2. Establishing leucaena

Chapter 2 Establishing leucaena

2 Establishing leucaena	3
2.1 Where does it grow best?	3
2.2 Paddock selection and planning	4
2.3 Which cultivar?	4
2.4 Seed treatment	7
2.5 Land preparation	9
2.6 Planting	12
2.7 Soil insect control	13
2.8 Weed control	13
2.9 Companion grasses	15
2.10 Early grazing management	17

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.

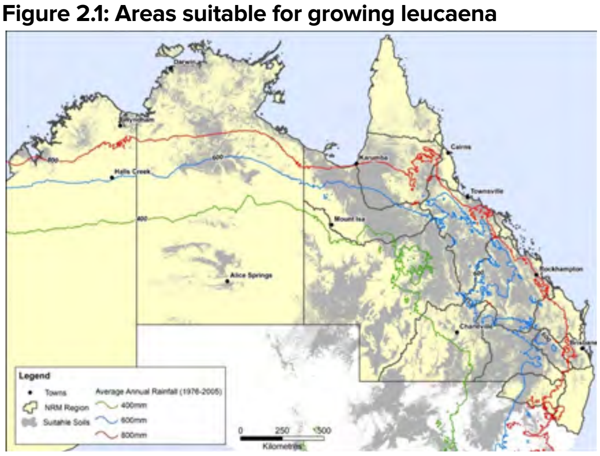
2.1 Where does it grow best?

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-resistant *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

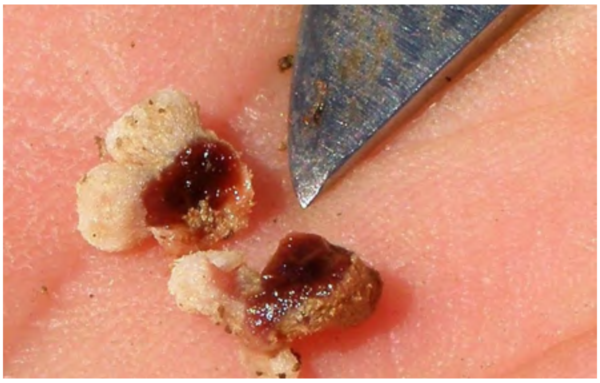
Most legumes form a symbiotic (mutually beneficial) relationship with soil *Rhizobium* bacteria – the plant provides the bacteria with energy and the bacteria fix atmospheric nitrogen (N) which the plant uses for protein production. These bacteria infect roots through the root hairs and form small root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

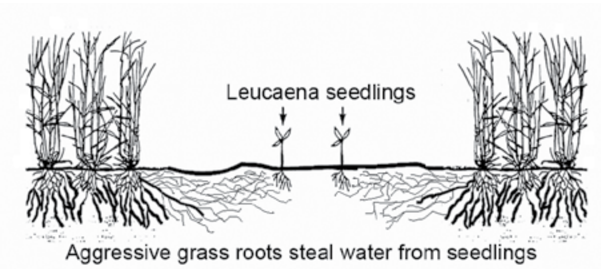
Northern Queensland

- 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.

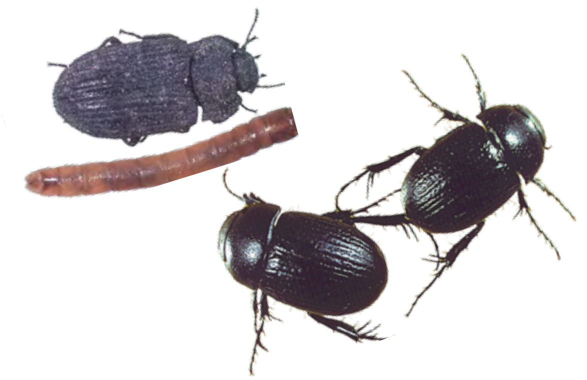
'Starter' fertiliser

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.