyu.

Wagyu cattle grazing leucaena

All categories of cattle graze the leucaena pastures including:

- stud bulls and feeder steers (400–450kg) which reach target weights quickly at reduced age
- young heifers which reach the desired mating weight of 300kg early
- cull females, bulls, cows and calves.

At first, some cattle showed symptoms of mimosine toxicity but there has been no problem since dosing with the 'rumen bug'.

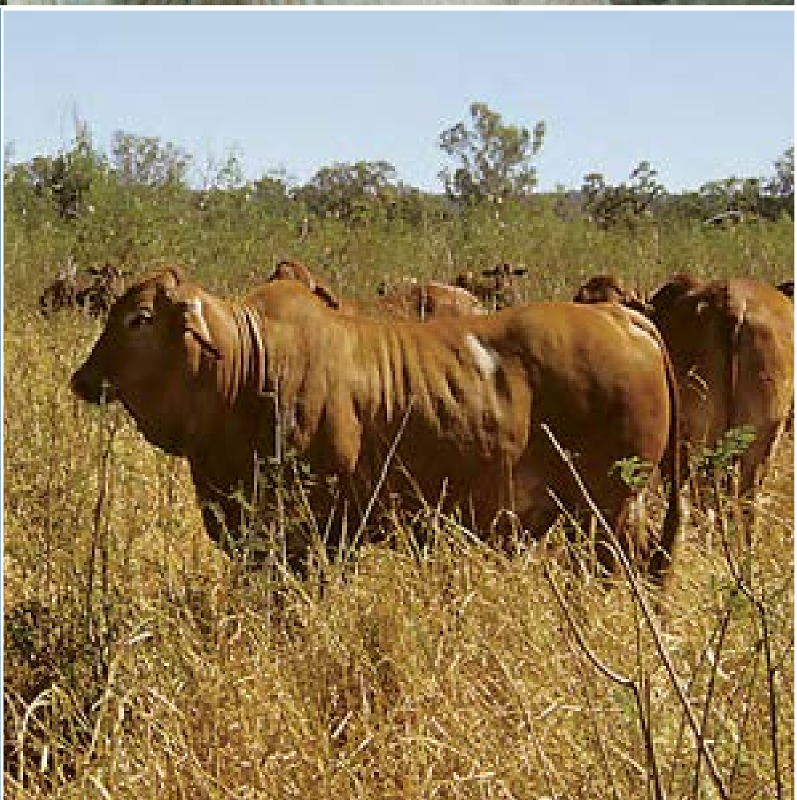
Psyllids have not been a significant problem.

Future plans. Leucaena is essential to their future operation. It greatly increases carrying capacity and rate of turnoff and profitability.

We have the soils, climate, equipment, staff and know-how to establish more leucaena but will not proceed until they are confident that they can manage it in accordance with The Leucaena Network Code of Practice.

Aerial view of some of the leucaena area

5. Nutritional value



Chapter 5. Nutritional value of leucaena-grass systems

5. Nutritional value of leucaena-grass systems

Leucaena-grass systems can achieve about double the live weight gains that might be achieved on native pastures alone. Steers can gain 0.6–0.7 kg/hd per day over an entire year, approaching 1.2 kg/hd/day over 80–120 days under favourable conditions.

On well managed leucaena-native grass pastures on good basalt soil, steers have gained as much as 0.84 kg/hd/day over 167 days in the dry season and 1.16 kg/hd/day over 119 days in the wet season.

On a dry matter basis, leucaena browse (leaf with minimal stem) can have more than five times the crude protein content (CP) of tropical grass pasture in the dry season, with nearly twice the (metabolisable energy (ME) and half the fibre (ADF and NDF fractions). When eaten with grass, leucaena improves the balance of nutrients consumed, increases overall feed intake and greatly improves feed conversion efficiency – resulting in more LWG per kg DM consumed.

Leucaena dry matter (DM) has:

- crude protein concentration of 20–25% (leaf with minimal stem)
- digestible organic matter (DOM) of more than 60%
- metabolisable energy value above 10 MJ/kg DM
- rumen degradable protein to digestible organic matter ratio of 188–236g RDP/kg DOM – well above the rumen microbial requirement of 130g RDP/kg DOM.

The crude protein content and digestibility of a leucaena-grass diet will vary depending on the proportion of leucaena in the diet. With paddock grazing, and in some cut-and-carry systems, animals select leaf and reject woody stems with a diameter greater than 6–10mm. However where leucaena is mechanically harvested through a forage chopper, animals have difficulty selecting leaf and the overall diet CP% and DMD of the diet will be reduced.

5.1 Leucaena as a total supplement

Crude protein supply

The high CP content of leucaena is its major nutritional advantage over other tropical forages. The addition of leucaena to pasture-based systems can remove the need for protein supplements such as urea and cottonseed meal in the dry season.

For rapid growth (more than 1kg LWG/day), cattle need about 13% crude protein in their diets and they cannot get this from grass alone (Figure 5.1).

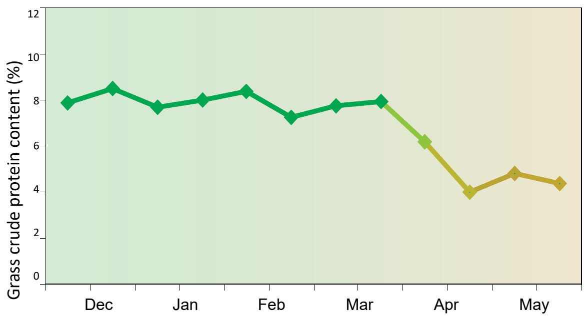
Adequate leucaena mixed with a tropical grass increases metabolisable protein (MP) to the animal providing the building blocks for milk and muscle production.

Acronyms

Some readers may be accustomed to the acronyms used in nutrition science, others less so. These are spelt out here for readability.

ME – metabolisable energy
MJ – megajoule
DM – dry matter
DOM – digestible organic matter
CP – crude protein
RDP – rumen degradable protein
MP – metabolisable protein
NDF – neutral detergent fibre
CT – condensed tannins
VFA – volatile fatty acids
DHP – di hydroxy-pyridone
LWG – live weight gain

Figure 5.1: Change in grass protein (December to May)



Crude protein is either degraded in the rumen (RDP) by the rumen microbes (beneficial bacteria, fungi and protozoa), or escapes (flows out of the rumen before being degraded) or, being indigestible by the microbes, bypasses to the small intestine. The CP degraded in the rumen is used by the microbes to grow and multiply and is the major source of MP for the animal when it moves out of the rumen and is digested further down the tract. The escape and bypass protein components make up a much smaller part of the total MP.

The higher RDP fraction of leucaena improves feed intake of low quality tropical grass in the dry season. This can enable cattle to at least maintain live weight during the dry season when cattle on grass-only pastures would be losing weight.

Energy supply

Higher dietary ME is also achieved by feeding leucaena. Higher DOM provides the energy that directly feeds the rumen microbes.

The microbes consume the DOM fraction and excrete volatile fatty acids (VFA) which are absorbed across the rumen wall into the animal's blood stream where they are transported to the liver to be converted to glucose (the animal's actual energy currency).

Glucose is the energy source that fuels maintenance and productivity or the production of muscle and fat. More glucose and MP stimulate more LWG, driven by more leucaena relative to pasture in the diet.

Volatile fatty acids

Not all volatile fatty acids are equal in terms of their glucose-producing potential in the liver. The growth of muscle and fat is especially efficient if the microbes produce a greater proportion of propionate to acetate (two different types of VFA), and this occurs in pasture-fed cattle supplemented with leucaena.

Condensed tannins, protein and bloat

Leucaena contains condensed tannins (CT), secondary compounds which bind to protein, at concentrations of 3–6% DM. While leucaena CT do not generate much usable bypass protein, the CT in leucaena do protect cattle from bloat.

Forages that contain high CP (such as immature lucerne) would normally be considered a bloat risk. Excess protein in lucerne degrades rapidly in the rumen to produce a stable foam that causes bloat. In leucaena, CT bind to enough of the leucaena protein in the rumen to slow down the rate of degradation, negating the foaming risk.

Minerals supply

Leucaena-grass pastures would be expected to have sufficient mineral content to support high cattle performance when established on suitable country and not on marginal soils. Leucaena on its own is a rich source of calcium and magnesium needed for strong bones and healthier metabolism. However, if cattle consume high amounts of leucaena, sodium and zinc could become limiting. Any deficiency from this or from marginal soil can be managed by providing a mineral lick.

5.2 How much leucaena in diet?

The optimal proportion of leucaena in the diet will depend on the targeted level of LWG and the nutritional value of the grass or other supplements in the diet.

Very high intakes of leucaena potentially waste protein if it is not balanced with enough grass or other energy supplements.

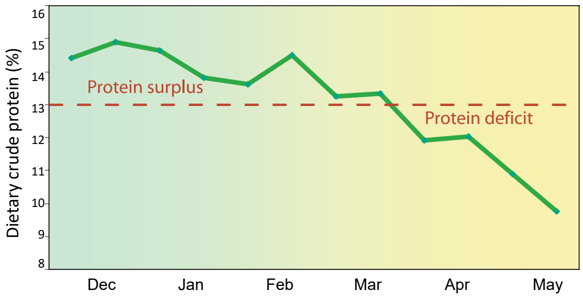
Overall, a nutritional aim across the season or whole year should balance the higher CP and ME in leucaena with the lower levels in grass to bring the overall level of the diet closer to the nutritional requirements of the animal (CP of 13–15% and ME of 8–10 MJ/kg DM). Cattle can obtain fibre from high leucaena diets by stripping the bark from stems.

However, the grazing behaviour of cattle on leucaena commonly makes it difficult to achieve that desired balance of leucaena to grass.

Cattle can maintain weights on dry season grass with small amounts of leucaena (5-10%) in diet. At these levels, leucaena effectively acts like a urea-enriched supplement; increasing total dietary CP% at a time when dry season grass could be 6% CP or lower.

Overall, cattle often prefer young nutritious grass early in the season and leucaena later in the season as the grass matures. However, if the leucaena area and associated grass is limited, cattle will keep eating the more palatable leucaena while it is available. Without a careful grazing strategy, cattle will tend to consume excessive amounts of leucaena protein early in the growing season — more than they need nutritionally — leaving insufficient leucaena forage for when the grass hays off in autumn (Figure 5.2).

Figure 5.2: Cattle grazing abundant leucaena in summer may be wasting protein needed in autumn

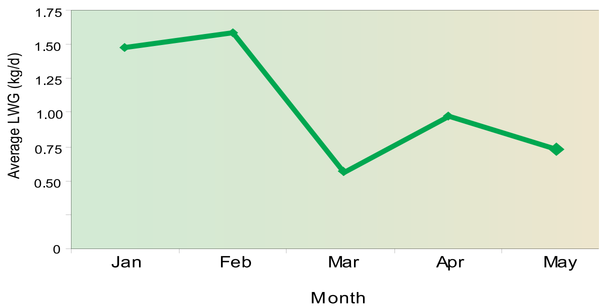


Cell or rotational grazing systems can be used to manage leucaena intake.

For higher LWG

Weight gain sufficient to finish steers (1–1.4 kg/AE/day) for high value markets is attainable in the wet season but not year round. As the dry season progresses, LWG will decline depending on how much leucaena is available at the time (Figure 5.3).

Figure 5.3: Cattle grazing abundant leucaena in summer may have insufficient in autumn



When cattle are introduced to leucaena paddocks in the wet season, they immediately select a high proportion of leucaena resulting in a high intake of crude protein. For cattle accustomed to leucaena, leucaena intake can initially exceed three quarters of the diet and then gradually reduce as leaf becomes less available, to less than one quarter of the diet by the beginning of the dry season.

To achieve high LWG into the dry season, the leucaena proportion in the diet must be maintained or animals would need to be supplemented with high quality silage or hay, winter active pastures such as oats, and/or energy-rich supplements such as molasses or grain (See Producer experiences – Craig Antonio, Don Heatley).

These strategies would also apply to cows and first calf heifers in early lactation.

The economics of these strategies require careful consideration, they are more complex to manage, and potentially increase the risk of digestive problems such as ruminal acidosis.

LWG for other classes of stock

It may be suitable to target moderate levels of productivity for some other classes of cattle than steers alone. Lower (less than 33%) rather than higher (more than 33%) levels of leucaena relative to grass in the diet would suit cattle with relatively low requirement targets such as heifers to calve at three rather than two years of age, pregnant rather than lactating cows (but not during the first trimester due to the risk of foetal abortion), or bullocks to be finished in more than three years rather than steers to be finished or sold into feedlots before 2.5 years of age.

5.3 Leucaena toxicity

While leucaena-grass pastures are the most productive, sustainable and profitable improved pasture option for northern Australia, concern about leucaena toxicity and its management has limited its adoption and potential as a forage for ruminants.

The toxicity of leucaena results from the presence of a non-protein free amino acid, mimosine, which occurs in high concentrations (4–12% DM) in foliage and pods and can have severe short-term effects on animal health and performance.

Leucaena toxicity explained

Mimosine is rarely severely toxic as it is normally broken down to DHP, but toxicity can occur when unaccustomed hungry cattle gorge on lush new leucaena growth at the break of a drought or directly after frost before companion grass pasture starts growing.

The acute mode of toxicity is initially due to the effects of mimosine on rapidly dividing cells – resulting in hair loss, salivation, loss of appetite, low bull fertility, foetal abortion in pregnant cows and, very occasionally, death.

Preventing acute mimosine poisoning

- Do not let hungry cattle gorge on lush leucaena.
- Make sure there is ample roughage (grass or hay) available in the paddock to minimise the risk of cattle eating too much leucaena too quickly.
- Introduce them to leucaena slowly to give time for mimosine to be converted to DHP.
- Give cattle time to adapt to high leucaena diets.
- Mimosine toxicity is remedied by immediately removing the animal from the leucaena.

To avoid the risk of fatal acute mimosine toxicity, do not allow cattle to gorge on leucaena regrowth after a frost or drought without adequate grass roughage.

However, after a short adaptation period of 1–2 weeks, mimosine is rapidly and effectively converted by enzymes and rumen bacteria to less acutely toxic compounds, isomers of dihydroxypyridone (known as DHP).

From mimosine to DHP

Acutely toxic mimosine is rapidly (within 1–2 weeks) converted by plant enzymes and rumen bacteria to less toxic compounds, isomers of dihydroxypyridone (known as DHP).

DHP itself is a goitrogen inhibiting thyroid hormone function and can be responsible for reducing feed intake and animal performance.

DHP strongly binds to essential metal ions leading to mineral deficiencies.

Cattle adapt to DHP with rumen microbes which degrade the toxin and by the action of the liver which neutralises and excretes toxins in urine.

Cattle can adapt to DHP toxicity through two mechanisms:

- Rumen microbes (the 'rumen bug') which can degrade DHP.
- DHP toxin absorbed into the bloodstream can be neutralised by binding compounds produced in the liver (a process called conjugation). The neutralised toxin is excreted in the urine.

See next page **Is there a different DHP detox pathway?** to understand the latest research in management of toxicity.

Administering the rumen inoculum

The 'leucaena bug' (*Synergistes jonesii*) can be purchased through the Queensland Government web site. The inoculum has been licensed by the Australian Pesticides and Veterinary Medicines Authority (APVMA) to be administered orally using a standard cattle drench gun.

The mixed culture bacterial inoculum is stored at –20°C and distributed frozen on wet ice in 500mL bottles. It must be handled carefully to ensure the bacteria survive, and should be thawed only immediately before drenching and with minimal exposure to air.

As the live bacteria in the inoculum are adapted to oxygen-free environments (as in the rumen), they cannot be applied to a water source (such as a trough) because oxygen in the water will kill the bacteria.

The recommended dose rate is that 10% of animals in the herd be inoculated with 100mL of culture each using a standard drenching gun. This means the 500mL bottle will treat five animals in a mob of 50.

Administering the 'leucaena bug' with a drenching gun

Further information on the use and management of the leucaena inoculum can be obtained from *https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/livestock/cattle/leucaena-inoculum-cattle.*

Managing cattle to prevent leucaena toxicity

Leucaena toxicity occurs when unadapted cattle first access lush leucaena, especially at the break of the season and when little grass is available.

Naïve animals must be introduced to leucaena slowly; providing adequate grass or hay roughage will assist in preventing the animals gorging on leucaena. This will allow the rumen microbes and animal's liver function time to up-regulate to detoxify the DHP.

Once adapted, cattle can be safely grazed on leucaena pastures without experiencing toxicity. However, first-calf heifers must be protected from mimosine toxicity if they have not been previously adapted.

Naïve pregnant cows should not be introduced to leucaena, especially during the first trimester, due to the possibility of foetal abortion.

It is a good strategy to adapt breeders by initially exposing them to small amounts of leucaena. Once adapted, heifers can safely eat diets containing high proportions of leucaena, and stud and herd bulls can be safely fed on leucaena (see Producer experience 4.5).

Is there a different DHP detox pathway?

Since the early work by Dr. R.J. Jones and colleagues in CSIRO identified a rumen bacterium (*Synergistes jonesii*), further studies on leucaena toxicity by the University of Queensland and CSIRO have found *S. jonesii* to be less effective than originally thought.

There have always been queries about how *Synergistes* can spread quickly through a herd in which only one in ten animals initially received an inoculum, and many producers do not inoculate regularly.

Testing of urine samples collected from many cattle herds on high leucaena diets in Queensland has indicated that DHP was not all degraded by *Synergistes jonesii*; rather it showed the potential importance of a lesser known pathway in which DHP toxin is neutralised by conjugation in the liver.

Taking urine samples for DHP testing from cattle eating leucaena in Queensland

Strong evidence for an alternative pathway of toxin management was previously found in Indonesia where numerous Balinese farmers feed uninoculated Bali bulls (*Bos javanicus*) with up to 100% leucaena. The bulls show no toxicity symptoms – apart from some hair loss, salivation and reduced appetite over an initial 1–2 weeks while they became adapted to the new diet. The bulls quickly recover and are not only healthy but gain weight at near their genetic maximum.

Urine tests showed that the Indonesian cattle were not degrading much of the DHP in the rumen, despite the presence of indigenous strains of *Synergistes jonesii*, but were excreting it in high concentrations in urine in the conjugated non-toxic form.

Ruminants in many tropical countries are commonly fed high leucaena diets – with no apparent long-term toxicity symptoms.

Bali bulls eating 100% leucaena and gaining weight without rumen inoculation.

Since there is no available source of *S. jonesii* in these countries, none of these ruminants are inoculated.

Urine sampling from cattle, buffalo and goats eating leucaena in Thailand and Mexico has shown the conjugation detoxification pathway.

All this evidence suggests that conjugation by compounds produced in the liver is a major pathway for neutralising the toxicity of DHP.

However until suitable research has been completed under Australian conditions, the recommendation remains for rumen inoculation with *Synergistes jonesii* as insurance against possible leucaena toxicity.

Other work has shown *S. jonesii* is not an isolated organism geographically. It can be found in the rumen fluid of animals in all countries tested, but always as a minor population just detectable using new PCR-based assays. Despite the ubiquitous nature of *S. jonesii*, its low resident populations in the rumen were insufficient to protect the animals from toxicity.

Further clarification needed on reproduction

Any toxic effects on the reproductive performance of ruminants consuming high leucaena diets need to be clarified.

Lowered calving percentages in females grazing leucaena have been reported by some Australian producers, probably due to foetal abortion, while other producers have reported that cattle accustomed to leucaena achieve high calving percentages. In Indonesia, where female cattle are adapted to high leucaena diets, there was no indication of foetal abortion.

Any negative effects on herd reproduction may be avoided by appropriate herd management.

6. Costs and returns

Chapter 5. Costs and returns

6. Costs and returns

Leucaena is a perennial legume which has a potential life of over 30 years. Any investment in leucaena involves a high initial outlay of funds to develop the pasture, a period of lower returns as the pasture is establishing, followed by a long period of high production and relatively stable returns.

The value of a leucaena investment to a business depends upon:

- the costs of establishing the pasture
- how successfully it establishes (this affects future profitability)
- the length of productive life of the leucaena (reduces the long-term impact of the high initial investment)
- the level of long-term productivity (live weight gains, stocking rates)
- the alternative land use if leucaena was not planted (establishing a leucaena pasture may not necessarily be the most profitable option)

In this chapter, the value of an investment in leucaena is analysed taking these factors into account.

Gross margin analysis is used to illustrate the profitability of converting a paddock of perennial grass to a leucaena-grass pasture. The important factors that contribute to making leucaena a successful investment are highlighted. A whole farm economic analysis of investment in leucaena by an independent consultant is recommended for your own business.

6.1. Costs of establishment

Good establishment will depend on using the correct techniques to maximise eventual productivity and minimise time to full grazing. The combination of cost of establishment, low animal production during establishment and the income foregone from the activity that leucaena is replacing, can reduce short-term cash flow of the farm business.

Clearing or blade ploughing paddocks, deep ripping, fencing and water reticulation, if needed, will add to establishment costs.

The cost of establishment will depend on the previous land use and condition as this will affect the method of ground preparation, seeding rates and cost, and method of pre- and post-plant weed control.

Operational (labour) costs depend on whether a contract planter or property owner plants the leucaena.

Costs of establishment will depend on previous land use. Old cultivation land is associated with costs of weed control and establishing new grass.

Typically the cost of consumables for planting by an owner/operator is around $250–300/ha (Table 6.1). For property owners using their own equipment and time, the major consumable costs at planting are purchase of seed, diesel, pre and post planting herbicides, and starter fertilizer (Table 5.1).

If an owner operator costs out personal time at $75/hour, labour cost would be $150–$175/ha. This increases the cost of establishment to $400–475/ha.

Using contract planters for total establishment can add $300 /ha depending on hourly rates (Table 5.2). This increases the cost of establishment to $550–$600/ha.

Good establishment is critical to long-term profitability.

6.2. Gross margin analysis

Returns to establishment

This analysis of the costs of establishment does not include the opportunity cost of the land being unused during establishment of the leucaena. With good conditions and with correct planting technique, leucaena rows should reach a height

Table 6.1: Development cost calculator for consumables used when establishing leucaena-grass pasture

Consumables estimate	% paddock planted	Rate/ha	$/L or $/kg	Estimated $/ha
Pre-planting and planting costs				
Leucaena seed - "Wondergraze"	100%	2	$50	$90.00
Insecticide seed dressing (Cosmos©[2])	100%	2.5	$1.05	$2.60
Beetle bait - including labour to mix	100%	5	$3.30	$16.50
Starter fertiliser (Starter Z) @ 25% area in row	25%	150	$0.90	$33.80
Spinnaker©[2] sprayed over 8m of row (generic brand)	100%	0.15	$140	$21.00
Glyphosate - fallow	100%	1.5	$5	$7.50
Glyphosate - pre-plant	100%	1.5	$5	$7.50
2,4-D - pre-plant	100%	1.5	$5	$7.50
Post-planting costs				
Glyphosate using shield spray	75%	1	$0	$0.00
2,4-D using shield spray	75%	1	$0	$0.00
Broad leaf weed control (Basagran©[2]) @ 20% (only if needed)	25%	0.4	$35	$14.00
Grass weed control (Verdict©[2]) (only if needed)	25%	0.25	$20	$5.00
Grass seed @ 75% (price dependent on variety and coating)	75%	10	$15.00	$112.50
Diesel - after rebate	100%	50	$1.10	$54.60

[1] Consumable costs may vary with source
[2] See Chapter 2 note on registration of chemicals

of 1.5–2m by the end of the first summer when the leucaena pasture can be lightly grazed.

Full grazing can be possible approximately 24 months after the leucaena is established, with stocking rates varying between 1 and 2 ha/AE.

Grass seed can be planted at the end of the first summer, or at the beginning of the second summer.

Variable seasonal conditions during the 12 months after leucaena planting can impact considerably on the estimated gross margin for the establishment year.

Typically, productivity and profitability of a leucaena-grass pasture over the whole establishment period is estimated at 20–25% of that of the fully established pasture.

Returns after establishment

Examples presented compare the profitability, using gross margin analysis, of converting to leucaena-grass pasture against a range of other high-input forage options for beef production at five sites in the Fitzroy River catchment.

This detailed gross margin analysis, conducted by the Queensland Department of Agriculture and Fisheries from 2011 to 2014, compared high-value pasture options in three regions:

- central Queensland open downs (Emerald – Capella area)
- central Queensland brigalow (Biloela – Rolleston area)
- southern Queensland brigalow (Taroom – Wandoan area).

The grazing options were:

- perennial pasture options (leucaena-grass pastures; butterfly pea-grass; buffel grass)
- annual forage crop options (oats, forage sorghum, lablab).

Although the commercial stock in the paddocks were of mixed size and class, assumptions used for the gross margin analysis were:

- an adjustment was made for interest on capital.
- stocking rate is expressed as ha/AE where an AE (adult equivalent) = 450kg steer, calculated for the duration of grazing for annual forage crops, and per annum for the perennial pastures.

Table 6.2: Development cost calculator for operational costs based on contract planter rates[1] for establishing leucaena-grass pasture

Operational estimate at contract rates (if $150/hour)	Estimated ha/ hour	$/hour	Estimated $/ ha
Pre-planting and planting			
Deep ripping (only if needed)	3	$150	$50.0
Primary discing	4	$150	$37.5
Second discing	5	$150	$30.0
Final seed bed prep (speed tiller or cultivator)	6	$150	$25.0
Fallow spray	10	$150	$15.0
Pre-emergent spray - glyphosate & Spinnaker©[2]	10	$150	$15.0
Planting/fertiliser/innoc/water inject/Spinnaker©[2]	3.4	$150	$44.1
Post-planting			
Crusting cultivation - yetter wheels (only if needed)	5	$150	$30.0
Beetle bait application	10	$150	$15.0
Inter-row cultivation (only If needed)	5	$150	$30.0
In crop grass weed spray - Verdict©[2] to control grasses	10	$150	$15.0
Inter-row shield spray (only if needed)	7	$150	$21.4
Pasture/cover crop inter-row planting (only if needed)	5	$150	$30.0

This table reflects costs of establishing leucaena into buffel grass pasture where there is no need for regrowth control or stick picking. If planting into recent cultivation there is no need for disc ploughing.
[1] Contract rates will vary with contractor
[2] See Chapter 2 for note on registration of chemicals

Animal productivity for five forage options

The most productive high-value forage option was leucaena-grass pasture with an average live weight gain of 192 kg/ha (Table 6.3). This was more than 2.5 times as productive as perennial grass alone, twice as productive as any annual forage crop, and 1.5 times the productivity of the other perennial legume-grass option of butterfly pea-grass.

The higher productivity of leucaena-grass pasture was due to:

- a longer period of grazing during the year (284 days)
- a relatively higher stocking rate (1.3 ha/AE) compared to the perennial pasture options
- a consistent high-quality diet (12% crude protein and 59% digestibility).

Profitability of five forage options

The most profitable high-value forage option was also leucaena-grass pasture at $184/ha (owner rates) (Table 6.4). This was twice the profitability of perennial grass alone, 300–400% more profitable than sorghum or lablab options, and 30–40% more profitable than butterfly pea-grass and oats options.

This higher profitability of leucaena-grass pasture was due to:

- Higher quality feed available for most of the year. This led to higher animal performance, although live weight gains varied with season. Among properties, live weight gains varied from 0 to 0.31 kg/hd/day in winter and spring to 1.23 to 1.52 kg/hd/day in early summer.
- Long-term productivity (more than 30 years), with no requirement to replant, spreading the costs of planting over the long life of the pasture
- Greater tolerance of regular grazing at relatively higher stocking rates than other perennial pasture options
- Greater growth of associated grass, through return of nitrogen, compared with sole perennial grass pasture which suffered from pasture run-down.

Table 6.3: Average stocking rate, grazing days beef production for six forage types grazed by cattle on commercial properties in the Fitzroy River catchment. Results are means with variability. (Bowen et al. 2018)

Parameter	Annual forages			Perennial forages		
	Oats	Sorghum	Lablab	Leucaena -grass	Butterfly pea-grass	Perennial grass
% of grazing area planted to improved forage[A]	59±8	67±5	58±15	77±8	88±12	-
Stocking rate[B] (ha/AE total grazing area)	1.0	0.6	1.0	1.3	1.7	2.7
Grazing days per year	116±9	107±15	107±4	284±59	181±24	224±79
% of legume / oats in diet[C, D]	77±5	-	54±23	51±5	21±15	11±2
Dietary CP (%)[D]	12.3±0.7	8.8±0.8	11.5±1.6	12.0±0.7	9.7±1.6	6.6±0.3
Dietary digestibility (%)[D]	63±1.3	55±1.2	59±0.5	59±3.8	59±0.3	55±1.0
Live weight gain (kg/ha/yr total grazing area)	93±12.9	108±40.3	99±57.5	198±32.2	125±60.6	76±32.8

[A] The remainder of the area consisted of perennial grass-only and, in some cases, timbered areas and watercourses.

[B] Total grazing area includes both sown high quality forage and associated perennial grass areas present in the paddock. The stocking rate for annuals was expressed as the average over the grazing period. The stocking rate for perennials was the average over each 365-day period of monitoring.
AE (adult equivalent = 450 kg non-lactating animal calculated as live weight to the power of 0.75)

[C] This is an indication of the proportion of the diet that was sown C3 species (oats and the sown legume species), although any consumption of naturalised legumes and weeds in the grass component of the pasture would be included in this measurement.

[D] Values represent the average over the entire grazing period.

Table 6.4: Average forage growing costs and gross margins, calculated using both owner rates and contract rates, for six forage types grazed by cattle on commercial properties in the Fitzroy River catchment. Results are mean and variability. (Bowen et al. 2018)

	Annual forages			Perennial forages		
	Oats	Sorghum	Lablab	Leucaena -grass	Butterfly pea-grass	Perennial grass
Forage costs per sown area ($/ha/year)[A]						
Contract rates[C]	194 ±24	142 ±47	144 ±17	39 ±6	26 ±3	3 ±2
Owner rates[D]	136 ±14	96 ±32	99 ±14	34 ±5	21 ±0	2 ±1
Gross margin per total grazing area ($/ha/year)[B]						
Contract rates[C]	102 ±20	24 ±48	18 ±2.5	181 ±35	140 ±119	96 ±52
Owner rates[D]	131 ±17	54 ±49	44 ±6.0	184 ±36	143 ±118	98 ±52

[A] Forage costs were the costs of forage establishment and maintenance. For butterfly pea-grass and leucaena-grass pastures that have a productive life of more than one year, the establishment costs were amortised (expressed as an average annual cost over the expected life of the forage).

[B] Gross margins were calculated as the gross income received from the sale of cattle less the variable costs incurred, and were expressed after subtracting interest on livestock capital.

[C] Calculated using a contract rate to cost actual machinery operations used by the co-operator.

[D] Calculated as if plant and machinery are owned by the business.

What the best leucaena properties achieved

The gross margins of the properties with leucaena paddocks varied between $90 and $305/ha/year.

The best gross margin of $305/ha/year was associated with:

- High yield of leucaena which occurred on deepest soils with highest soil phosphorus, or where P fertiliser was applied. This in turn led to highest % leucaena in diet (61%) and high crude protein in diet (12.9%). The protein content of diet increased with percentage of leucaena in diet. Around 50% leucaena in diet delivered a dietary protein intake of 12% which was needed to maximise live weight gain.
- Greater number of grazing days on the leucaena-grass pastures (318 days) leading to higher average stocking rate over 365 days of 1.2 ha/AE.
- High yield of companion grasses leading to higher stocking rates.
- Good grazing management (rotation plus strategic cutting to maximise productivity) which resulted in achieving higher stocking rates and higher beef production per ha.
- The above factors contributed to achieving the highest animal performance (kg/ha/year).
- A cattle weight gain monitoring program allowing managers to optimise timing of sales.

In summary, profitability was strongly influenced by higher beef productivity (kg/ha/year), lower forage planting costs and better cattle price margins.

Note that while calculation of paddock gross margins is the first step, a more complex whole farm economic analysis is recommended.

6.3. Economics of irrigated leucaena

Widespread dryland plantings of leucaena have been shown to be a productive and profitable investment in central Queensland.

Uncertainty

Some landholders have access to irrigation water and are applying it to leucaena to improve establishment and production and to reduce the uncertainty of animal output.

There is some level of uncertainty in the profitability of irrigated leucaena because it is a relatively new but highly intensive production system – especially if using overhead irrigation.

The significant capital investment in overhead irrigation equipment must be considered in the economic analysis of pivot irrigating leucaena.

To be profitable the investment must be able to cover all costs and provide a return on the capital invested.

The value of irrigated leucaena as an investment is sensitive to:

- development and infrastructure costs
- operational costs (e.g. water allocation, pumping and application costs, other costs)
- productivity of the pasture (kg of beef/ha/yr) over the life of the pasture
- trading margins and value per kg of weight gain
- returns from alternative production systems that may be available for investment.

To accurately assess the economics of irrigated leucaena, it is important to have good data on:

- water requirements, availability, reliability and pricing
- development costs for pumps, furrow irrigation, ring tanks or spray systems
- pasture production during the year
- animal growth rates and stocking rates.

This data is being generated through the efforts and records of some innovative producers but is not yet good enough for any broader recommendations. All prospective irrigators need to critically assess their own circumstances.

6.4. Producer experience – central Queensland

Scott and Judy Smith, 'Glenlivet', Thangool, central Queensland

Scott and Judy Smith run more than a thousand head of cattle on their property 'Glenlivet' near Thangool. The 2,660ha property is made up of 1,850ha of forest country and 810ha of scrub country. In March 2001, they planted 40ha of leucaena at a cost of just over $210/ha and found that the leucaena greatly increased its carrying capacity. By 2019, they had 210ha of leucaena across Glenlivet.

Seedbed preparation and planting. Scott and Judy have changed their seed bed preparation from total cultivation to strip planting, preparing the strips with cattle still grazing the paddock.

Leucaena planted in strips ploughed in an existing pasture

The strips are 4m wide with the first pass being deep-ripped to a depth of 500mm, followed by cultivation with offset discs and a scarifier until a good seedbed is achieved. When rain is predicted, the cattle are removed while the soil profile fills. They apply Spinnaker® and Roundup® at planting, and have found it best to plant in February to April.

Their first planting was cv. Cunningham with a row spacing of 6m, but they now plant cv. Wondergraze at 7m.

Control of unwanted plants. Weeds and grasses (especially buffel and green panic) in the strips are controlled mechanically as they can rob moisture from the seedbed. After the leucaena germinates the strips are scuffled if weeds emerge, and the inter-row grass is disc ploughed to control vigorous growth until the leucaena reaches 1m in height.

Grazing management. Scott and Judy have 21 paddocks of leucaena each averaging 10ha and they stock at 1 beast to 1–1.5ha. After a 2–3 day graze, each paddock gets 40 days of rest during the growing season. During the non-growing session, they will increase the rest period and reduce cattle numbers, or destock the leucaena. This ensures recovery of the whole system. Cattle are initially purchased at around 230kg LW, and are grown out on the forest country, before being finished on the leucaena for 60–70 days, often grain assisted.

Height control. Even with the high stocking rate the leucaena can still become tall and this reduces the amount of grass between the rows. They now use a tractor-mounted mulcher to cut all paddocks every year in spring to about 150mm.

Slashing leucaena down to 150mm to encourage bushy growth.

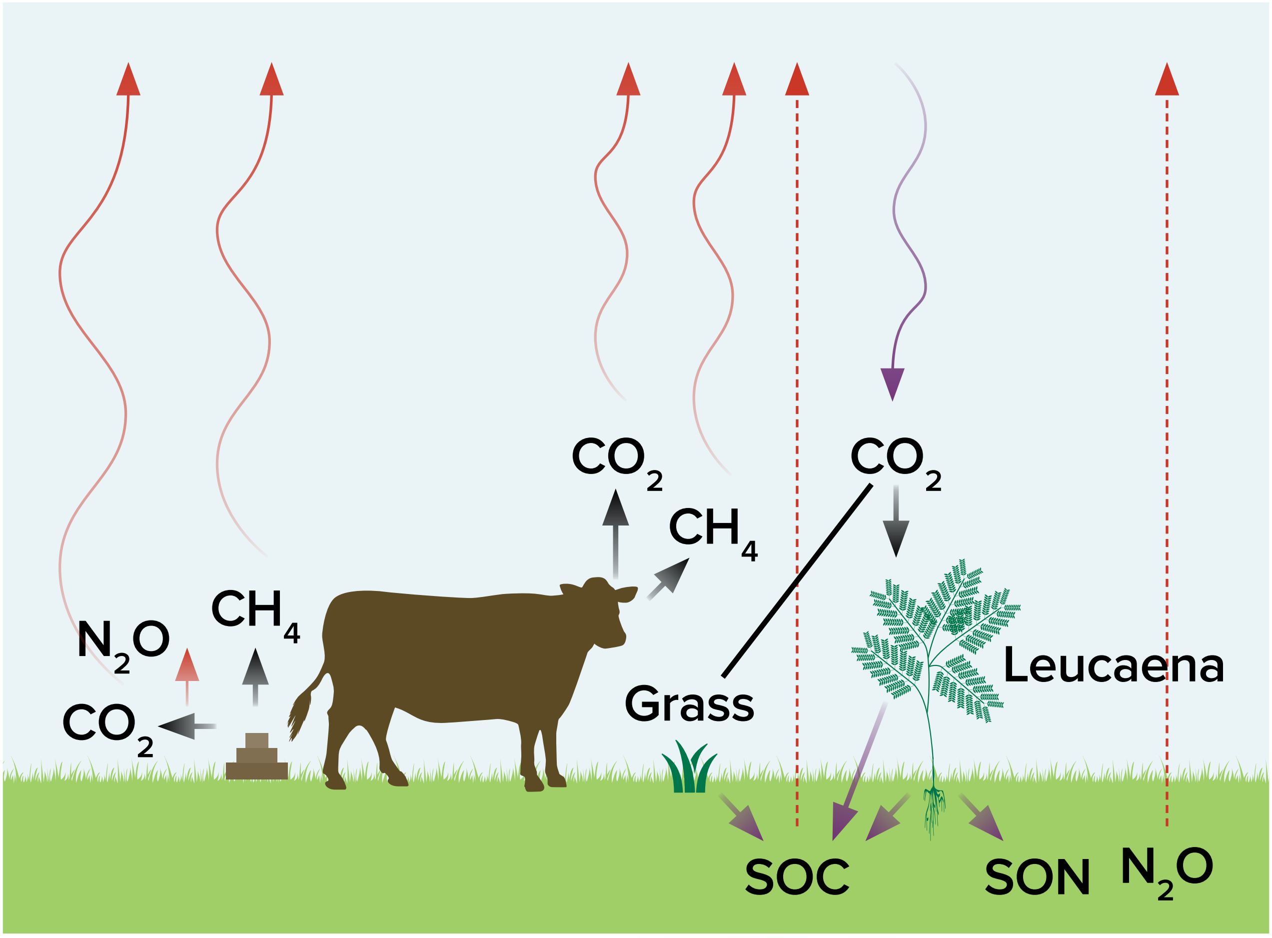
General comment. Good management for grazing and height control is paramount to achieve the maximum production from rain. They mulch any seedlings between the rows and then apply Grazon® and Ally® herbicides to the young regrowth. This practice gives very effective control.

The cost of establishment is currently approximately $380/ha; their payback period depends on rain but is generally two to three years.

The next level of management of the leucaena system is to improve soil health so that the leucaena system produces even higher quality feed and is even more sustainable into the future.

Leucaena and grass pasture at 'Glenlivet'

7. Leucaena and the grazing environment



Chapter 7. Leucaena and the grazing environment

7. Leucaena and the grazing environment

There are important environmental implications with planting and maintaining an improved grazing system based on leucaena. Such a long-term grazing system influences the physical, social and economic characteristics of the local environment, with both positive and negative impacts.

The environmental considerations associated with a perennial leucaena-grass pasture are:

Positive

Leucaena systems:

- are a long-term sustainable shrub-based pasture option
- are a significant drought mitigation strategy which can provide a bank of dry season biomass when managed appropriately
- improve ground cover which reduces the potential for runoff and erosion
- respond quickly following drought-breaking rainfall
- provide shade and shelter, and mitigate seasonal feed gaps, thereby improving animal welfare
- improve soil fertility through accretion of soil carbon and nitrogen
- improve pasture biodiversity, especially when combined with trees
- reduce methane emission intensities from beef production
- reduce dryland salinity and improve water quality
- can be managed proactively through adoption of The Leucaena Network Code of Practice

Negative

- There is an ongoing weed issue associated with non-cultivated leucaena.
- There is inconsistency between local and state government policy in the control of weed leucaena.

7.1 Sustainable production system, drought mitigation, animal welfare

Leucaena pastures are unique among animal production systems in the tropics and subtropics in that they offer graziers the opportunity to intensify production in a sustainable manner. Leucaena-grass pastures are persistent, productive and allow higher stocking rates than grass-only pastures when managed appropriately.

Beef production can be up to four times greater than from unimproved native pastures; this enables cattle to be moved off ecologically vulnerable native pastures and out of riparian zones.

This approach to grazing management prevents land degradation and contributes to conservation and biodiversity of dedicated sites whilst maintaining overall farm productivity and profitability.

The extensive root system of leucaena allows the plant to use water deeper in the soil profile and so produces high quality green leaf during dry periods in summer, autumn and early winter – or until frosted. Property owners using leucaena report improved and near consistent growth rates in animal production during dry times, with rapid leaf growth when rainfall breaks the drought.

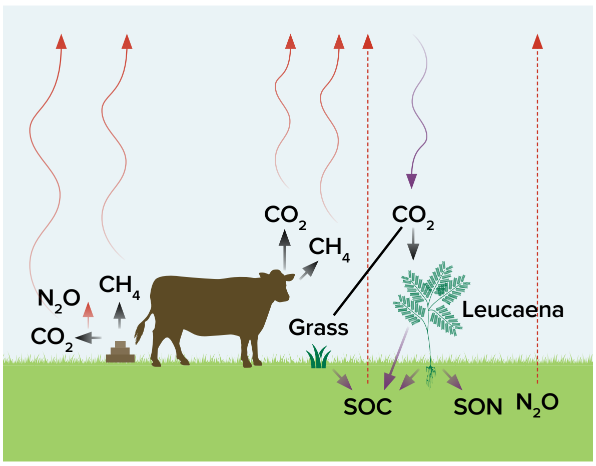
7.2 Greenhouse gases and soil carbon

As ruminants, cattle emit methane as part of the fermentation and digestion of a highly fibrous diet.

Direct livestock emissions account for around 10 per cent of Australia's greenhouse gas emissions (GHG). Ruminant livestock are responsible for approximately 65% of total emissions from the agriculture sector.

Methane and nitrous oxide are significant GHG with significantly greater global warming potential than carbon dioxide. Reducing enteric methane and nitrous oxide emissions from livestock will help reduce Australia's overall GHG emissions and mitigate future climate change.

Figure 7.1: Emissions and sequestration under a leucaena-grass grazing system



Adoption of a leucaena-based production systems by the Australian beef industry has multiple benefits. In addition to better productivity for livestock, leucaena contains secondary compounds that effectively lower enteric methane production by about 20% compared to a grass-only diet.

Measuring methane emitted from cattle fed leucaena-grass diets

These compounds include mimosine, flavanol glycosides and condensed tannins, and result in subtle, but significant, changes to the rumen microbial populations.

Generally the rumen microbiomes share similar bacterial taxa, but the diversity of methanogens in the rumen of cattle grazing leucaena is significantly different from those grazing grass-only pastures. Some bacterial populations decrease, while others increase in abundance, resulting in more microbial protein synthesis and a change in fermentation patterns. This change in fermentation to end-products such as propionate, butyrate and branched-chain fatty acids can be associated with the redirection of energy into animal productivity (growth) and an alternative hydrogen sink, redirecting available hydrogen away from methane production.

Growth rates of cattle grazing leucaena-rhodes grass pastures are substantially higher and enteric methane production commensurately lower than those of cattle grazing a rhodes grass-dominated tropical grass pasture, particularly when the leucaena is irrigated.

As a perennial legume, leucaena fixes nitrogen and increases the store of carbon in the soil. Leucaena has the potential to sequester about 780kg carbon/ha/year in the first five years of growth through accumulation in its woody stem and roots; a further 8–10t carbon/ha can be stored under leucaena-grass pastures in the top 15cm of soil. Compared with old cropping country, sequestration with leucaena pastures is much higher and equates to about 3.9t carbon/ha. This can be a valuable input to newly developed grazing systems where soil organic matter has been depleted by years of previous cultivation for cropping.

Where soils are low in phosphorus and sulphur, nitrogen fixation and carbon storage can be improved by applying fertilisers.

The Commonwealth Emissions Reduction Fund presents an emissions mitigation opportunity for leucaena growers. The fund will credit abatement resulting from innovations which reduce emissions intensity by adopting new practices on-farm.

Modelling of leucaena-based production systems can provide estimates of the impacts on farm profitability of improved live weight gain, increased soil carbon storage, methane emission reduction and higher urinary nitrogen concentration.

Soil sampling has shown significant increases in soil carbon in grazed leucaena-grass pastures

To compute GHG emissions on a whole-farm basis, herd numbers and age/class structures can be used in static GHG emissions calculators, such as the Beef-Greenhouse Accounting Framework.

7.3 Leucaena, soil fertility, dryland salinity, erosion and water quality

Much of the nitrogen fixed by leucaena is returned to the soil reversing the 'nitrogen rundown' that occurs in pure-grass swards. Soil carbon is enhanced by the decomposing woody branches and leaf and root litter from both leucaena and inter-row grass growth. Leucaena pastures can revitalise the fertility and structure of degraded soils; however, the period for establishment and grazing on these soils may need to be extended.

Leucaena hedgerows have a beneficial impact on the hydrology of catchments. Leucaena planted across the slope (along contours) with vigorous grass cover between rows encourages water infiltration, decreases run-off and so reduces sediment load in local waterways. In central Queensland, established leucaena pastures have reduced run-off, soil loss and sedimentation after high intensity rainfall.

Contoured hedgerows of leucaena have also reduced run-off and soil erosion in farming systems in Indonesia and the Philippines.

Contoured leucaena encourages water infiltration and decreases run-off.

Leucaena in catchments can mimic the water use of the original native woodland vegetation, thus preventing the development of dryland salinity by restricting deep drainage of excess rainfall. Whereas the roots of grass can extract water from the soil to a depth of 1.5–2m, leucaena roots can pull water from 3–5m, thus preventing rising water tables bringing salt to the soil surface.

Contoured leucaena on sloping land reduces erosion in Indonesia.

Most leucaena roots are in the same soil zone (0–150cm) as companion grasses; however leucaena's ability to extract water from below this zone provides superior drought tolerance. There is less risk of deep drainage under leucaena-grass pastures than under annual crops, such as sorghum or wheat, due to the perennial nature and deep root systems.

In central Queensland, leucaena in established leucaena-grass hedgerows has root systems similar to native tree root systems in terms of rooting depth and water use, and so can lower water tables to combat dryland salinity.

This has been observed on a beef cattle property where localised salinity broke out at the base of a slope after the 1974 wet season. The saline seepage disappeared within two years of leucaena being planted over 220ha of the recharge area in 1980.

7.4 Environmental benefits reported in other countries

Leucaena contributes to sustainable cattle production in Latin America under intensive silvopastoral systems. These combine high-density cultivation of leucaena (4,000–40,000 plants/ha) with grasses and timber trees. The layers of vegetation enhance habitat complexity and biodiversity.

Although the leucaena is managed to generate livestock products, significant leaf material deposited as litter on the soil has positive effects on soil properties and on biodiversity.

The silvopastoral system with leucaena supports more species of birds, ants, dung beetles and woody plants than conventional grass monocultures. It contributes to landscape-scale habitat connectivity and provides environmental services. Although these systems have been successfully implemented in Colombia, Mexico and other countries, they are currently adopted in a small area relative to the total available land suitable.

7.5 Leucaena – an environmental weed

While leucaena is recognised as a commercially valuable plant, it is also considered an environmental weed. Weedy leucaena can form dense thickets in previously disturbed areas and so reduce biodiversity, especially if it is not proactively managed or grazed.

Leucaena probably reached northern Australia via Papua New Guinea in the late 1800s, and it was reported that a weedy type of leucaena (*L. leucocephala* ssp. *leucocephala*) had become naturalised in coastal north Queensland by 1920. 'Common' leucaena is a weed of disturbed land in coastal Queensland, around the Gulf of Carpentaria and the Northern Territory. It grows on the banks of waterways, but cannot tolerate waterlogging.

The area of 'common' leucaena in northern Australia is relatively small despite it being present in northern landscapes for over 100 years.

While there has been some escape of leucaena from cattle properties since commercial plantings in the early 1980s, leucaena seed has also been deliberately spread to stabilise earth works along roads and approaches to bridges. It also spreads through the movement of seed pods in flowing water and in contaminated soil via machinery.

However, leucaena has not been an explosive weed compared to the millions of hectares of weeds such as prickly acacia, rubber vine or lantana.

Leucaena that has escaped from the paddock onto the roadside

The invasive nature of leucaena is due to its large seed production potential and relatively long-lived seed banks allowing it to spread initially between rows, and even outside planted paddocks into disturbed locations such as roadsides and riparian zones. These characteristics pose management challenges to landholders and relevant jurisdictions who acknowledge the value of commercial varieties but also the need to manage weedy types off farm.

Nevertheless, producers can employ various methods to control overgrown leucaena. The treatment of leucaena varies between local government agencies ranging from no action to formally recognising it as an environmental weed and applying requirements to minimise its impact.

7.6 The Leucaena Network and Code of Practice

The Leucaena Network has developed a voluntary 'Code of Practice for the Sustainable Use of Leucaena-based Pasture in Queensland' (see Appendix for details).

Aims of best management Code of Practice

- avoid planting leucaena near potential risk zones
- minimise seed set in grazed stands
- diminish the risk of seed dispersal
- control escaped plants from grazed stands.

The Leucaena Network Code of Practice recommends maintaining a vigorous grass in the inter-row. This aims to prevent seedlings establishing and thickening.

7.7 Government policy

Leucaena has been included in formal weed prioritisation and/or risk assessment processes in Australia to determine appropriate strategies to minimise its potential or current impacts.

While not declared a weed at a national or state/territory level in Australia, leucaena has been declared by several local government authorities in Queensland.

The weed status of leucaena in Queensland has been reviewed by the Department of Natural Resources and Mines in 2003 (see Further reading Appendix).

Control of weed leucaena

A voluntary **Code of Practice for best management of leucaena-based Pasture in Queensland** is promoted by The Leucaena Network. It aims to avoid planting leucaena near potential weed risk zones, minimise seed set in grazed stands, diminish the risk of live seed dispersal, and control escaped plants from grazed stands.

Other control options include:

- Selection of herbicides and development of a sterile leucaena variety.
- Control of excess height and seed production by grazing cattle and by periodic slashing.
- Insect predators such as the leucaena psyllid, a flower-eating caterpillar, and the seed-eating bruchid beetle but these are only partially effective.

Landholders and relevant jurisdictions in charge of invasive species need to work together to minimise its spread as a weed and manage existing infestations.

Relevant states and territories provide information such as fact sheets on the potential weed impacts of leucaena as well as options to control infestations. In Queensland, the Biosecurity Act 2014 legislates that everyone has a general biosecurity obligation to take reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control, including leucaena.

In Western Australia, leucaena has been classified as a high environmental weed risk for the Pilbara and Kimberley regions where it is not recommended for use on pastoral leases, but can be grown on freehold land (though this represents less than 2% of the area).

The recent investment in Australia by industry and government to develop sterile leucaena varieties is a positive and proactive initiative. Jurisdictions which currently ban or discourage the growing of leucaena may consider allowing the introduction of sterile varieties in certain situations. This would lead to an expansion of the leucaena industry not only in Australia, but also potentially in other countries where weed concerns are preventing it from being grown or promoted for commercial purposes.

7.8 Control of unwanted plants

Mechanical control

Dense stands of leucaena can be controlled using bulldozers with stick-rake or blade-plough attachments, or with forestry mulching machinery. However, ground disturbance is often followed by extensive seedling emergence.

Cutter bars that sever the root system below ground (at 30cm) will kill most plants but, if cut at ground level, most will re-shoot.

Some graziers blade plough between the hedgerows to control unwanted leucaena seedlings and to invigorate grass growth.

Herbicides

Effective herbicides for control of leucaena are currently under investigation. As with other woody weeds, highest mortality is achieved by controlling younger plants.

Application

Basal bark treatment is effective on larger plants. The stems are sprayed to a height of around 30–40cm from ground-level with herbicides mixed with diesel or oil-based products. Triclopyr/picloram (Access™) based product mixed with diesel is registered for both basal bark and cut stump applications on leucaena in Queensland.

Cutting plants at ground level and spraying the cut stem immediately afterwards is effective but expensive and impractical for large areas unless machinery such as a mulcher is used. The herbicide must be applied immediately after slashing.

Screening tests show that foliar applications of glyphosate, clopyralid and triclopyr/picloram-based products can kill leucaena but with variable results especially with larger plants. However, there are no current label registrations for any herbicides to be applied using foliar application in Australia. Permits have been approved for control of leucaena seedlings on mine rehabilitation sites using a foliar application of triclopyr/picloram (150/50g a.i./100L water).

In Australia, collaborative research between industry, producers, government and Dow AgroSciences (now DowDuPont) provide some promising results:

- Basal bark techniques (both the traditional and newer thin-line method which involves spraying a more concentrated mix to the bottom 5cm of stem) using triclopyr/picloram (Access™) consistently gave the best results.
- Cut stump applications of aminopyralid/metsulfuron-methyl (Stinger™) mixed with water and an aminopyralid/picloram gel (Vigilant™ II) provided greater than 80 and 60% efficacy, respectively.
- Ground applications of picloram granules (Tordon™ Granules) also show promise, with limited impact on surrounding grasses and legumes.

- Ineffective treatments included cut stump applications using glyphosate (Glyphosate 360®) and metsulfuron-methyl (Brush-Off®), gas gun applications using metsulfuron-methyl (Brush-Off®) and aminopyralid/metsulfuron-methyl (Stinger™) and ground applications of tebuthiuron (Graslan®) and hexazinone (Velpar® L).

Fire is not a control option for leucaena and often results in large-scale seedling regrowth unless combined with follow-up control.

Biological control

A seed-consuming bruchid beetle (*Acanthoscelides macrophthalmus*) has become established in many countries including Australia but its effectiveness is variable.

The sap-sucking psyllid (*Heteropsylla cubana*), accidentally introduced into many countries, has negative impacts on the productivity of leucaena, but has not reduced its weediness.

Grazing management plays an important role. As leucaena seedlings are not competitive, maintaining a strong grass pasture within the leucaena paddock and in surrounding buffer areas will greatly reduce spread into new areas.

Use of time-controlled grazing (short-duration high-density grazing) is effective for controlling height and reducing the amount of seed that can be dispersed. Periodic slashing of tall leucaena in paddocks will also reduce seed production.

In countries such as Indonesia and Thailand, intensive harvesting of naturalised (weed) leucaena for fuelwood and fodder has minimising the impacts and spread of leucaena.

Control of isolated or small patches of weed leucaena before they get the opportunity to spread and establish large and persistent seed banks is the best preventative strategy.

Mulcher used to control leucaena plant height and hence reduce seed production

7.9 Weed status in some other countries

While the native distribution of leucaena is mainly restricted to Mexico and Central America, a combination of deliberate and non-deliberate dispersal has led to it becoming a widely naturalised species around the world.

Leucaena is a widespread weed in all tropical Pacific islands, and indeed can be found in more than 125 countries.

Hawaii

Leucaena was introduced to Hawaii after European settlement and was spread widely through use for fuelwood and cattle fodder.

It has become naturalised and has spread into previously disturbed and drier habitats. Although it is much less common in intact native dry forests, its resilience to wild fires and grazing could threaten the integrity of remnant native dryland forest.

The succession in areas dominated by leucaena has not been well-studied but non-native, rather than native species, are more likely to replace it.

Because of its widespread distribution, especially on steep slopes, leucaena is a low priority for eradication or control.

Leucaena is widespread on steep slopes in Hawaii.

Eastern Indonesia

Leucaena has been present in Eastern Indonesia for well over seventy years and is regarded by communities as a highly beneficial plant with a multitude of uses.

These include livestock forage, firewood, building timber, as a vegetable for human consumption and has several medicinal uses.

While leucaena has a moderate risk of becoming weedy under an Australian weed risk assessment, local communities and authorities regard it as a resource and an economically valuable plant rather than as a pest.

They report that wider adoption of leucaena by local communities would discourage timber and forage cutting in conservation areas and reduce the pressure on existing forest resources.

Leucaena being harvested for cattle fattening in Eastern Indonesia

In Eastern Indonesia, where leucaena is regularly cut and harvested, it is unlikely to become weedy. Even in disturbed areas it is harvested regularly by locals and new seedlings are grazed by wandering livestock.

7.10 Soil acidification

Rates and sources of soil acidification under temperate legume pastures in southern Australia are well documented, but less is known about the soil acidification potential of tropical legume pastures.

Acidification occurs under pastures usually occurs as a result of:

- the accumulation and cycling of organic matter in the topsoil (0–15cm) and the release of carbonic and carboxylic acids
- legume roots extracting calcium, magnesium and potassium from lower in the soil profile for use in biological nitrogen fixation and excreting hydrogen into the rhizosphere
- the removal from the paddock of soil nutrients in livestock product or manure/urine
- leaching of excess nitrogen in nitrate or ammonia from the soil profile.

The high rates of nitrogen fixation and longevity of leucaena pastures have led to speculation that soil acidification could occur.

However, soil type (and buffering capacity) and environment also have a significant influence. Most acidification in the tropics occurs on light textured soil with neutral to slightly acid pH and in monsoon environments with relatively low grass production. These conditions are basically the opposite to those under which leucaena is planted in Australia – medium-heavy textured soils, neutral to alkaline soils with high buffering capacity, moderate rainfall and good grass growth.

Globally, leucaena is often found in high pH calcareous limestone-derived soils where acidification would not be a problem.

Little change in pH after nearly 40 years

The pH of a soil has not changed under a leucaena-green panic pasture grazed for more than 37 years.

Specifications at this site:

- Gayndah, subtropics, 730mm annual rainfall
- calcareous basaltic Vertosol soil with 60% clay content
- pH 1:5 soil:water 7–9.5
- CEC 65 meq/100g soil.

As this calcareous clay soil is similar to the alkaline, highly buffered cracking clay soils in which most leucaena is planted in Queensland, soil acidification is not likely to threaten the long-term sustainability of leucaena pastures.

However, leucaena established on lighter, poorly buffered soils of lower initial pH, particularly in high rainfall areas or under irrigation, may require applications of lime to prevent soil acidification suppressing leucaena growth and damaging soil chemical properties.

Globally, leucaena is often found in high pH calcareous limestone-derived soils where acidification will not be a problem.

8. Leucaena use in other countries

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Leucaena is widely used in many tropical countries for forage for feeding ruminants and for other purposes. Even though their livestock feeding systems and scale of operation may be different from Australia, there is still much to be learned from their accumulated experience.

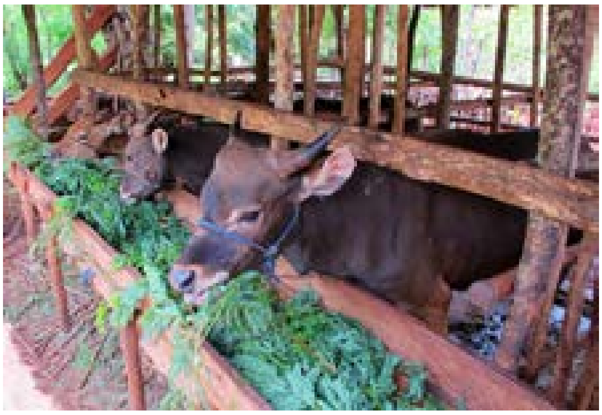
8.1 Regional use of leucaena

Indonesia

Leucaena or 'lamtoro' has been well known for decades in Eastern Indonesia. On Sumbawa Island, and in the Amarasi District of Timor, smallholder farmers profitably fattening Bali bulls with leucaena.

Smallholder farmer in Sumba, Indonesia transporting leucaena cut for cattle feeding

The animals are tethered in pens, and fed high leucaena diets (often 100% leucaena) using 'cut and carry' leucaena from nearby plantings of 0.5–5ha and for feeding 2–20 head).



Fattening Bali bulls on 100% leucaena diets in Timor, Indonesia

Farmers say that their cattle initially show mimosine toxicity symptoms such as salivation and hair loss, but they quickly recover in one or two weeks without inoculation with *Synergistes jonesii.*

Subsequent weight gains are near the genetic maximum for this breed of cattle. With support from the Australian Centre for International Agricultural Research, cattle fattening with leucaena has been strongly promoted. Greatly increased animal growth rates, carcase dressing percentage and meat quality are having a significant positive impact on household incomes and on regional economic growth.

Thailand

In Thailand, leucaena is widely available and is fed to meat and milk goats, and to dairy cattle. It is collected from naturalised stands on roadsides and fed fresh, as partially fermented silage or as dried leaf meal.

Transporting roadside leucaena for feeding goats in northeast Thailand

Feeding leucaena lowers mortality of young animals and increases the productivity of mature animals.

Goat rearing for meat and milk has long been practiced in Thailand, mostly associated with the Thai Muslim community. Leucaena has gained wide acceptance among goat farmers as a suitable basal feed and is often supplemented with combinations of other feeds which vary between farms and season, for example pelleted concentrate feed and/or napier grass or corn silage and pineapple waste.

Feeding goats 100% leucaena diets in Northeast Thailand

There are no reports of mimosine toxicity symptoms. The main constraint that goat farmers face is seasonal shortages in leucaena forage due to slow growth during the dry season.

India

The semi-arid climate and intense pressure on limited land resources have increased the importance of tree and shrub fodders for ruminants compared with traditional grasses or grass-legume pastures. Although the woody type of leucaena is a relatively new introduction to India, it has been promoted to meet the needs of rural communities for fuel wood, small timber and forage.

India is one of the major world producers and consumers of paper and pulp products (3–4% of global share).

Growing and transporting leucaena timber for paper pulp in India

The farm forestry plantation program initiated by JK Paper Ltd, Unit CPM (Central Pulp Mills) has engaged some 7,800 farmers who have established leucaena plantations covering an area of 18,400ha in parts of Gujarat, Maharashtra and Madhya Pradesh states. JK Paper Ltd is undertaking a leucaena genetic improvement program to increase biomass and pulp yields.

Latin America

Over the past 10–15 years, establishment and management of leucaena feeding systems in Latin America have varied between countries. In Paraguay and Argentina, broadacre leucaena is direct seeded in single or double hedgerows with improved grass inter-row alleys 6–8m wide, following Australian practices and is used for beef production.

Beef cattle on leucaena in Argentina

In Mexico, leucaena is also cultivated with *Tithonia diversifolia* (Mexican sunflower), a leafy forage shrub that can reach a height of two to three metres and is rich in protein suitable for ruminants and rabbits.

Beef from leucaena in Mexico

In countries such as Cuba, leucaena has been established as protein banks using single/twin rows with inter-row spacing of 2–4 m for direct grazing by beef, dairy or dual-purpose cattle. Paddock sizes for protein banks and Intensive silvopastoral system (ISS) range between 0.3 and 50ha; broadacre hedgerow pasture systems are generally established over larger areas (20–500ha).

The ISS models are widely promoted in tropical regions of Colombia, Mexico, Cuba, Venezuela and North-east Brazil with a strong emphasis on the contribution to the environment: carbon


Dairy cattle in an intensive silvopastoral system

sequestration, reduced methane emissions, improved animal welfare, atmospheric nitrogen fixation and transfer, trees for timber and landscape improvement.

In ISS, leucaena is planted at high density (10,000 trees/ha), in combination with improved tropical grass and high-value timber tree species (at 200–400 trees/ha), and intensively managed employing rotational grazing.

Despite the significant benefits demonstrated by scientists and innovative farmers, the adoption of leucaena feeding systems remains low across Latin America.


High-density leucaena in ISS in Colombia

The Leucaena Network

Promoting the responsible development of leucaena in sustainable and productive grazing and agroforestry systems to build stronger rural communities.

Introduction

The Leucaena Network was formed in July 2000 by a group of producers and industry representatives who wished to progress the beef industry with the adoption of a perennial legume and address environmental concerns associated with leucaena at the time.

The organisation's aim is to "promote the responsible development of leucaena in productive and sustainable ecosystems to build stronger rural communities".

In 2000, the Network developed The Leucaena Code of Practice to promote responsible management of the legume in response to the environmental concerns.

Today, The Leucaena Network is a leading producer group in the grass-fed beef industry across nothern Australia. Members include livestock producers, leucaena and pasture seed growers, industry representatives, researchers and extension personnel. The Network remains true to its message, continuing to focus on the responsible management of the legume while working to promote the industry and provide current and relevant information and research to its members.

The release of the psyllid-tolerant leucaena variety Redlands has presented producers across Northern Australia with the opportunity to benefit from the increased productivity provided by leucaena.

To this end, the Network is working closely with government, industry representatives, Meat & Livestock Australia (MLA) and producers to ensure the Leucaena Code of Practice addresses the current needs of the grazing industry.

A specific Northern Territory Leucaena Code of Practice has been developed, in conjunction with the Northern Territory Government, the Pastoral Lands Board, industry representative bodies and producers.

The current Code of Practice for your State or Territory may be accessed from leucaena.net or from the Network's Executive Officer at admin@leucaena.net.

The Network encourages membership to foster ongoing activities and research to assist the industry to prosper.

The Network continues to address the ongoing high demand for the provision of quality information and strategies for successful leucaena establishment for new producers and strives to provide established producers with research and extension information.

The Leucaena Network's information provision is its website, www.leucaena.net. Current information on Network activities and member information may also be accessed through the Network's Facebook site.

Research projects

The Leucaena Network has partnered with MLA to undertake several research and adoption projects. These include the MLA Donor Company (MDC) and MLA Producer Innovation Fast Track (PIFT) 'Redlands for Regions' establishment trials of the new psyllid-tolerant leucaena variety in north Queensland; and a Producer Demonstration Site (PDS) trial in the Wandoan, Central Queensland district to assess the impact of fertiliser on established leucaena and grass pastures. The Queensland Department of Agriculture and Fisheries (DAF) provided the extension for these activities.

The Network facilitates an MLA funded PDS project in collaboration with the Northern Territory Department of Primary Industries and Resources (DPIR), to determine the most suitable leucaena variety and row spacing for the Douglas Daly region in the Northern Territory.

The Network continues to seek and assess improved strategies for the establishment, maintenance and management of leucaena as well as investigating potential value-adding activities for leucaena producers.

The Leucaena Code of Practice

Purpose of the Code

The Code aims to promote the responsible, sustainable and productive development of leucaena-grass pastures. The Code should be adopted by all producers and natural resource management agencies.

The Standard Leucaena Code of Practice

The key message of The Leucaena Code of Practice for producers is to plant leucaena ONLY if you intend to manage it and are prepared to accept responsibility to control leucaena that establishes outside the planted area on your property, including watercourses. Producers are advised that this can be achieved by adopting the following practices:

- Do not plant leucaena in areas where rivers, creeks and flood channels can disperse seed pods or seed. If leucaena becomes a restricted or regulated plant under future government legislation, growers must comply with the relevant requirements.
- Keep leucaena at least 20m away from external fence lines.
- Maintain a buffer strip of strong grass pasture between leucaena plantings and creeks or boundary fences.
- Fully fence leucaena paddocks to avoid the unlikely risk of stock spreading ripe seed.
- Graze or cut leucaena to keep it within the reach of animals and to minimise seed set.
- Chemically manage leucaena escapees with Access® (currently the only registered herbicide for controlling unwanted leucaena).
- Establish and manage vigorous grass in the inter-rows to:
  - provide competition to minimise establishment of volunteer leucaena seedlings
  - minimise the risk of seed being transported during heavy rain
  - productively utilise the fixed nitrogen that the system produces
  - maintain ground cover and prevent soil erosion.
- Maintain the practice of:
  - regularly monitoring creeks and major watercourses to detect any escaped leucaena seedlings and plants
  - controlling all plants detected adjacent to property boundaries on creek banks and other adjoining areas where cattle do not normally have access, and on public roadsides (after first obtaining a permit from Main Roads Department or Shire Council).
- Comply with local laws (weed declarations, etc.) and assist Local Government agencies to identify any escaped leucaena so that action can be taken to control it.
- Promote the responsible management of leucaena in accordance with this Code.
- Keep abreast of best-practice developments in the management of leucaena.

For further information regarding the Leucaena Code of Practice, please contact:

The Executive Officer – The Leucaena Network

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leucaena.net

Further reading

Two Special Issues of Tropical Grasslands-Forrajes Tropicales were published under an agreement with the Organizing Committee of the International Leucaena Conference (ILC2918) held at The University of Queensland, Brisbane, Australia, 1–3 November 2018.

International Leucaena Conference

Anon. 2019. SPECIAL ISSUE I. International Leucaena Conference 1–3 November 2018, Brisbane, Queensland, Australia. *Tropical Grasslands – Forrajes Tropicales*, Volume 7, No. 2 February – May 2019.

SPECIAL ISSUE I contains the 24 papers presented during Sessions 1–4 of the Conference, pp 56–213.

Session 1: Germplasm resources of leucaena, pp 56–103
Session 2: Establishment and management of leucaena, pp 104–145.
Session 3: Feeding and management for animal production, pp 145–192.
Session 4: Alternative uses of leucaena, pp 193–213.

Anon. 2019. SPECIAL ISSUE II. International Leucaena Conference 1–3 November 2018, Brisbane, Queensland, Australia. *Tropical Grasslands – Forrajes Tropicales*, Volume 7, No. 4 July – September 2019.

SPECIAL ISSUE II contains the 36 papers presented during Sessions 5–8 of the Conference, pp 359–478.

Session 5: Leucaena and the environment, pp 259–302.
Session 6: Leucaena systems in Australia, pp 303–352.
Session 7: Leucaena systems in tropical America, pp 353–409.
Session 8: Leucaena systems across Asia, pp 410–468.

An overview of the papers presented at the Conference by researchers, extension consultants and graziers is given in:

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Max Shelton and Scott Dalzell (co-authors of this publication) discuss leucaena production with Alex and Geoff Liddle in central Queensland.