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Tropical pastures for livestock production in NSW

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Citation: Boschma SP, Murphy SR, Harris CA, Freebairn RD, Baker SJ (2026) *Tropical pastures for livestock production in NSW*. (Meat & Livestock Australia, Sydney)

Acknowledgements

The research and extension described in this publication have been conducted as part of multiple projects funded by various organisations, including Meat & Livestock Australia and the NSW Department of Primary Industries and Regional Development.

Many staff members have contributed to the research and development summarised in this book, as well as the extension efforts that have led to the widespread adoption of tropical grasses across NSW. Producers who hosted experiments, demonstration areas, and field days have contributed to local knowledge. District agronomists and cooperating producers have established and managed grass evaluation trials. Seed companies have often provided seed for evaluation or inclusion in experiments.

The authors acknowledge the contributions made to previous versions of the tropical grass establishment and management manual, including Lester McCormick, Greg Lodge, Bob McGufficke (deceased), Michael Lollback, Alastair Rayner, Mark Brennan, Neil Griffiths, Fiona Scott, Phillip Graham, Geoff Casburn, and Todd Andrews. This manual draws on material published in Harris et al. (2014) *Tropical Perennial Grasses for Northern Inland New South Wales* – Second Edition (Future Farm Industries Cooperative Research Centre: Perth). We thank Lester McCormick and Peter Watt, who provided constructive reviews of the current version.

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MLA acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Contents

Introduction

The potential of tropical perennial grasses (hereafter referred to as tropical grasses) for livestock production in northern inland NSW was first recognised in the 1950s. Although early research recommended their use, adoption was low due to limited seed availability and the higher profitability of cropping enterprises at the time.

Research during the 1970s–1990s addressed issues associated with establishment on heavy soils and evaluated species/cultivars, however, it was not until the 2000s that there was widespread interest and adoption of these grasses in northern inland NSW. This period was characterised by highly variable seasons and extended dry periods, often with dry autumns and springs. Under these conditions tropical grass pastures proved to be more resilient than temperate perennial grass pastures and more productive than native pastures. It has been estimated that around 1 million hectares of tropical grasses have been sown in NSW.

The variable climatic conditions have also led to feedbase challenges for producers in central and southern NSW. Over the last 25 years, producers in some areas have observed increased summer rainfall and are seeking alternative forage options that can better utilise this rainfall, which traditional temperate, winter-growing pastures cannot do. Some producers have successfully trialled tropical grasses and are now growing commercial areas in central and southern NSW. These producers are pleased with their persistence and productivity, and interest is increasing.

Figure 1: Weaner cattle grazing digit grass (Photo: R Freebairn)

This manual outlines the benefits, establishment and management of tropical grasses in NSW. This information is drawn from various sources, including the experience of the authors via field experiments and working alongside producers. However, it is primarily based on research and extension conducted by the NSW Department of Primary Industries and Regional Development (NSW DPIRD). Tropical grass pastures can increase the productivity, persistence and resilience of the feedbase for grazing enterprises. Successful establishment will ensure a strong start to pasture production, while effective management maximises pasture quality and animal productivity (**Figure 1**). Therefore, the manual is divided into four sections:

1. The characteristics of tropical pastures and their benefits to NSW grazing systems
2. Steps to successful establishment
3. Companion legumes
4. Managing tropical pastures for production and persistence.

What is a tropical grass?

Tropical grasses are also referred to as C4 or warm season grasses and in NSW, the species commonly sown can also be called subtropical grasses. Fundamentally, the difference between temperate and tropical grasses is – at a cellular level – in the way they capture carbon dioxide during photosynthesis. Temperate or C3 grasses have a photosynthetic pathway which results in three-carbon molecules. In contrast, C4 grasses produce four-carbon molecules.

In practical terms, tropical grasses are adapted to warm environments and grow during the warmer months of the year. They are well-adapted to high temperatures, and some species have a high tolerance for drought conditions and even flooding. Tropical grasses typically have rapid growth rates when conditions are favourable and deep root systems that help them access water during dry periods. Many tropical grass species have higher water and nitrogen use efficiencies than temperate grasses.

The changing role of tropical perennial grasses in inland NSW

Tropical grasses took longer to gain recognition in NSW than temperate pasture species such as phalaris, lucerne, and annual legumes. For much of the 20th century, NSW Agriculture/ Department of Primary Industries (herein referred to as the Department), CSIRO and university research institutions focused on temperate species, viewing tropical grasses as less suitable for most NSW areas outside the coastal zone. These early assumptions contributed to their delayed evaluation and adoption in inland regions.

1950s–1960s: Early interest and limited evaluation

Initial evaluation of tropical grasses occurred in northern inland NSW in the 1950s. District agronomists Eric Darling and Vic Gidley, at Moree and Inverell, respectively, experimented with species such as purple pigeon grass. This early trial work, conducted with support from the Department and the NSW Soil Conservation Service, demonstrated the potential for tropical grasses in specific environments. The lack of coordinated research, extension, or promotion of tropical grass limited adoption.

1970s: Search for a suitable summer grass companion for winter annual legumes

Research in the Central West—particularly around Coonabarabran and Binnaway—highlighted serradella's potential as a winter-growing legume suited to light, acidic soils. This work expanded into other districts, including Dubbo, Mudgee and Narrabri. While serradella provided a valuable option for winter feed, it also created a clear seasonal gap in production. Researchers and advisors sought complementary summer-growing grasses to extend the productive grazing period into early autumn.

1980s: Breakthrough with Consol lovegrass

The introduction and evaluation of Consol lovegrass in the 1980s marked a turning point for tropical grass use in NSW. Selected for its persistence on acidic, low-fertility soils, Consol was also palatable and did not outcross with less desirable African lovegrass types. Consol was assessed in the Department and NSW Soil Conservation Service trials, particularly in the Temora and later in the Binnaway district. When sown into paddocks, which had previously been improved with serradella and superphosphate, Consol proved both productive and persistent. Its success helped establish the role of tropical grasses in light, hostile soils across inland NSW. Demonstration trials and on-farm validation in partnership with local producers helped drive adoption. Producers in the Binnaway area began seed production, and annual field days attracted strong interest from the wider region. These events, supported by the Department and local agribusinesses, helped build momentum for the broader use of tropical grasses in pasture systems.

Late 1980s–1990s: Expansion of evaluation – New tropical species

Building on the success of Consol, and a revisit of the 1960s trials near Inverell where Premier digit grass was persisting well, agronomists with the Department sowed trial kits to evaluate a range of tropical grass species across the northern half of NSW in the late 1980s. These kits included species such as digit grass and Bambatsi panic. Field trials across various environments demonstrated the persistence and productivity of these species. Digit grass performed well, especially on highly acidic soils with elevated aluminium levels. This confirmed its value as a second acid-tolerant tropical grass. Field days, on-farm demonstrations, and collaborative research reinforced the value of these species and expanded their use across NSW.

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2000s–Present: Broadscale research, new cultivars and statewide adoption

Over the last 26 years, tropical grass research expanded substantially, led by Department research teams based at Tamworth and Glen Innes. This work was largely supported by Meat & Livestock Australia, plus several other organisations through various programs. Pasture evaluation programs confirmed the long-term persistence and high productivity of species such as Premier digit grass and Bambatsi panic across a wide range of environments. This work also contributed to the improved understanding of establishment, management, and legume integration. These evaluation programs developed new cultivars of panic grass, offering producers additional options for summer feed. Across NSW, many experiments and trials have been established in diverse environments from north to south and east to west, showcasing the adaptability of tropical grasses to NSW's variable climate and soils.

Today, tropical grasses are integral to many pasture systems in NSW. Their adoption reflects decades of research, field trials, and producer-driven innovation. Importantly, tropical grasses now play a role in productivity and building climate resilience, enhancing groundcover, and supporting sustainable livestock production across a wide range of NSW environments.

The role of producers and collaboration in adoption

Research alone has not driven the adoption of tropical grasses in NSW. The authors acknowledge the many producers, producer networks and innovative farming families who have supported the research and extension of tropical grasses over the decades, for example, the Avendano family of Boggabri, who since the 1980s have collaborated with the Department hosting trial sites, seed production and field days to demonstrate the persistence and value of tropical grasses.

Characteristics of tropical pastures and their benefits to NSW grazing systems

Why grow tropical grass pastures?

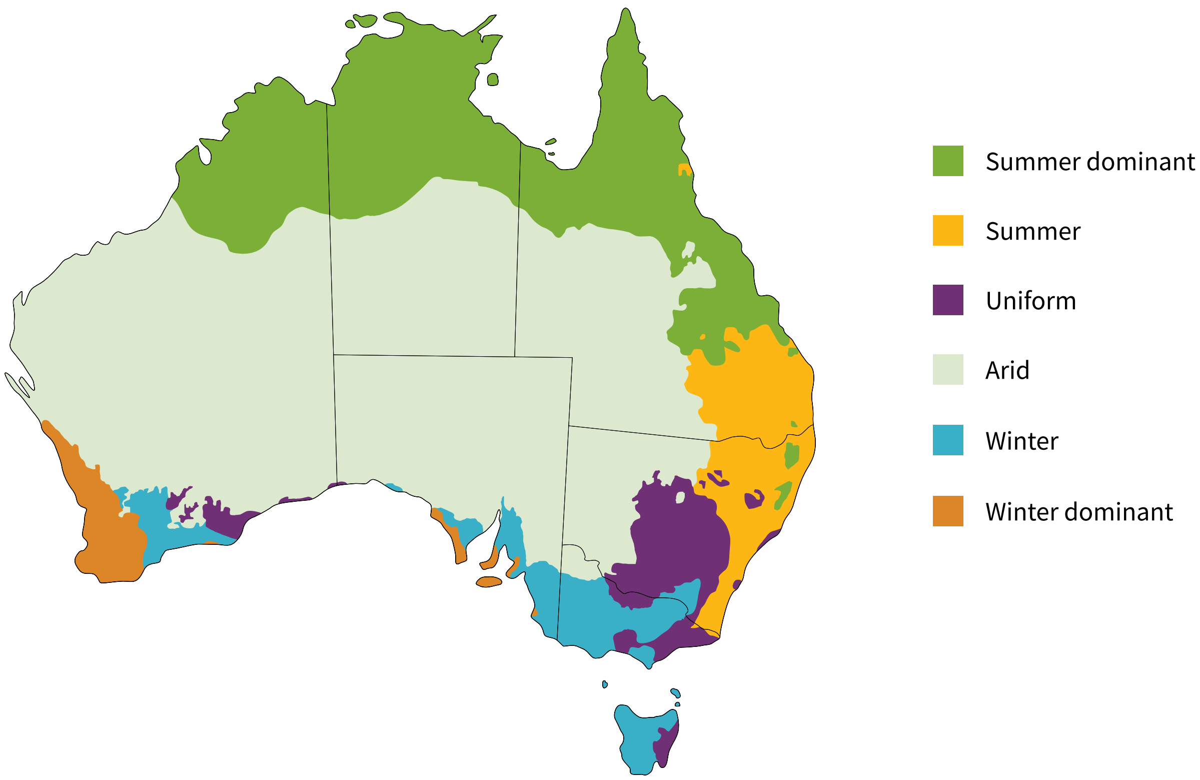
Tropical grass pastures grow during the warmest months of the year in NSW. Growth commences in spring as day temperatures rise, it slows in autumn as overnight temperatures fall and ceases with the onset of frosts. Little to no growth occurs during the winter. Across NSW, tropical grasses can be productive for about 10 months of the year on the North Coast, 8–9 months on the North and Central West Plains, and up to eight months on the Slopes. Even in higher altitude, cooler environments, their growth period can be at least 5–6 months.

Most areas of NSW receive a good portion of their average annual rainfall over the summer months, with a large area classified as having either a summer or uniform rainfall distribution (Figure 2). This summer rainfall has traditionally been considered 'out of season' from a temperate pasture or winter cropping perspective. Tropical pastures provide an opportunity to capture and utilise this rainfall to maximise year-round feed production at the whole farm level. Climate data also show that the proportion of annual rainfall falling in summer has increased, and this trend is projected to continue. This reinforces tropical pastures as a sound investment for developing a feedbase into the future.

Tropical pastures add to the profitability of grazing enterprises

Tropical perennial grasses offer a long-term pasture option for NSW grazing systems where they are increasingly being profitably grown. Incorporating them as a part of the feedbase, adds to enterprise profitability. The following case study is an example of the profitability that can be achieved by growing tropical grasses with temperate legumes.

Figure 2: Major seasonal rainfall zones in Australia, 1991–2000 (Source: Bureau of Meteorology)



CASE STUDY

Steer fattening enterprise in Central West NSW

Steers gazing a tropical grass pasture, under sown with temperate annual legumes (Photo: R Freebairn)

Observations

- The owner considers pasture establishment to be a capital cost as the pasture can remain productive for many decades with good management.
- Fertiliser application is budgeted to occur annually, but once phosphorus and sulphur levels have reached recommended levels the application frequency can be reduced. Regular soil testing should inform ongoing application rates and frequency.
- Winter forage crops are sown on 20% of farm and used to reduce the weed burden before sowing tropical grass pasture.
- Winter forage crops can gross over $2,042/ha (150 days grazing x 1.1kg/head/day x 2.5 head/ha x $4.95/kg).
- Dry-lick and home-produced hay are fed to steers in dry spells. No additional supplementary feeding is conducted. Drought strategy is to reduce stock numbers if feed budgeting indicates and rebuild numbers quickly after rainfall.

A 285ha property in Central West NSW (625mm average annual rainfall) has successfully fattened steers with tropical grasses since 2010. Soils on the property range from loam to sandy. Most are acidic, both in the surface (0–10cm) and subsoil (10–30cm), with a sodic clay deep subsoil (30–100cm depth). These soil types are considered lower-value because they restrict high-yielding crop and pasture production.

The property in a past era, before it was improved with fertiliser and improved species such as winter legumes and tropical grasses, had a stocking rate of 2 DSE/ha. Since 2010, the property has been transformed and now comprises 50% tropical grass with temperate annual legumes, 20% winter forage crops, and 30% native grasses. Today all paddocks have had soil phosphorus and sulphur deficiencies corrected via fertiliser.

With these changes the stocking rate has increased to 8 DSE/ha.

For simplicity, the owners run a steer fattening enterprise. Steers are purchased at around 250kg/head and sold at around 470–500kg/head to markets, including supermarkets, feedlots, sale yards and abattoirs. An average of 220 steers are turned off each year.

The gross margin of this enterprise, over 15 financial years (2010–2025), ranged from $250/ha in a drought year to around $350/ha in average years. These gross margins included all variable costs such as pasture fertiliser, animal health and fodder crop costs, as well as livestock marketing, transport and related fees. A summary of the gross margin for the 2024–25 financial year is shown in Table 1.

This example is not based on the most profitable enterprise choice, however, it shows what can be achieved on 'low value' country, with a sound pasture improvement

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program which incorporates tropical grasses. The winter forage crop phase supplies winter feed for livestock, and it has an integral role cleaning up winter weeds (in-crop) and summer weeds (fallow period) in preparation for sowing tropical grass pastures. The estimated gross margin for this enterprise before any of the pasture improvements were made is less than $100/ha due to lower stocking rates and animal daily weight gains.

Table 1: Income, costs and gross margin of a steer fattening enterprise in Central West NSW in 2024–25. Steers graze tropical grass-temperate annual legume pastures, fertilised native pastures oversown with temperate annual legumes, and winter forages

Income	
Return per animal = $660 (i.e. sell price minus purchase price based on delivery). 230 steers at a stocking rate of 8 DSE/ha. Average of 10 DSE per steer	$530/ha
Variable costs	
Average livestock costs (includes dry-lick, home grown hay, drenches, vaccinations, marketing, transport)	
Winter forage crop costs (seed, sowing, starter fertiliser, urea topdress, weed and insect control)	$180/ha
Pasture fertiliser (annual to biannual topdress of 100kg/ha single superphosphate)	
Annual Gross Margin	**$350/ha**

Cattle grazing digit grass (Photo: R Freebairn)

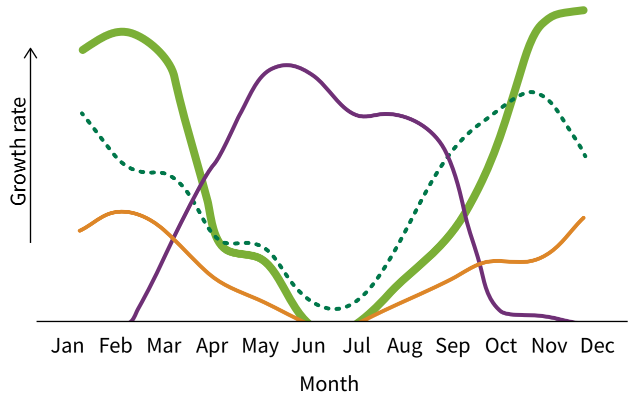
Benefits of tropical grasses to the feedbase

Adding tropical grasses to grazing systems can strengthen the feedbase, particularly under the pressures of climate variability. When tropical grass species are matched to soil type and soil deficiencies are addressed, these deep-rooted perennials produce large quantities of quality forage with excellent water use efficiency. This supports a more reliable year-round feed supply for livestock. In addition, tropical grasses maintain high groundcover levels which reduces erosion and improves soil health.

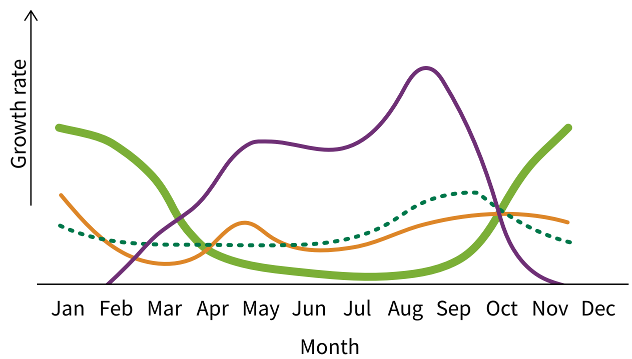
Valuable addition to the feedbase

A feedbase with both winter and summer-growing pastures and forages is best positioned to take advantage of rainfall whenever it occurs, providing feed for livestock year-round. This feedbase may include paddocks of native pastures, lucerne, annual forage or dual-purpose crops, temperate grasses (e.g. phalaris, tall fescue), temperate annual legumes, and tropical grasses (**Figure 3**). The exact range of species and their proportion of area in the feedbase should be tailored to each property, location and soil type.

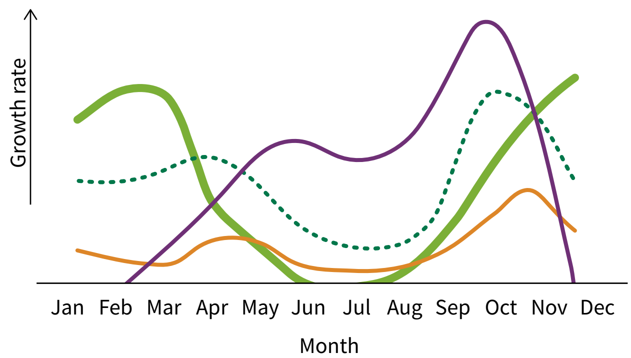
Figure 3: Relative growth rates (kg DM/ha/day) of tropical grasses and common pastures and forages illustrating how different species contribute to year-round feed for livestock in (a) northern and central NSW, (b) western NSW, and (c) southern NSW



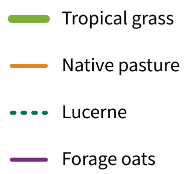
(a) Northern and Central NSW



(b) Western NSW



(c) Southern NSW



Persistent, productive and responsive to summer rainfall

Tropical grasses are persistent across variable seasons with some well managed, productive pastures being over 40 years old and showing no sign of decline. Tropical grasses are highly productive, and when fertilised, capable of yielding up to 17 tonnes of dry matter per ha (t DM/ha) in a growing season and averaging 9.4t DM/ha long-term when fertilised. A key advantage of tropical grasses is their rapid response to summer rainfall. Under good conditions they can grow at rates of 100–150kg DM/ha/day. With adequate stored moisture and fertility, yields of 4–6t DM/ha in 5–6 weeks are possible (**Figure 4**).

Tropical grasses are widely adapted with options for many environments

Tropical pastures can persist in a range of environments, from western regions with average annual rainfall as low as 400mm to more eastern areas with rainfall above 700mm, and over 1,000mm on the coast. Tropical grasses perform well at altitudes of up to 800m and occasionally above. Experiments have shown success in areas like Goolgowi (south of Hillston) in South West NSW (370mm annual average rainfall), and in the South Australia Mallee, where annual average rainfall is less than 300mm. In the Mallee, tropical grasses persisted for over six years, with production after summer rainfall ranging from 1.5–3.0t DM/ha, peaking at 9.0t DM/ha in wetter years. Tropical grasses are suited to a wide range of soil types and provide a productive option for soils less suited to cropping.

Tropical grasses are well suited to lighter soils. Despite lighter soils having a lower water holding capacity, tropical grasses can respond quickly to small rain events even after a protracted dry period. Tropical pastures also perform well on heavy sodic soils. On these soils, tropical grasses provide litter and other organic matter from pasture residues, which contribute to providing a friable soil surface without the need for regular inputs of gypsum or other amendments.

Year-round groundcover captures rainfall and reduces erosion for higher productivity

Tropical grasses increase the presence of perennial species across the landscape, helping to maintain high groundcover levels year-round. This lessens the risk of surface water runoff and erosion occurring. Low groundcover levels can lead to significant water losses in rainfall events, especially in storms (**Table 2**). In contrast, high groundcover allows the pasture to capture rain in both summer and winter. This stored soil water is critical for reliable pasture growth.

Figure 4: Tropical grasses are responsive to summer rainfall and recover quickly after drought. At the end of October 2019, the pasture had experienced exceptionally low rainfall over the prior 18 months (left). In December, a minor rainfall event contributed to some recovery in early January (middle), but significant rainfall during January sparked an explosion of growth within three weeks (right). With good fertility, the growth rate of tropical grasses can be around 100–150kg DM/ha/day (Photos: C Harris)

End October

Early January

End January (3 weeks)

Table 2: Groundcover and resulting rainfall capture, six week herbage production and water use efficiency for digit grass and lucerne as pure and mixed pastures following 237mm rainfall in January–February 2020. The three pastures each had a total plant density of eight plants/m^2 (Photos: S Murphy)

Pasture	Digit grass	Digit grass-lucerne mix	Lucerne
Pasture groundcover (%)	60–80	40–60	20–40
Rainfall capture (mm)	145	123	38
Rainfall capture (%)	61	52	16
Herbage mass (t DM/ha)	3.9	2.9	0.8
Pasture growth rate (kg DM/ha/day)	93	70	20
Water use efficiency (kg DM/ha/mm)	42	25	4
Before rain			
3 weeks regrowth			

Tropical grasses have high water use efficiency and rainfall utilisation. For example, digit grass pastures at Tamworth in northern NSW have shown water use efficiency of 9–25kg DM/ha/mm of water use in individual years, depending on soil water availability and fertility. Higher fertility enhances root development and further improves water utilisation.

Deep rooted to access more soil water and nutrients, and reduce deep drainage

The depth from which tropical grass roots extract water varies with soil physical and chemical properties. Data from experiments in northern NSW show that tropical grass roots can extract soil water from depths of 1.1 to 1.9m (Table 3). The amount of water plants can extract from the soil (plant available water capacity, PAWC) is influenced by plant root depth and density. Some tropical grasses can extract similar amounts (100–250mm), and to a similar depth to lucerne (Table 3). The fibrous root systems of tropical grasses are particularly effective at utilising available soil water in the top 1m of the soil. Deep roots and effective soil water extraction minimise losses through deep drainage, which is especially beneficial in regions prone to lateral flow, high water tables, and salinity.

Deep-rooted pastures typically access more soil water, which helps buffer against rainfall variability and enhances their persistence. This deep-rooted nature allows rainfall to deeply infiltrate the soil, which can be used later in the growing season. Stored winter rainfall can be accessed in spring and early summer, improving pasture persistence and productivity.

Table 3: Tropical pastures possess deep root systems, enabling them to extract soil moisture from significant depths (m) and exhibit plant-available water capacities (mm) comparable to lucerne

Pasture	Depth (m)	Plant available water capacity (mm)
Digit grass	1.3–1.9	130–250
Rhodes grass	1.2–1.4	180–210
Bambatsi panic	1.1–1.6	110–120
Gatton panic	1.0–1.8	100–110
Native grasses	1.6–1.9	140–160
Lucerne	1.5–1.8	210–240

Provide effective control of difficult weeds

Tropical grasses can effectively suppress problem weeds through strong competition, particularly when pastures are dense, well fertilised, and well managed. This competition reduces opportunities for weed establishment. Examples of weeds that can be suppressed by tropical grass pastures include:

- Spiny burr grass (*Cenchrus incertus*)
- Blue heliotrope (*Heliotropium amplexicaule*)
- Lippia (*Phyla canescens*)
- Galvanised burr (*Sclerolaena birchii*)
- Khaki weed (*Alternanthera pungens*)
- Rock fern (*Cheilanthes* spp.)
- Catheads (*Tribulus terrestris*)
- Bathurst burr (*Xanthium spinosum*)
- Paterson's curse (*Echium plantagineum*)
- Silverleaf nightshade (*Solanum elaeagnifolium*)
- Fleabane (*Conyza* spp.)
- Thistles (*Cardus, Cirsium, Onopordum, Silybu*m spp.).

Tropical grass pastures can also reduce invasion of weedy summer perennial grasses such as Coolatai grass (*Hyparrhenia hirta*) and African lovegrass (*Eragrostis curvula*). While these weeds can sometimes reinvade from public roadsides and neighbouring properties, well managed tropical pastures with good plant density, legumes and vigour can prevent these weeds from dominating, minimising their invasion.

Support effective natural resource management

Tropical grasses contribute to effective natural resource management by improving soil structure and hydrological function. Research on long-term tropical grass pastures in northern NSW indicates a link to higher soil organic carbon levels and greater root abundance, depth, and length, resulting in enhanced soil structure and improved water infiltration and storage. These factors create a cycle of continuous improvement in pasture and soil health.

Tropical grass species

There are a range of grass species suited to NSW. These grasses have varying characteristics that make them suitable for different soil types and environments. The species adapted to areas of NSW and some of their characteristics are described below.

Angleton grass or Floren bluegrass (*Dichanthium aristatum*)

Angleton grass, sometimes called Floren bluegrass, is a tufted perennial grass, with slender erect or climbing stems that grow up to 1m tall. Best adapted to heavy textured soils, such as cracking clays, but may be found on medium textured soils as well. It is drought, flood and salt tolerant. Angleton grass is suitable for paddocks subject to periodic waterlogging and flooding and is commonly sown in a mix with Bambatsi panic in these areas. It is susceptible to frost although plants recover with warmer conditions. It has less cold tolerance than other tropical grasses and typically recommences growth in spring 4–6 weeks after grasses like digit grass. It grows mainly in summer and autumn. It provides good groundcover, so competes well with weeds and helps prevent soil erosion (**Figure 5**). While it is mainly a tussock grass it can spread vegetatively from prostrate stems. Angleton grass is palatable and persists well under grazing but has low seedling vigour and is slow to establish. Mature plants flower very late in the season which can result in low seed production.

Minimum average annual rainfall: 500mm

Cultivars: Floren ⦶

Figure 5: Floren bluegrass in the Tamworth area (Photo: S Boschma)

Bambatsi panic or Makarikari grass (*Panicum coloratum* var. *makarikariense*)

This grass is correctly called Makarikari grass but mostly referred to as Bambatsi panic. It is an erect to semi-prostrate, tussocky perennial that has rhizomes (swollen stem bases), but rarely develops stolons. It can grow to 2m tall and has an open panicle seedhead (**Figure 6**). Bambatsi panic has proven to be an outstanding tropical grass in NSW. It is particularly suited to heavy textured soils including heavy clays, self-mulching clays and clay loams, also medium loam soils. The cultivar Bambatsi is suited to paddocks prone to periodic flooding or waterlogging. It has good drought tolerance, and some tolerance to frosting. Both its leaves and stems are palatable to livestock. It is highly persistent once established but is slower to establish than Rhodes grass and panic grass. Pastures dominated by panics may cause saponin poisoning and photosensitisation.

Minimum average annual rainfall: 450mm.

Cultivars: One cultivar available, Bambatsi. It has distinctive, blue-coloured foliage and white mid rib.

Figure 6: Bambatsi panic near Coonabarabran, central NSW (Photos: R Freebairn, S Boschma)

Buffel grass (*Cenchrus ciliaris*)

Buffel grass is a perennial tussock grass with range of growth types from erect to sprawling. It is suited to soils with pH_{Ca} 7–8, but it will grow on soils down to pH_{Ca} 5.5. It does not tolerate high levels of available soil aluminium and manganese. Buffel grass grows on a range of soils from heavy to lighter-textured. It is deep rooted and highly drought tolerant when well established (**Figure 7**). It is best suited to hotter environments and is more sensitive to cool temperatures than digit grass, performing best in areas where mean minimum winter temperatures are above 5°C. Early spring and late autumn growth can be less than other species. It is considered to have moderate palatability and needs good fertility to maintain feed quality and production. Buffel grass is moderately tolerant of soil salinity (less than Rhodes grass) and has low tolerance of waterlogging, particularly during winter. Its tolerance of flooding varies; the taller cultivars appearing to be more flood-tolerant than the lower-growing types. Buffel grass is considered an invasive grass in rangeland environments by some groups in NSW and Victoria and is a declared weed in South Australia.

Minimum average annual rainfall: 300mm. When sown in areas with higher rainfall, winter rainfall should be less than 400mm.

Cultivars: A range of cultivars are available. Early maturing cultivars are most suited to the low rainfall and highly variable climate in western NSW. American, a short early-maturity cultivar, and Gayndah, a short mid-maturity cultivar are suited to lighter soils. Later maturing cultivars may better suit higher rainfall areas. Biloela is a tall late-maturity cultivar suited to medium-heavier textured soils.

Figure 7: Buffel grass at Collarenebri and inflorescence (Photos: R Freebairn, S Boschma)

Creeping bluegrass (*Bothriochloa insculpta*)

A perennial grass that spreads by stolons (runners), forming a dense mat, providing high groundcover under grazing (**Figure 8**). Its leaves and stems have a distinctive scent which does not taint milk or meat, and plants may also grow up to 1m tall. It has moderate production potential on heavier more fertile soils but will persist under low fertility conditions. It has slower spring growth than Rhodes grass but good late summer–autumn growth. It is tolerant of heavy grazing and has moderate palatability. It is drought tolerant.

Minimum average annual rainfall: 550mm.

Cultivars: There are two cultivars: Bisset ⦶ and Hatch. Bisset is finer leaved and has stronger stolon development and rooting characteristics than Hatch.

Figure 8: Creeping bluegrass at Tamworth in late May (Photo: S Boschma)

Curly Mitchell grass (*Astrebla lappacea*)

This native perennial grass is suited to hotter environments in North West NSW with heavy cracking clay soils usually with high pH and free limestone (calcium carbonate present in the soil discrete particles). It does not perform as well in eastern areas of NSW or on many lighter or loam soils. There are four Mitchell grass species; curly Mitchell grass being the most widespread and common species. Other useful but less dominant species include hoop Mitchell grass (*A. elymoides*) and barley Mitchell grass *(A. pectinata*).

Curly Mitchell grass is a deep rooted, long living perennial (**Figure 9**). It grows to about 50cm tall and is densely tufted with crowns that can grow to 60cm diameter. It has some tolerance to salinity. It is highly drought tolerant and does not tolerate prolonged water inundation, especially during its main growth periods. It does recolonise after sporadic flooding given careful management. It is tolerant of heavy grazing, except during prolonged drought. It is best maintained by moderate grazing as this stimulates tillering and seed production. Mitchell grass is sometimes referred to in the literature as having average quality, but like most grasses, if soil fertility issues have been addressed, or natural soil fertility is high, it can be of high quality.

Minimum average annual rainfall: 250mm.

Cultivar: Single cultivar available, Yanda ⦶. Seed is sometimes readily available at competitive prices to other tropical grass species.

Figure 9: One year old stand of curly Mitchell grass sown at Walgett (Photo: R Freebairn)

Digit grass (*Digitaria eriantha*)

A tufted perennial grass that grows to over 1m tall (**Figure 10**). It is the most widely adapted tropical grass sown in NSW and proven to be the outstanding tropical grass for many soils. Digit grass is productive, persistent, highly palatable and well utilised by stock. It is suited to soil pH_{Ca} 4.2–8.0 and tolerates moderate to high levels of exchangeable aluminium; 34% of total cation exchange capacity, with reports of tolerance in some soils with 40% of total cation exchange capacity. Soil textures can range from sandy and sandy loam to many clay loam and clay soils, although digit grass grows best on light to medium soils. It has good drought and fire tolerance.

Digit grass has poor waterlogging tolerance but can persist a short period of water inundation. Digit grass grows better than most species during cool shoulder seasons, for example, autumn before frosts commence and spring once frosts cease. In late winter-early spring, it is one of the first tropical grasses to commence growth. Digit grass is suitable for hay and silage production. It grows well with temperate legumes when carefully managed. Stands typically thicken over time as it recruits from seed. Foliage is low in oxalate, so it is suitable for horses.

Minimum average annual rainfall: 400mm.

Cultivars: Only one cultivar is commercially available, Premier.

Figure 10: Digit grass cv. Premier growing in the Lake Cargelligo area, western NSW (Photo: A McFadyen, S Boschma)

Forest bluegrass (*Bothriochloa bladhii* spp. *glabra*)

A perennial, erect, tussock grass that can grow over 1m tall (**Figure 11**). It grows on a range of soil types, but is best suited to light textured, lower fertility soils. It is drought hardy and moderately frost tolerant but is susceptible to waterlogging and leaf rust. It is slow to establish, tolerates heavy grazing and is not as palatable as many of the other tropical grasses, such as digit grass. Its foliage is strongly scented but does not taint meat or milk.

Minimum average annual rainfall: 600mm.

Cultivars: Swann ⒫.

Figure 11: Forest bluegrass cv. Swann at Tamworth (Photo: S Boschma)

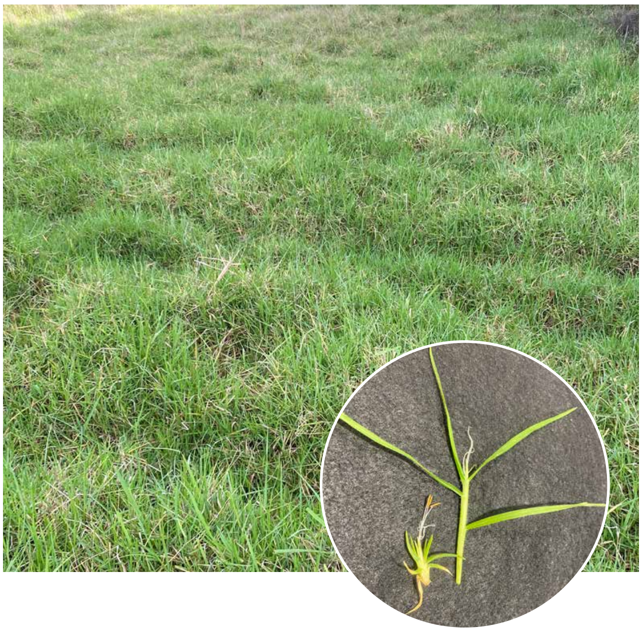
Kikuyu (*Cenchrus clandestinus* syn. *Pennisetum clandestinum*)

Prostrate, summer-growing perennial grass suited to highly fertile, well-drained soils (**Figure 12**). Kikuyu is widely used in higher rainfall coastal and irrigated pastures on dairy farms. It can persist but is not as productive in areas with annual rainfall to around 650mm. It has a long growing season and high yield potential with high soil fertility and good grazing management. Kikuyu is persistent and can rapidly spread by rhizomes, stolons or seed. It does not grow in the winter and tolerates frost, waterlogging and heavy grazing. It has excellent drought tolerance. Responds well to nitrogen fertiliser, irrigation, and intensive grazing (e.g. strip grazing). Kikuyu is palatable and has high feed value but becomes unpalatable if it is ungrazed and becomes rank. Not suitable for sowing with other grasses due to its competitive habit. Can be oversown via direct drill with ryegrass or oats in winter to provide a year-round feed supply. Excellent for erosion control and is also used as a hardy turf grass.

Minimum average annual rainfall: 800mm or irrigation in drier climates, however, persists well in areas with annual average rainfall of 650mm.

Cultivars: The common type is naturalised and only available by vegetative propagation (i.e. runners). Cultivar Whittet is available as seed.

Figure 12: Kikuyu stand near Tamworth, northern NSW (Photos: S Boschma)



Lovegrass (*Eragrostis curvula* var. *conferta*)

A long-lived perennial, with robust stems up to 0.5m in height (**Figure 13**). Its leaves and stems are a blue-green colour, particularly when moisture stressed. It grows into autumn until frosts commence, recommencing growth in early spring. It grows in a compact tussock which increases in diameter, eventually forming a ring of independent plants. Particularly suited to light textured acidic soils, with high levels of exchangeable aluminium. It is not tolerant of waterlogging. Lovegrass has small seeds that may be difficult to sow. It is very drought tolerant, persistent and frost hardy. Feed quality is good if soil fertility is high and like for most grasses, quality depends on growth stage. It can grow vigorously, providing high groundcover for soil erosion control and is useful for controlling spiny burr grass and other summer-growing weeds such as blue heliotrope.

> **WARNING**
>
> African lovegrass (*Eragrostis curvula*) is a highly invasive weed naturalised in many areas of NSW. Since Consol seed cannot be distinguished from the unpalatable naturalised strains, it cannot be sown without approval in some local government areas. Speak with a local advisor or weeds officer.

Minimum average annual rainfall: 400mm.

Cultivars: Consol.

Figure 13: Lovegrass cv. Consol (Photo: R Freebairn)

Panic grass (*Megathyrsus maximus*)

Sometimes referred to as Gatton panic, this grass and green panic are closely related and have recently been combined under a single name. Previously green panic was classified as a different variety of the species, that is *M. maximus* var. *trichoglume* while Gatton panic was *M. maximus*.

Panic grass is a leafy tussocky perennial with a deep root system with some cultivars capable of growing to 2m tall. The main growth period is over spring, summer and autumn, with better spring growth than many tropical grasses (**Figure 14**). Shade tolerance varies from moderate (e.g. cv. Gatton) to high (e.g. cv. Petri) and drought tolerance is moderate. It is well suited to medium-textured soils with good fertility but has performed well on lighter textured loamy soils in northern NSW. It is neither as productive nor persistent in northern and central NSW as digit grass and Bambatsi panic. It establishes readily and is palatable to stock. It can withstand heavy grazing for short periods during good seasons. Recovery will be slow if it is heavily grazed during dry periods. Heavy grazing is also not recommended in autumn, as plants can die when frosted. Newly harvested seed has post-harvest dormancy, that is, seeds absorb water and swell, but do not germinate. To avoid sowing dormant seed only sow seed that is at least 8–10 months old.

Minimum average annual rainfall: 600mm.

Cultivars: There are multiple cultivars including Gatton, G2 ⦶, Megamax 049™, Megamax 059™, NuCal (*M. maximus* x *M. infestus*), Petrie (formerly the only green panic cultivar. It is usually paler green and hairier than cv. Gatton). Megamax 049™ and 059™ have shown improved persistence and productivity under grazing in northern inland NSW, although they have not performed as well in southern NSW.

Figure 14: Panic grass cv. Gatton at Tamworth (Photo: S Boschma)

Paspalum (*Paspalum dilatatum*)

Paspalum is a naturalised species in many northern, central and southern NSW areas, including drier areas in western NSW. It is commonly regarded as a high rainfall perennial tropical grass suited to areas with 800mm or more average annual rainfall. It also has good frost tolerance and is one of the last tropical grass species to be frosted in late autumn or early winter. Paspalum is suited to soil types ranging from lighter loams to clay loams (**Figure 15**). It is tolerant of waterlogging. Good soil fertility is important for persistence and productivity. Where it becomes too dominant it can become sod-bound in long-term pastures.

Minimum average annual rainfall: 600mm. Mainly in parts of paddocks periodically prone to waterlogging.

Cultivars: The naturalised species is commercially traded as paspalum or common paspalum.

Figure 15: Common paspalum commonly grows well in areas prone to waterlogging (Photos: S Boschma)

Purple pigeon grass (*Setaria incrassata*)

A tufted, erect perennial that can spread by short rhizomes and grows to a height of 1.5m, with a spike like seedhead (**Figure 16**). It is relatively drought tolerant and is well suited to heavy textured soils. It is susceptible to frosting and less palatable than Bambatsi panic. It needs moderate to high fertility soil to persist and is intolerant of continuous heavy grazing. It has some tolerance to waterlogging, but not the extent of Bambatsi panic. It establishes readily and is quite palatable to livestock. Seed has high levels of post-harvest dormancy and should be stored for 7–18 months before sowing.

Minimum average annual rainfall: 600mm.

Cultivars: One cultivar, Inverell.

Figure 16: Purple pigeon grass stand at Coolatai in northern NSW (Photo: R Freebairn)

Rhodes grass (*Chloris gayana*)

A tufted perennial plant with above ground stolons (runners) that anchor at the nodes and can rapidly provide groundcover. The leafy, erect stems can grow up to over 1m tall (**Figure 17**). Seedheads are distinct with 10–12 radiating brown-green seed spikes. Rhodes grass is suited to a wide range of soils from light textured sandy loams to heavy textured clays. It is better suited to higher rainfall areas but is considered to have moderate drought resistance. It is not as hardy as digit grass or Bambatsi panic, especially in environments with less than 750mm average annual rainfall. It is susceptible to frost but recommences growth in spring. Rhodes grass has strong stolon growth and a vigorous root system suitable for erosion control and control of spiny burr grass. It is easier to establish than many other tropical grasses, although its fluffy seed can be difficult to sow with conventional machinery. It is not as persistent as some grasses, but reasonable long-term persistence can be achieved when management allows for good recovery after grazing.

Minimum average annual rainfall: 650mm.

Cultivars: There are many cultivars of Rhodes grass, and they form two groups based on their chromosome number: diploids (2n = 20 chromosomes) and tetraploids (2n = 40 chromosomes). Diploids are generally considered early flowering as flowering is insensitive to daylength and occurs throughout the growing season. In contrast, tetraploids tend to be late flowering, in response to shortening daylength. Therefore, most flowering occurs after the summer solstice with intense flowering commonly occurring from April in NSW. The tetraploids also tend to have a 3–6 month period of postharvest seed dormancy while the diploids do not.

Earlier maturing diploid cultivars are better suited to marginal growth areas or lighter soils and include Katambora, Pioneer, Topcut Ⓟ, Finecut Ⓟ, Reclaimer Ⓟ, Salcut Ⓟ, Tolgar Ⓟ and Nemkat Ⓟ. 'Katambora-types' (e.g. Finecut, Reclaimer, Nemkat) have finer leaves and stems than 'Pioneer-types' (e.g. Topcut, Salcut). Late maturing tetraploid cultivars are more suited to higher rainfall areas and respond to higher levels of input (e.g. nitrogen fertiliser, irrigation and intensive grazing). Late flowering cultivars include Callide, Samford and Sabre Ⓟ while very late flowering tetraploid cultivars include Mariner Ⓟ and Toro Ⓟ.

Figure 17: Rhodes grass at Tamworth, northern NSW (Photo: S Boschma)

Sabi grass (*Urochloa mosambicensis*)

Stoloniferous grass that can grow to 1m in height. It is suited to a wide range of well drained soils including sands, loams and lighter clay soils of low to high fertility (**Figure 18**). Sabi has performed well in erosion control on sloping land. It is sensitive to frost and is moderately drought tolerant although not as drought hardy as digit grass. It is a palatable pasture species that tolerates heavy grazing. Sabi grass is suitable for mine site rehabilitation and can germinate and establish on moderately saline soils.

Minimum average annual rainfall: 650mm.

Cultivars: Three cultivars are available: Nixon, Saraji and Manzini. Saraji shows better winter growth than Nixon (tufted grass) and a lower level of seed dormancy.

Figure 18: Sabi grass at Boggabri, northern NSW and inflorescence (Photos: R Freebairn, S Boschma)

Setaria (*Setaria sphacelata*)

Setaria is a summer-growing perennial grass best suited to higher coastal lowlands which receive at least 1,000mm average annual rainfall (**Figure 19**). It is suited to a wide range of soils from sandy to clay, performing best on deep soils with good moisture-holding capacity. It is tolerant of acid soils (pH_{Ca} 5.5 and above) and moderate waterlogging. Setaria can persist with low soil fertility but requires medium to high fertility for productive growth. Setaria is grown for grazing by dairy and beef cattle, but high oxalate levels make it undesirable for horses.

Minimum average annual rainfall: 800mm.

Cultivars: Four cultivars are available: Narok and Solander are frost tolerant compared with Splenda and Kazungula. Kazungula is the most drought- and flood-tolerant cultivar but has the highest oxalate levels.

Figure 19: Setaria (Photos: S Boschma)

Steps to successful establishment

Establishment

A well-established tropical pasture can remain productive and persistent for many years. Care during the establishment phase minimises the risk of unsuccessfully establishing an expensive pasture. Tropical grass seedlings are generally slower growing than annual grass weeds and should be sown in paddocks practically free of these weeds.

A good plant density is essential for a productive tropical grass pasture. Aim for 9 plants/m^2 in an established pasture, but no less than 4 plants/m^2. This plant density provides both good herbage production and water use efficiency. At high plant densities it can be difficult to add a companion legume. At low plant densities, herbage production decreases, groundcover falls below 70%, and water runoff increases.

Sowing into a weedy seed bed or where perennials and annuals are present, generally results in establishment failure or a pasture with lower plant density and vigour. While a poorly established pasture can be 'nursed' to productivity, it can take years to reach this outcome. In contrast, tropical pastures that establish well can be productive within three months given good weed control and seasonal conditions. Even with poorer seasonal conditions, full production can be achieved relatively quickly.

There is no alternative to well-thought-out, well-managed preparation before sowing tropical grasses for reliable, high-probability establishment success.

Prior planning and preparation

Successful establishment of tropical pastures requires careful planning with at least two years lead time. Factors to consider when planning and preparing to sow a tropical pasture include:

1. Select an appropriate paddock
2. Control weeds, especially annual summer grass weeds
3. Select the right species
4. Store soil water
5. Maintain groundcover
6. Purchase quality seed.

Select an appropriate paddock

When identifying a paddock to sow consider the soil type, the potential of the paddock to be productive, its position in the landscape and the paddock history. Tropical grass pastures can grow in both lighter and heavier soils that are not ideally suited to cropping or lucerne, for example, acid soils including those with acidic subsoils. Lighter textured soils with lower water storage capacity can be particularly effective sown to tropical grasses as pastures can respond to light falls of rain. Tropical grass pastures sown on heavy sodic soils can also perform well. They can be slower to establish, but once well established, plant residues on the ground protect the soil surface making it more friable without the need for ongoing inputs of gypsum or other amendments.

Figure 20: Most tropical grasses are intolerant of waterlogging over winter. All plants of digit grass died in an area that was waterlogged for several months over winter. Regeneration was poor and the area required resowing (Photo: P Perfrement)

Avoid selecting low lying creek flats or areas that are prone to waterlogging in winter for tropical grass pastures. While most of the grasses described in this publication can tolerate frosts once they are established, waterlogging during winter can greatly reduce persistence (**Figure 20**).

In environments where conditions are less favourable for tropical grasses, considering paddock aspect can be helpful. In cooler environments a northern aspect may be warmer and more favourable than a southern aspect, while in hot environments a western aspect would be warmest and less favourable.

If planning to sow a tropical grass into previously cropped paddock, check the herbicide history. Residual grass herbicides can reduce tropical grass emergence, and a history of sulfonylurea herbicide usage can impact legume establishment.

Control weeds, especially annual summer grass weeds

Tropical grass seedlings are vulnerable to competition from weeds in the seedbed. These include existing perennial and annual grasses, broadleaf plants, and any seedlings that will germinate from their seed banks. To minimise this competition, effective weed control before sowing a tropical grass pasture is essential.

Tropical pastures are often sown in old cropping paddocks, which can have high numbers of summer-growing annual grass weeds. Across the state, these species can dominate soil seed banks and capitalise on summer rainfall. Some of the common grasses include liverseed grass (*Urochloa panicoides*), barnyard grasses (*Echinochloa* spp.), button grass (*Dactyloctenium radulans*), arm grass (*Brachiaria gilesii*), stinkgrass (*Eragrostis cilianensis*), and annual panics including native hairy panic (*Panicum effusum*), witchgrass (*P. capillare*) and Hillman's panic grass (*P. hillmanii*). While these grasses can provide feed and groundcover, they also build large soil seed banks, and their seedlings compete strongly with establishing tropical grasses.

Summer annual grass weeds germinate and grow at the same time as sown tropical grasses, providing severe competition to the newly sown grass (**Figure 21**). By nature, annual grass seedlings establish faster than perennial grass seedlings. Without previous control, annual grasses can have seed banks of more than 50,000 seeds/m^2, so when tropical grass seed is sown at only several hundred seeds/m^2, they are vastly outnumbered. Paddocks heavily infested with summer grass weeds can result in the sown species failing to establish or establishing with plant densities too low for a productive pasture.

Figure 21: Bambatsi panic establishing where pre-sowing weed control of summer growing annual grasses was conducted for two years before sowing (left), one year before sowing (middle) and only in the spring before sowing (right) (Photos: G Lodge)

Grass weed seedlings are extremely difficult to control in an establishing perennial grass pasture and no herbicides can selectively remove them without damaging the perennials. The only way to ensure that summer-growing grass weeds do not pose a problem during establishment is to deplete their seed banks beforehand. This can take at least two years. One summer-growing annual grass seed per handful of soil is equivalent to about 400 seeds/m^2 and would be sufficient to reduce the establishment of sown tropical grasses (**Figure 22**). If the soil seed bank levels remain high after two years, delaying sowing for another year may be advisable rather than risking poor establishment.

Figure 22: Three handfuls of soil with varying levels of summer-growing annual grass weed seeds corresponding to: almost no seeds/handful or about 15 seeds/m^2 (left), an average of about four seeds/handful or 1,650 seeds/m^2 (middle), and an average of about 14 seeds per handful or 5,550 seeds/m^2 (right) (Photo: G Lodge)

To reduce the soil seed bank, seeds need to germinate, and the new plants must be prevented from setting seed and further adding to the seed bank. To deplete the seed bank, this process needs repeating over multiple germination cycles. Annual summer-growing grass weeds can start germinating in August, and some may continue until the following May if rainfall and temperatures are favourable. While seeds will not germinate during the colder winter months, the seed bank can be reduced by soil insect and pathogen activity, especially in wet winters. In some seasons, there may be multiple weed germination events, offering more chances to reduce the seed bank through herbicide applications. During dry summers, only 1–2 sprays might be feasible, so preparing a paddock to sow tropical grasses during consecutive summers with low rainfall or few rainfall events may take longer than two years, as there are fewer germination opportunities.

Livestock can be used to graze grass weeds, however, they may not prevent all plants from setting seed. Grazing should be used in conjunction with other methods, such as herbicides and/or tillage. If planning to sow with a tyned seeder that will cause significant or deep soil disturbance, incorporating tillage into the weed control phase can be crucial for reducing the seed bank at depth as well.

Conducting a weed control program does not mean a paddock must be out of production. Weed control can be incorporated into either a winter forage or grain crop program. Forage oats or other dual-purpose cereals are a practical option during this period. They can provide quality forage for grazing livestock over the winter, with stubble providing groundcover against erosion over the summer fallow while allowing weeds to be controlled. In the winter before establishing the pasture, a forage cereal is best sown as the crop needs to be removed August–September to allow soil water to accumulate for the new pasture.

Summer crops can be an option in some areas. Pre- and post-sowing residual chemicals can control grass weeds and reduce the annual grass soil seed bank. However, tropical grasses should not be sown in areas treated with these chemicals until the recommended plant-back period has passed. Therefore, crops applied with residual herbicides are best used in the first year of the 2–3 year weed control program only. Irrespective of the program used, it is important that no grass weeds set seed.

Select the right species

Tropical grasses are adapted to a wide range of environments and soil types. The following information is based on evaluation and experience and should be used when selecting species. A summary of species for light, medium and heavy soil types are provided below and suitability by region summarised in **Table 4**. Older cultivars have mostly been listed. As new cultivars progressively become available, they may, or may not, have similar attributes.

Light soils

Digit grass cv. Premier has proven well adapted and is highly suited to many soils, particularly light to moderately acidic loams. It has successfully been grown over the last 40 plus years in many environments, from low western rainfall areas (400mm average annual rainfall) to the slopes, tablelands, and coastal environments. It has performed well across NSW from the Queensland border to Victoria.

Rhodes grass cvv. Katambora and Pioneer and forest bluegrass cv. Swann perform well across multiple regions including the slopes and Hunter Valley on sand and sandy loam soils with a pH$_{Ca}$ less than 5.0–6.0. Panic grass cv. Gatton will grow on these soil types but is not as productive as other species. Lovegrass cv. Consol is suited to highly acidic lighter soils with high levels of aluminium toxicity.

Table 4: Tropical grass species suitable for light, medium and heavy textured soils for regions in NSW. In each region, the relative persistence of species varies with location and management

Grass species	Soil texture and pH_{Ca}			Region									
	Sands & sandy loams <5.0–6.0	Clay loams & silty clay loams 5.0–7.0	Medium & heavy clays 6.0–8.0	North Coast	North West Slopes	North West Plains	Central West	Hunter Valley	Tablelands	Central Slopes NSW	Southern Slopes & Riverina	South West	South Coast
Angleton grass/Floren bluegrass[A] (*Dichanthium aristatum*)		✓	✓	✓	✓	✓	✓						
Bambatsi panic/Makarikari grass[A] (*Panicum coloratum* var. *makarikariense*)		✓	✓		✓	✓	✓	✓	✓[F]	✓	✓	✓	
Buffel grass (*Cenchrus ciliaris*)	✓[D]		✓[E]			✓							
Consol Lovegrass (*Eragrostis curvula* var. *conferta*)	✓				✓	✓	✓						
Creeping bluegrass (*Bothriochloa insculpta*)		✓			✓		✓						
Curly Mitchell grass (*Astrebla lappacea*)		✓	✓		✓	✓							
Digit grass (*Digitaria eriantha*)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Forest bluegrass (*Bothriochloa bladhii* spp. *glabra*)	✓	✓				✓	✓						
Kikuyu (*Cenchrus clandestinus*)	✓	✓		✓		✓		✓	✓[F]		✓		✓
Panic grass (*Megathyrsus maximus*)	✓	✓			✓	✓	✓	✓					
Paspalum[B] (*Paspalum dilatatum*)		✓	✓	✓	✓	✓		✓	✓		✓		✓
Purple pigeon grass[BC] (*Setaria incrassate*)		✓	✓	✓	✓	✓							
Rhodes grass (*Chloris gayana*)	✓	✓		✓	✓	✓	✓	✓		✓			✓
Sabi grass (*Urochloa mosambicensis*)	✓	✓			✓								
Setaria[AB] (*Setaria sphacelata*)	✓	✓		✓				✓					

[A] Tolerant of flooding. [B] Tolerant of waterlogging. [C] Performs with high nutrition. [D] Buffel grass cvv. America and Gayndah. [E] Buffel grass cv. Biloela. [F] Persisted 4 years in Orange, NSW.

Medium soils

Digit grass cv. Premier is well suited to medium textured soils. Rhodes grass cv. Katambora also performs well on clay loam and silty clay loams with a pH_{Ca} 5.0–7.0, however, its persistence is not as good as digit grass in many lower and medium rainfall environments. Rhodes grass cvv. Finecut and Topcut, establish faster than other cultivars on hard-setting soils, but are not as persistent as Katambora.

Creeping bluegrass cv. Bisset performs well on medium soils. Forest bluegrass cv. Swann also grows well but is not as readily eaten by livestock. Panic grass cvv. Gatton and Megamax 059 have performed well in many medium to higher rainfall environments.

Bambatsi panic is suitable for loams and heavier soils with a high pH and persists in low to higher rainfall areas. It can be mixed with digit grass in many medium and heavy textured soils. Its tolerance to wet conditions adds to its attractiveness as a species.

Heavy soils

The best performing species on clay soils with a pH_{Ca} 6.0–8.0 are Bambatsi panic, angleton grass cv. Floren and purple pigeon grass cv. Inverell. Digit grass is sometimes included in mixes for these soils. Plant survival, production and forage quality of purple pigeon grass is closely related to soil nitrogen status. Curly Mitchell grass also suits heavy soils in North West NSW.

Pasture mixes

Tropical grass seed is often sown as mixes, a mix of tropical grass species or mix of tropical grass and legume species. An advantage of mixes is that species with different growth habits, seasonal growth patterns and responses to management can complement each other. The individual species in the mix can exploit different environmental niches for light, water and nutrients, providing a balanced pasture. This can be particularly beneficial in a variable climate, where different species can respond to markedly different temperatures and rainfall events. Species with different growth habits can also provide high groundcover year-round.

The disadvantage of mixes is that individual species may directly compete when establishing or growing together. Aggressive competition among seedlings may restrict the establishment of slower growing, less vigorous species, resulting in a pasture that does not reflect the mix sown. For example, Rhodes grass has a stoloniferous growth habit which can fill gaps in the pastures. However, it has a vigorous seedling which can adversely affect the establishment of more upright and slower growing species such as digit grass and Bambatsi panic. In the long-term, both digit grass and Bambatsi panic will be the more persistent and productive species in many environments.

In established pastures, competition for soil water may adversely affect the long-term persistence of some species. Species with different growth habits (e.g. upright versus prostrate) may also have different management requirements. Additionally, preferential grazing of one species over another may affect persistence. In many situations Kikuyu is best sown as a pure grass sward as it is highly competitive against other grasses and requires different grazing management.

Seed mixes of multiple tropical grasses are available on the market. When considering these, ensure the species in the mix are suited to the environment, soil type, intended grazing management and included in the mix at the desired proportion.

Legumes are commonly sown in mixes with tropical grasses. They fix nitrogen for use by the perennial grass and provide high-quality dry matter for livestock, increasing animal production. Compatible legumes include temperate annual legumes and perennial legumes such as lucerne, and in some areas, tropical legumes may be an option.

Temperate legumes have the advantage of extending the growing season of the pasture from spring to late autumn into the cooler months. In northern NSW, especially on the North Coast, tropical grass mixes containing tropical legumes are available. Like grass mixes, ensure the grasses and legumes included in the mix are suited to the region, soil type, enterprise type and management regime. Compatible legumes are discussed later in this manual.

Sowing mixes of tropical and temperate grasses

It is not recommended to sow temperate perennial grasses with tropical grasses. Temperate grasses, like phalaris, tall fescue and cocksfoot, establish best at different times of the year to tropical grasses. The grasses that establish first will be highly competitive against those which germinate later. They access the available resources, soil water, nutrients and space before the other grass species establish. If the tropical and temperate grasses are sown at the same time, seed of the second species may emerge at the wrong time of the year or lay in the soil for multiple months. Seed which germinates at the wrong time may be prone to adverse environmental conditions and fail to persist. Grass seed which sits in the soil for multiple months will also be prone to the weather and attack from pathogens and insects reducing the likelihood of its survival until environmental conditions are suitable for establishment.

Store soil water

Storing soil water before sowing is an investment in the success of the future pasture. It provides a reserve for the new pasture to utilise during establishment. Aim to accumulate at least 70% of the plant available water capacity (PAWC) of any soil. The more soil water stored, the deeper the pasture roots can grow unimpeded and the longer their growth can continue without additional rainfall. Applications such as 'Australian CliMate' (**climateapp.net.au**) or the 'SoilWaterApp' (**soilwaterapp.net.au**) can be helpful tools for estimating how much soil water might be accumulated under different scenarios leading up to pasture establishment.

Apps for estimating how much soil water might be accumulated

The 'SoilWaterApp' can simulate different crop types, cover crops, pastures, and fallow scenarios. It can be used to evaluate the progress of a fallow or when to remove a forage crop to accumulate soil water before sowing a tropical pasture. It provides the current status, can make forward projections up to an intended sowing date, and can display the distribution of soil water in the profile. Users can save scenarios for their paddocks and revisit them as needed, using local rain gauge data if desired.

The '*How Wet/Nitrate*?' tool inside Australian CliMate, estimates the current soil water available and nitrate levels during a fallow and compares these with previous years. For any chosen location, soil type, groundcover level and starting soil water, graphs show the indicative accumulation of soil water and nitrate in the fallow. This tool can be used to track the progress of a current fallow leading up to sowing, for example, tracking the build-up of soil water since taking out a cover crop in late winter-early spring.

How long does it take to build stored soil water?

The time required to accumulate soil water varies with soil type, rainfall received, and the level of groundcover. Groundcover improves fallow efficiency, allowing the soil profile to fill faster. Light-textured soils hold less water but fill faster. In contrast, medium and especially heavy-textured soils can store more soil water but are also slower to accumulate it due to the higher clay content. In low rainfall regions, a longer period is required to accumulate soil water to support pasture establishment.

A general recommendation when establishing a tropical grass pasture is to use a forage crop in the prior winter. In addition to providing opportunity for weed control, the crop builds groundcover in preparation for sowing the pasture in the coming spring. However, the timing of forage crop removal has implications for the subsequent build-up of soil water before sowing the tropical grasses. A forage crop is recommended rather than a grain crop. This is because the forage crop can be sprayed out, terminating it before it has matured, lessening the drawdown of soil water and increasing the window to rebuild it to levels that will support an establishing pasture.

When should the winter forage crop be terminated?

Sowing forage oats, or other suitable grazing crops, in a paddock with adequate soil moisture and terminating them by mid-August increases the likelihood of the soil profile exceeding 70% PAWC, in time for sowing tropical grasses by mid-November. In heavier soils, good preparation before sowing the forage crop and an earlier crop removal date will be required. In lighter soils, conditions tend to be more forgiving, particularly if the area receives sufficient winter rainfall. Due to greater winter rainfall in southern NSW, a later removal date in these locations can still provide sufficient time to reach the target PAWC. The crop should be removed earlier to achieve the target in lower rainfall areas.

The 'SoilWaterApp' can be used for specific locations to explore scenarios for the optimal timing to terminate a forage crop and its effect on the stored soil water when sowing tropical grasses. In this example, a red chromosol with a maximum PAWC of 122mm and a rooting depth of 1.2m was used across six locations in NSW (**Table 5**). Forage oat was sown on 15 March and grazed up to termination from 15 June, allowing for fallow periods of up to five months before sowing tropical grasses on 15 November. To achieve over 70% PAWC by mid-November, the oats must be terminated at least three months before sowing at all locations (**Table 5**).

Table 5: The termination date of forage oats used as a cover crop influences the soil water accumulated for sowing tropical grasses in mid-November. For oats sown on 15 March into a red chromosol (PAWC 122mm, root depth 1.2m) at 50% PAWC, the values show the percentage (%) of profile capacity achieved after terminating at different dates. Terminating oats in mid-August consistently achieved at least 70% PAWC ( ) by 15 November, suitable for sowing tropical grass. Terminating after August reduced PAWC to 40–70% ( ) or less than 40% ( ) in some locations. These scenarios were analysed using SoilWaterApp

Date oats terminated	Fallow (months)	Tamworth	Coonabarabran	Trangie	Condobolin	Cowra	Wagga Wagga
15 Jun	5	96	92	84	84	97	92
15 Jul	4	94	90	80	82	96	92
15 Aug	3	93	89	71	81	96	90
15 Sep	2	86	76	51	59	91	89
15 Oct	1	60	53	34	36	89	82
1 Nov	0.5	48	35	23	25	68	71

Use a push probe to check the depth of wet soil

In the paddock, a push probe is a practical way to test the depth of wet soil (**Figure 23**). Before sowing, it is best to have about 1m of moist soil on medium to heavy soils, while light soils can have less.

Maintain groundcover for sowing

Retaining stubble from a forage crop has several benefits. Initially, it provides groundcover, reduces erosion risk, and supports soil water accumulation before sowing. Once the pasture is sown, the cover keeps the soil surface moist for longer following summer rains. Also, it provides some protection to emerging seedlings from wind and water erosion.

Stubble cover is especially critical on hard setting soils and when rainfall is marginal. On hard setting soils, 10–25cm tall cereal stubble can provide sufficient groundcover to support the establishment of a tropical pasture, resulting in seedling densities more than five times greater than a pasture sown into bare ground (**Table 6**, **Figure 24**).

Figure 23: A soil probe can be used to estimate the depth of accumulated soil water. These plots near Manilla in northern NSW show the effects of managing temperate legume growth on soil water in November. Legume pasture growing to maturity allowed the wetting front to reach less than 0.1m (left). Removing the legumes four weeks earlier allowed the wetting front to reach 0.5m (middle). With no legumes through winter, the wetting front reached 0.9m (right). Rainfall in autumn, winter and spring was 119mm, 31mm and 27mm, respectively (Photos: M Brennan)

Table 6: Cereal stubble, either short (10cm) or tall (25cm), increases tropical grass seedling emergence. Soil surface disturbance provided by a tyned seeder can increase weed emergence if tillage is not incorporated as part of the pre-sowing weed control program

Soil surface at sowing	Grass density (seedlings/m²)	Weed density (seedlings/m²)	Groundcover (%)	Stubble weight (t DM/ha)	Stubble height (cm)
1 Bare ground	4	1	1	–	–
2 Bare + disturbance	13	7	<1	–	–
3 Short stubble	21	4	23	1.7	10
4 Short + disturbance	10	15	14	1.7	10
5 Tall stubble	23	5	63	3.3	24
6 Tall + disturbance	11	15	26	3.3	24

Figure 24: Digit grass seedling densities were highest when groundcover was provided by stubble and lowest when the soil was left bare. Soil surface disturbance provided by a tyned seeder as opposed to a disk seeder, funnelled rainfall into the furrow, but in this example also increased weed emergence. The treatments correspond with those in **Table 6:** (**1**) bare ground, (**2**) bare ground + disturbance, (**3**) short stubble, (**4**) short stubble + disturbance, (**5**) tall stubble, and (**6**) tall stubble + disturbance (Photo: S Boschma)

Soil disturbance provided by a tyne seeder or similar will provide furrows to funnel soil moisture to the emerging seedlings. However, the benefit is short-lived and not as effective as groundcover. Soil disturbance during sowing can increase weed densities, however, assuming reasonable weed control before sowing this is generally not an issue (**Table 6**).

Spray the first flush of grass weeds

Before sowing the pasture, controlling at least one germination of annual grasses is advisable. This controls any residual grass weeds and confirms that soil temperatures are suitable for tropical grass emergence.

Sowing

Key components for sowing success are sowing quality seed, using an appropriate sowing rate, sowing at an appropriate time, and placing seed at the correct depth (**Figure 25**). Soil fertility is also an important consideration.

Figure 25: Good tropical grass establishment occurs when high quality seed is sown into a weed-free seedbed at the right depth and time of the year. This pasture was sown six weeks earlier following three years of weed control at Boggabri, northern NSW (Photo: R Freebairn)

Purchase quality seed

To establish a productive pasture, it is essential to sow enough viable seeds. Always consider buying seed with the highest purity and germination and the lowest cost per unit of seed weight. Sowing low-quality seed can result in poor or failed establishment, even if everything else is done well. The quality of tropical grass seed available through retailers or 'over the fence' from other producers varies widely. A certificate of seed analysis is essential to know the quality of the seed (**Figure 26**). Ensure the certificate is from an accredited laboratory and is no more than 12 months old. There are two main sections of the certificate to check: purity test and germination test.

The purity test indicates the percentage, by weight, of pure seed, inert matter and other seeds of the seed lot tested. Pure seed refers to the percentage of caryopses (seeds removed from the floret), while empty florets and trash are classified as inert matter. Seeds of species other than the one being purchased, including weeds, will be represented by the value for 'other seeds'. The germination test shows the percentage of seeds that germinated into normal seedlings. It also gives percentages of the number of hard, fresh and dead seeds and abnormal seedlings. Tropical grasses do not have hard seeds. Fresh seeds are those which remain firm but do not germinate and can include immature, damaged and dormant seeds. They should not be included as part of the germination percentage. Purity and germination percentages for a range of tropical grasses is shown in **Table 7**.

Germination percentages of most tropical grasses are more varied and lower than those for temperate pasture species and crops. Temperate grasses frequently test with at least 80% germination, more than double many of the tropical grasses listed in **Table 7**. This is because many tropical grasses have not had extensive breeding and selection for seed production characteristics that the temperate grasses and crops have received. Seed production and harvesting techniques of tropical grass seed have improved so the overall quality of seed has increased compared to 15 years ago.

Some certificates of analysis may give results for a tetrazolium test (**Figure 26**). This test determines if a seed has a viable embryo and is an important test for seeds with high levels of dormancy. It also includes seeds that are dormant, immature and damaged and so should not be included in the germination percentage or used as a substitute for germination. There have been cases where private seed was available for sale based on a tetrazolium test of 80% but the germination was only 6%.

Seed dormancy in tropical grasses

Seed of some species experience primary or post-harvest dormancy which needs to be considered when buying seed. Certificates of seed analysis of species with high dormancy will have a large proportion of fresh seeds but have low germination. Fresh seed may mature and germinate, but if they were harvested too early, they may never reach maturity.

Panic grass and purple pigeon grass have primary dormancy. Diploid cultivars of Rhodes grass (e.g. Katambora), Bambatsi panic, forest bluegrass and digit grass generally do not display post-harvest seed dormancy. The time required for dormancy to be broken varies with species. For example, panic grasses can require storage for 8–10 months to achieve maximum germination while seed of purple pigeon grass may require storage for 24 months. Germination of purple pigeon grass can increase from 15% to 70% after storage from 12–24 months.

Figure 26: An example certificate of seed analysis for a seed lot showing excellent purity (98%) and average germination (47%). The tetrazolium test (75%) determines the proportion of seed that has a viable embryo and is not a suitable alternative for germination

Seed Testing Laboratory
A.B.N.: XX XXXXX

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025 - testing
Accreditation number XXXXX

STATEMENT OF ANALYSIS
Lab No: **TXXXX**

4 Marsden Park Road
Calala NSW 2340

Date Received: 23/10/2020
Testing Commenced: 23/10/2020

Kind: ***Digitaria eriantha*** (Premier digit grass)
Sample ID: Top paddock
Variety: Premier

The lot size represented by this sample was not stated by the applicant

PELLETED PURITY (% by weight) SOP202

Pure Pellets	Unpelleted Seed	Inert matter	Other seed
98.2	0.0	0.8	1.0

GERMINATION (% by number) SOP101
Conditions: TP 20/35°C DormancyTreatment: KNO3

Interim Day 7	**Normal** Day 21	Abnormal	Hard	Fresh	Dead
18	47	4	0	24	25

VIGOUR (% by number) SOP102

Day 7	Day 14	Day	Day	Day
0	32	-	-	-

Inert Matter:
Straw, dead insects, loose pelleting material

OTHER SEEDS (Total weight examined 101.0 g)
Chloris gayana (Rhodes Grass)
Urochloa panicoides (Liverseed Grass)

Moisture (%)	SOP103 **Tetrazolium Test** (% Viable)	SOP401 **Seed Count** (Seeds per Kg)
-	75	-

XXXXXXX
Laboratory Manager

Date : 13/11/2020

Australian Seed Federation
SOWING SEEDS

Results only apply to the sample received by the laboratory on date indicated. The interpretation and application of these results is the responsibility of the customer.
The certificate can only be reproduced in its entirety

Pure Live Seed

This is a measure sometimes used to determine the overall quality of a seed sample and is expressed as a number between zero and one. Pure Live Seed (PLS) is the purity percentage multiplied by the germination percentage (shown as a value for normal seedlings) and divided by 10,000. The higher the seed quality the closer the PLS is to one. Pure live seed of tropical grass species and cultivars varies and average values for some grasses are shown in **Table 7**. These values can be used as a guide to determine whether the seed being purchased is above or below average. If the quality is below average, consider looking for better seed.

Sowing rate

After securing high quality seed, the aim is to sow enough viable seeds to achieve about nine established plants/m^2. This is largely related to the sowing rate.

Seed resellers can provide recommended sowing rates (kg/ha) for tropical grasses. These generally vary according to seed weight, intended purpose of the pasture (e.g. irrigated versus dryland grazing) and the proportion of seed coating. Sowing rates should also take account of seed purity and germination and the potential strike rate. It should be noted that seed coating can be a high percentage of the seed weight.

It is important not to reduce sowing rates to save sowing costs. If sowing rates are too low, moderate savings made on seed can incur losses in the early years after establishment. Low density stands have lower production, lower groundcover and are more prone to weed invasion.

Strike rate

Strike rate is the term used to describe the proportion of seedlings that emerge as a percentage of seed sown. It tends to be highly variable due to the many factors that impact pasture establishment. With good rainfall (or irrigation) a common strike rate is around 14%. However, it can be as low as 3% or less if the seed bed, sowing equipment, sowing depth, or germination conditions are not ideal.

Seed weight variation

The size and weight of caryopses (seeds removed from the floret) can vary greatly due to a range of factors at seed fill including nutritional and soil water status. Average size and weight of caryopses of a range of tropical grasses are shown in **Table 8**. Generally, the larger the seed, the more vigorous the seedling, however, there are exceptions. For example, Rhodes grass cv. Katambora has a small caryopsis weight, but seedlings grow rapidly. In contrast, Bambatsi panic cv. Bambatsi have a moderately sized seed, but seedlings tend to grow more slowly.

Seed coating

All seed is sold and sown by total weight (includes coating for coated seed). Most tropical grass seed sold by seed companies is coated, while seed produced and sold by producers is commonly bare (uncoated). Seed coating improves the flow of light, fluffy seeds through sowing equipment. Some seed coatings also contain insecticides and fungicides to protect the seed from insect predation or seedling diseases. However, they do not affect the purity, nor improve the germination of the seed. While coated seed looks consistent, it still contains all the material contained in bare seed lots, empty florets, other seeds, plus any other trash.

The choice whether to sow coated or bare seed is individual, but it is important to remember that sowing rates also need to be increased as coating greatly increases seed weights. The proportion of seed coating varies with species and seed company, and the seed coat proportion can be 500% or more of the bare seed weight (**Figure 27**). For example, with a 2:1 seed coating (2kg of coating for every 1kg of 'seed' material by weight), the sowing rate per hectare needs to be tripled to sow the same number of seeds/m^2. Similarly, seed coated at 5:1 will increase the sowing rate six-fold. For seed of the same quality (germination and purity), bare seed is usually more cost effective than coated seed. When purchasing seed, ask for the seed coating ratio so that the sowing rate can be adjusted accordingly.

Table 7: Average germination (%) and purity (%) of some tropical grasses sown in NSW. Pure live seed accounts for both the germination and purity of a seed lot and is sometimes used to assess its overall quality. The closer the value is to 1.0 the higher the quality (Source: AgEtal, 2025; agetal.com.au)

Grass	Germination (%)		Purity (%)		Pure Live Seed	
	Average	Range	Average	Range	Average	Range
Angleton grass	23	10–38	72	63–78	0.13	0.06–0.19
Bambatsi panic	60	10–91	94	70–100	0.56	0.13–0.91
Buffel grass	14	0–58	96	82–100	0.12	0.00–0.55
Creeping bluegrass	13	0–48	79	66–89	0.16	0.06–0.28
Digit grass	46	0–85	82	6–100	0.54	0.08–0.78
Forest bluegrass	29	9–58	85	72–99	0.30	0.12–0.49
Kikuyu	81	1–98	99	97–100	0.88	0.42–0.97
Panic grass	24	0–77	80	46–100	0.21	0.00–0.76
Paspalum	58	1–93	61	5–84	–[A]	–
Purple pigeon grass	38	2–67	96	93–98	–	–
Rhodes grass	50	0–78	96	86–100	0.46	0.04–0.75
Setaria	41	0–72	94	91–99	–	–

[A] Data not available

Figure 27: Bare digit grass seed (left) compared to two lots of coated digit grass seed with different coating proportions (middle and right). Each seed lot is 100 seed units. As the proportion of seed coating increases, the sowing rate also needs to increase to sow the same number of seeds (Photo: S Boschma)

Sowing bare seed

If sowing bare seed, recommended sowing rates of tropical grasses can be found on the NSW DPIRD website. Bare seed can be mixed with fertiliser and sown through most fertiliser boxes to aid seed flow. Superphosphate or a low nitrogen compound fertiliser can be mixed with the seed, provided only 10–15kg/ha nitrogen is applied.

Calculating the sowing rate

The seed reseller can provide recommended sowing rates. These are commonly given as a range and can vary with the seed company. This range is to consider the intended purpose of the seed (e.g. dryland versus irrigated pasture), location (e.g. low or higher rainfall area), whether the grass will be sown as part of a mix or single species pasture and the potential strike rate. Selecting a rate that is middle to high within the range is suggested. While the recommended rates account for some variation in germination and purity, sowing seed at the higher rate within this range provides allowances for situations like poor seasonal conditions and weed competition. Germination success can be less than ideal if the establishment year is difficult, such as a relatively long dry summer with intermittent small rain events.

If either the germination or purity of a seed lot is low, the sowing rate can be adjusted to account for this. The calculation to adjust for germination is as follows:

$$\text{Your sowing rate kg/ha} = \frac{\text{Recommended sowing rate kg/ha}}{\text{Germination \%}} \times 100$$

To adjust for purity, substitute purity% for germination%.

The number of seeds sown per m^2 can also be calculated if the 1,000 seed weight is known. As described previously, this seed weight will vary with seed company and seed lot (Table 9). The calculation to determine the number of seed sown per m^2 is:

$$\text{Number of seeds sown/m}^2 = \frac{\text{Your sowing rate kg/ha}}{\text{1,000 seed weight g}} \times 100$$

Table 8: Caryopsis (seed removed from the floret) weight and number of seeds per kilogram varies with tropical grass species and cultivar. Growing conditions can also affect caryopsis weight (Source: W Scattini and G Lodge, unpublished)

Common name	Cultivar	Weight (g/1,000 seeds)	Number of seeds/kg
Angleton grass	Floren	0.90	1,111,100
Bambatsi panic	Bambatsi	0.93	1,075,300
Creeping bluegrass	Hatch	1.16	862,100
Digit grass	Premier	0.43	2,325,600
Forest bluegrass	Swann	0.17	5,882,400
Lovegrass	Consol	0.21	4,761,900
Panic grass	Gatton	0.68	1,470,600
Purple pigeon grass	Inverell	1.04	961,500
Rhodes grass	Callide	0.33	3,030,300
Rhodes grass	Katambora	0.24	4,166,700
Rhodes grass	Pioneer	0.37	2,702,700

Sowing time and soil temperature

Tropical grasses have different optimum temperatures for seedling emergence. In most areas tropical grasses can be sown from mid-October or November until around mid-March (**Table 10**). However, the best ‘sowing window’ in most areas is early in this period: November to early December. Sowing in spring is ideal as ambient and soil temperatures are increasing and the chance of receiving sufficient summer rainfall for germination and establishment is highest.

Grasses like Rhodes grass and digit grass can be sown earlier in this ‘window’ as they can emerge at lower temperatures, while Bambatsi panic and panic grass require higher temperatures. Sowing too early in spring when temperatures are low can reduce seedling vigour making them less competitive against any weeds that may still be present in the soil, inhibiting establishment.

In warmer environments if good rainfall is guaranteed and a warm autumn forecast, autumn sowing can be successful. While seedling emergence can be high for a range of species sown in autumn, their ability to over-winter as young plants varies. Young digit grass and Rhodes grass plants can successfully over-winter, however, those of Bambatsi panic and angleton grass do not. Reduced productivity from these grasses sown in autumn has been observed for at least 18 months after sowing.

Sowing time and germination rainfall

Tropical grasses are ideally sown before rain (**Figure 28**). When sowing after rainfall during the warmer months, soil moisture near the surface (0–5cm) typically has evaporated before sowing is completed, often delaying germination until the next rainfall event. The amount of rainfall required for germination varies with soil type, groundcover level, and the presence of subsoil moisture. Groundcover and stored soil water are essential as they support conditions for germination during smaller rainfall events, which are more likely to happen.

Figure 28: Sowing tropical grasses in November ahead of a rain event in the Holbrook area, southern NSW (Photo: A Hunter)

Modelling germination events of panic grass at various NSW locations showed that germination was closely linked to the amount of rainfall received over a five-day period. For instance, at Tamworth, germination was associated with receiving 45mm of rainfall over a five-day period, which occurs at least once during the period from October to March in 86% of years (**Table 11**). Across all NSW locations modelled, soils with good groundcover required 5–10mm less rainfall for germination over the five-day period than bare ground soils (**Table 11**).

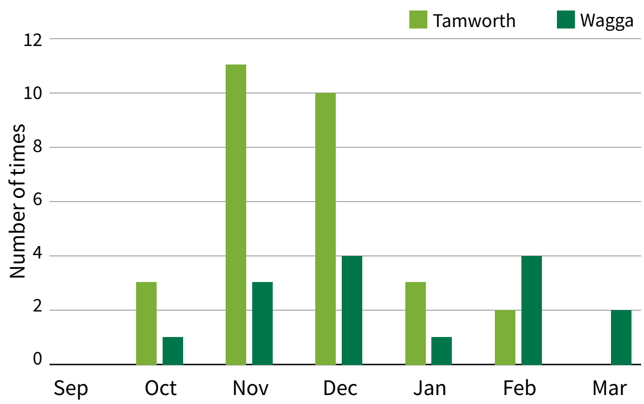
Table 9: Examples of seed weights and the number of seeds/kg of coated seed for tropical grasses. Seed weights of individual species, even cultivars, can be quite variable. Additionally, the proportion of seed coating often varies with the seed company

Grass	Cultivar	Weight (g/1000 seeds)	Number of seeds/kg
Bambatsi panic	Bambatsi	3.92	254,940
Creeping bluegrass	Bisset	10.81	92,540
Digit grass	Premier	2.55	391,900
Kikuyu	Whittet	7.84	127,610
Panic grass	Gatton	3.94	253,970
Panic grass	Megamax 059	2.76	362,320
Panic grass	Petri	3.88	257,460
Rhodes grass	Callide	4.06	246,310
Rhodes grass	Endura	3.69	271,370
Rhodes grass	Katambora	3.63	275,170
Rhodes grass	Mariner	4.06	246,610
Sabi Grass	Manzini	11.08	90,250
Setaria	Splenda	2.97	336,890
Setaria	Solander	7.52	132,920

Multiple falls over a five-day period are more likely to keep the seedbed moist for a sufficient period to support germination and seedling emergence. The later the pasture is sown within the sowing window, the lower the probability of receiving that event. The 'Australian CliMate' app (see the 'Store soil water' section) can be used to estimate how often these events occur for most regions, and the 7- and 14-day forecasts can help guide the timing of sowing. While forecasts beyond seven days are uncertain, longer-term projections can provide a lead time to prepare for sowing.

In NSW, the month when the first rainfall and germination event is likely to occur in the sowing window changes from north to south. In Tamworth, the first event will likely occur in November or December. In southern areas like Wagga Wagga, there are fewer events, and the timing of the first event is spread across the sowing window, and in some years, it is in March. Both outcomes reinforce the notion of sowing as early as practical in the sowing window to have a higher chance of success (**Figure 29**).

Figure 29: For the 30-year period, 1990–2020, the first germination of panic grass in northern NSW (Tamworth) was more likely to occur between November and December. However, in southern NSW (Wagga Wagga), there were fewer events, and they were more evenly distributed across the sowing window



Can tropical grass seed survive over winter?

Seed sown one year is unlikely to remain viable through winter and establish the following spring. This is because seed sitting in moist soil over winter is prone to attack by insects, soil fungi and bacteria attack and losses can be as high as 100%. In dry winters, some seeds may survive and germinate later, but this is a risky method of establishment.

Table 10: Temperature requirements in warming (August–January) and cooling soils (January–July) for some common tropical grasses to achieve **50% of maximum emergence**. Indicative months when these temperatures occur at several NSW locations are provided

Pasture species	Warming-cooling soil temps (°C)	Indicative periods these temperatures occur at different locations				
		Tamworth	Trangie	Orange	Cowra	Wagga
Rhodes grass	17–17	Oct–Apr	Early Oct–Late Apr	Early Dec–Feb	Late Oct–Early Apr	Late Oct–Early Apr
Kikuyu	18–17	Oct–Apr	Oct–Late Apr	Dec–Feb	Early Nov–Early Apr	Early Nov–Early Apr
Digit grass	20–22	Nov–Mar	Early Nov–Late Mar	Jan	Late Nov–Early Mar	Late Nov–Early Mar
Bambatsi panic	20–21	Nov–late Mar	Early Nov–Late Mar	Jan	Late Nov–Mar	Late Nov–Mar
Panic	20–20	Nov–late Mar	Early Nov–Early Apr	Jan	Late Nov–Late Mar	Late Nov–Late Mar

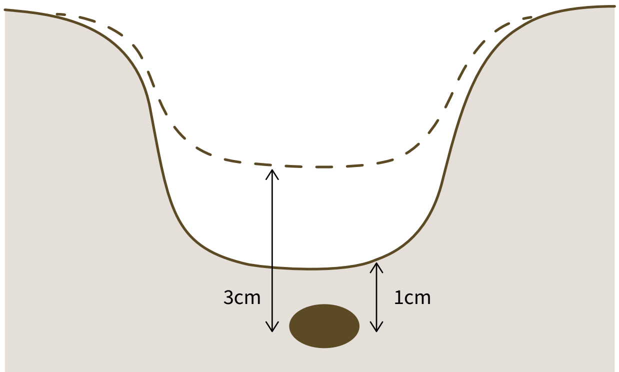
Sowing depth

The best seedling emergence results from seeds placed at 10mm depth. Seeds of most species are small and emerge best from shallow soil placement. Seeds placed on the soil surface fail to remain moist long enough to germinate, while those sown deeper than 25mm have markedly reduced emergence. Sowing seed too deep is one of the main causes of tropical grass establishment failure. Seeder type is not critical but seed placement is.

If sowing into a furrow made by a tyned seeder with press wheels, chains or harrows, seed is best sown at 0–10mm as the sides of the furrow are likely to melt into the furrow with summer rain, placing more soil on the seed (**Figure 30**). Seed sown with a precision disc seeder into an undisturbed soil surface could be placed at a depth of 10mm. The surface variation that occurs will ensure seed is placed no more than 25mm deep. Groundcover can also help maintain soil stability and reduce seed burial.

Soils that seal or crust on the surface after rain can prevent seedling emergence, particularly if they are sown deeper than desirable. Tropical grass seeds are tiny, with limited energy reserves, making it imperative that emergence is not impeded. Soils with low groundcover and organic matter will be the most likely to crust and prevent emergence.

Figure 30: When considering sowing depth, assess aspects that can result in seed being deeper than intended. For example, when seed is placed in a depression resulting from a tyne seeder and press wheel, consider what depth may eventuate if storm rains melt the adjoining ridge alongside the press wheel depression



Fertiliser at sowing

Essential soil nutrients need to be present to support seeding development. A soil test conducted by a National Association of Testing Authorities (NATA) accredited laboratory prior to sowing will highlight soil nutrient deficiencies.

On soils with reasonable fertility, tropical grasses will establish well with minimal fertiliser application. Soil nitrogen levels can be adequate for establishment when a pasture is sown into a prepared seedbed that has been in fallow due to mineralised nitrogen. However, a low rate of nitrogen at sowing will encourage grass growth. Depending on sowing equipment a typical fertiliser applied when tropical grasses are sown is 40–100kg/ha of a starter fertiliser, or diammonium phosphate (DAP) if sulphur levels are satisfactory.

Table 11: Mean 5 day total rainfall for establishment events of panic grass from 1990–2020 at a range of locations in NSW, and the probability of receiving that rainfall event in all years in the October–March sowing window. Preparing a paddock with groundcover reduces the rainfall required to trigger germination, which increases the likelihood of receiving that event. Later sowing reduces the probability of receiving that event

Location	Germination rainfall event (mm)	Probability of receiving the germination rainfall event (%)					
		All years	Oct–Mar	Nov–Mar	Dec–Mar	Jan–Mar	Feb–Mar
With groundcover from a forage crop							
Tamworth	45	86	81	75	67	61	28
Coonabarabran	40	100	94	89	89	83	47
Trangie	50	78	78	75	64	53	22
Condobolin	45	75	72	72	67	50	31
Cowra	55	69	69	58	50	42	25
Wagga	45	69	67	61	53	44	28
Bare ground							
Tamworth	50	83	78	75	61	53	22
Coonabarabran	50	89	86	83	75	67	33
Trangie	55	67	67	61	50	36	17
Condobolin	50	69	67	64	56	42	22
Cowra	60	64	64	56	47	39	19
Wagga	50	64	61	50	42	33	22

If starter fertiliser is applied with the tropical grass seed in the same furrow at sowing, use rates up to 10–15kg/ha nitrogen only. Higher rates can cause damage to emerging seedlings and should be placed separate from the seed or applied after emergence.

Delaying nitrogen application until the pasture has emerged provides the opportunity to assess the density of both the pasture and any emerging weed population. In a poor stand, the decision might be made not to apply nitrogen fertiliser as this will benefit any weeds present and increase competition for establishing tropical grass seedlings.

The establishment year

Identifying sown grass and weed seedlings in an establishing pasture

Tropical grasses are often sown as a mix of at least two species. Distinguishing between sown species or annual grass weeds at the seedling stage can be difficult (**Figure 31**). To assist in identifying sown tropical grass species and several common summer-growing annual grass weeds, photos and descriptions of some seedling characteristics are provided in Appendix 1.

Figure 31: It can be difficult to distinguish between seedlings of sown species and weed grass species (Photo: M Brennan)

Broadleaf weed control

In a mixed grass-legume pasture there are limited herbicide options for broadleaf weed control. In a grass-only pasture, there are two options for broadleaf weed control; broadleaf herbicide application or grazing.

A timely application with a broadleaf herbicide can reduce broadleaf weed competition in establishing grasses. The tropical grasses must be well rooted and developing a secondary root system before application. A range of herbicides are registered for broadleaf weed control in tropical grasses under a minor use permit from the Australian Pesticides and Veterinary Medicines Authority (APVMA, PER12362). These include 2,4-D amine, MCPA amine, fluroxypyr, and mixes with metsulfuron-methyl. Check the APVMA website (**apvma.gov.au**) for current permit status and list of herbicides permitted.

Grazing may be considered as a lower cost weed control strategy, but it is less effective than herbicide application. If grazing for weed control, the weeds must be palatable to livestock, and the tropical grass plants must be well anchored. Give the establishing pasture plants a small tug; if they can be easily removed by hand, livestock will pull them out while grazing. Some summer-growing broadleaf weeds can have cumulative poisonous effects on livestock, for example, caltrop or cat's head can be associated with nitrate poisoning, photosensitisation and sheep staggers under certain conditions. If unsure of the impact of weeds on grazing animals, consult a veterinarian or livestock advisor for advice. Grazing should use high stocking numbers for short periods to ensure that the sown grasses are not overgrazed.

Grazing in the first year

Ideally, allow new tropical grass pastures to flower before first grazing. At this stage they are well anchored and have good root reserves, important for regrowth. Flowering can occur in less than 12 weeks after sowing in a favourable year. In marginal years when grasses establish over several rainfall events, or plant development is slow, it might be autumn before the pasture can be grazed. If the plant density is low allowing grasses, such as digit grass, to set seed will provide seed for seedling recruitment the following spring-summer. If the season is poor during the establishment year, or if the pasture was sown late and plants have not flowered, maintaining bulk on the plants will be important to help them survive their first winter.

Don't give up on a new pasture

Tropical pastures often emerge over multiple rainfall events. This can result in a patchy pasture and can be judged a failure (**Figure 32**). However, because delayed emergence is common, it is generally sensible not to give up on a new pasture until growth the following spring-summer has been observed. Many pastures thought to be failures in the establishment year look fine the following year.

Figure 32: Multiple germination events of digit grass resulted in plants of various sizes (Photo: S Baker)

Companion legumes for tropical pastures

Why are legumes important as companions?

Nitrogen is essential for maintaining the productivity and quality of tropical pastures. It can be supplied either by fertiliser or legumes. The annual or biannual application of fertiliser nitrogen can be costly, both in terms of money and time, making legumes an attractive option. Legumes also produce high quality dry matter for livestock, increasing animal production and improving soil features such as organic matter, making them a doubly valuable addition to a pasture.

Selecting a compatible legume

When selecting a companion legume to grow with tropical grasses, it must suit the soil type, rainfall conditions, and grazing management. To be effective, it also needs to:

1. **Fix nitrogen.** To achieve this a legume must be adequately nodulated with an effective strain of rhizobia. Functional nodules are pink and are commonly found near the crown and lateral roots of the legume. Look for the green tick when purchasing rhizobia inoculant products.

   Quality assured inoculants for Australian conditions

2. **Be productive.** The amount of nitrogen fixed is proportional to the amount of dry matter produced by the legume. Many factors affect nitrogen fixation, but as a rule of thumb, temperate legumes fix about 20kg nitrogen (N)/t DM. Of this, 13kg N/t DM is available for the perennial grass. For a legume to produce 50–100kg N/ha that is required to maintain a productive tropical grass pasture, the legume needs to produce at least 4t DM/ha annually.
3. **Persist and be resilient**. An effective legume needs to be persistent and able to coexist with the tropical grass through highly variable seasons year-to-year. As well, it needs to be able to respond quickly to rainfall when it falls during its growing season. Annual legumes need to establish quickly and set large quantities of hard seed to maintain a seed bank. Perennial legumes need to have strategies to survive highly variable seasons.

The key soil factors for legume growth include pH, aluminium toxicity in acidic soils, soil texture, drainage, waterlogging risk, and fertility. Variations in pH, texture, and elevation often occur across a paddock. To support legume productivity and nitrogen fixation, maintaining soil fertility is crucial, especially phosphorus and sulphur, which are often lacking in many NSW soils. Periodically adding molybdenum also helps optimise rhizobia development and nitrogen fixation.

Legumes suitable for growing in a mix with tropical grasses fall into three categories: temperate annual legumes, temperate perennial legumes, and tropical legumes. The advantages and disadvantages of each group are summarised in Table 12, and details of a range of legume species are provided in Appendix 2.

Temperate annual legumes

These legumes are the most widely sown with tropical grasses in NSW. Temperate annual legumes grow during the cooler months of the year (autumn to spring). They regenerate from seed in autumn, then flower and set seed in spring before senescing. An advantage of a tropical grass-temperate annual legume mixed pasture is that it has the potential to provide quality feed almost year-round (Figure 33).

Figure 33: Temperate annual legumes (---) regenerate in autumn and provide forage during the winter–spring period and tropical grasses (▬) provide feed over spring–autumn. This tropical grass-legume mix has potential to provide quality feed almost year-round (■)

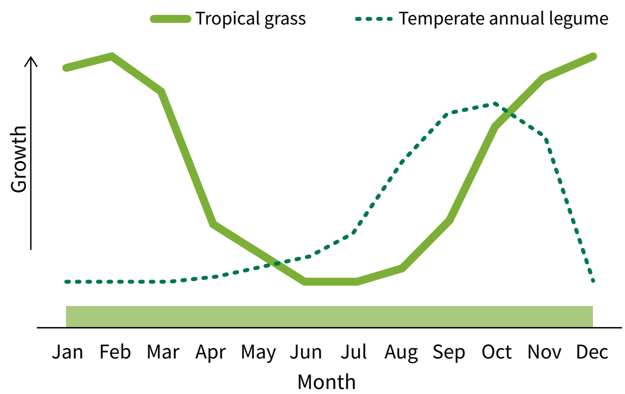


Table 12: Advantages and disadvantages of different legume types as companion legumes with tropical grass pastures

Legume type	Advantages	Disadvantages
Temperate annual	■ The grass-legume mix can provide almost year-round feed (10–12 months) ■ Appropriate cultivars are persistent long-term ■ Bloat tolerant legume species are available.	■ Limited/nil opportunity to accumulate soil water (more an issue on heavy textured soils) ■ Legume depends on autumn rainfall to regenerate and growing season rainfall for growth and seed set ■ Active management is required in spring and autumn to ensure suitable pasture conditions for both grass and legume persistence.
Temperate perennial	■ Extends pasture growth period to approximately September–May (9–10 months) ■ Opportunity to accumulate soil water over the winter period when a low winter activity legume is used[A].	■ Lucerne can use all stored water in spring before the tropical grass recommences growth.
Tropical	■ Allows soil water to accumulate over winter for use in spring[A] ■ Growing season from about November–May (6–8 months).	■ Green feed is only available over the warmer months of the year ■ Few options available and only for limited areas.

[A] Assumes there is no/little temperate annual grass or weed growth in winter

The characteristics required for long-term persistence of temperate annual legumes include high seedling vigour to establish quickly, deep rootedness to access more soil water, early flowering to ensure reliable seed set, especially in lower rainfall environments, and high seed yields to maintain a large soil seed bank. Choosing adapted species/cultivars that have high levels of hard seed also provides seed bank longevity, reducing its decline during years that are not suitable for legume regeneration, growth or seed set. The long-term persistence of annual legumes depends on the development and maintenance of a large seed bank. An additional characteristic of some legumes is their ability to continue growing after flowering if the season is suitable. This allows the maximum amount of nitrogen to be fixed and additional seed set in ‘good’ years.

Species or cultivars of annual legumes which have high levels of hard seed include serradella, biserrula, bladder clover, gland clover, arrowleaf clover, medics, rose clover and subterranean clover (**Figure 34**). It is often good practice to choose a range of temperate legume species for inclusion in a tropical grass pasture. This allows for variations in soil pH, texture and aspect across the paddock, also tolerance among the legumes to pests, grazing management, and less risk of animal health issues like bloat. Most annual legumes are aerial seeders and require careful grazing management to ensure high seed set for regeneration.

Figure 34: Serradella growing through a senesced tropical grass pasture in September (Photo: R Freebairn)

Challenges for tropical grass-annual legume mixes include their limited ability to replenish soil water due to ongoing pasture growth. Variable rainfall and low stored soil water during legume regeneration in autumn and seed set in spring can affect their persistence, especially on heavier soils. Stored soil water under tropical pastures is lowest in April–May, meaning annual legumes need good rainfall to establish, grow, and set seed. Dry autumns worsen this situation, as legumes struggle to regenerate. Growing season rainfall will determine dry matter production of the legume, with seed set dependent on spring rainfall. This is less of an issue in southern areas of NSW which receive more winter rainfall. On lighter soils, with lower water-holding capacity, adapted species can respond more quickly to smaller rainfall events.

Approaches to establish temperate annual legumes in tropical grasses

Temperate annual legumes are commonly sown into an established tropical pasture in the autumn following grass establishment. It is ideal to sow these legumes into the pasture before the autumn break, for example, in late February–March for some areas.

An alternative method is to sow unscarified/hulled seed with the tropical grass in spring or sow into the tropical grass pasture over the summer. This technique is only suitable for the hard seeded legumes, such as serradella, biserrula and bladder clover, which can be sourced unscarified or in hull. Rhizobia can be supplied at sowing using a long-life granular inoculant (e.g. Alosca granules, **alosca.com.au**). Using this technique to sow softer seeded legumes like subterranean clover and vetch is not recommended as premature germination, similar to a false-break is likely, and the seedlings will die.

A third option is to sow legumes in autumn before the tropical grass. This allows the legumes to establish a seed bank prior to sowing the tropical grass. In this case, the legumes could be an alternative to oats or dual purpose crop during the two-or-more year period during which weeds are controlled prior to sowing the tropical grass pasture. This approach is not recommended if significant broadleaf weed issues exist due to fewer herbicide options to control these weeds in legume pastures. Furthermore, legume flowering and seeding often happen at the same time as these weeds setting seed, complicating management.

Irrespective of the method used to establish temperate legumes, it is essential that they set seed the year they are sown to build a seed bank, or two years if seed set was poor in the first year. After the initial period, allowing the legumes to set seed every 2–3 years will ensure they maintain a large seed bank long-term.

Direct drilling legumes via a narrow point or disc seeder is the best method to add legumes to new or older tropical grass pastures. However, especially for moderate to higher rainfall environments, topdressing seed of hard seeded legumes into the pasture in late summer-autumn when spreading fertiliser can be reasonably reliable in many areas. If the season following their sowing receives below average rainfall, it is important to graze the legumes only lightly, or not at all, until after seed set to ensure plants set the maximum amount of seed.

It is advisable to choose earlier maturing hard seeded temperate legume cultivars as companion legumes for tropical grass pastures (Appendix 2) as they persist better over a series of tough years. In higher rainfall areas, mid to late maturing cultivars are better suited. In these environments, early maturing cultivars can be frost damaged at flowering. Additionally, earlier maturing cultivars are not always as productive as later maturing ones if spring conditions are favourable for growth. If longer season cultivars are not persisting, legume production will be limited by lower plant density.

Tropical grasses containing temperate annual legumes need to be grazed to reasonable dry matter levels in late summer–early autumn. Grazing will reduce grass herbage and ‘open’ the pasture, allowing light penetration for legume regeneration. In spring, aerial seeding annual legumes require rest from grazing to allow flowering and seed set. In contrast, annual legumes that bury their seeds, such as subterranean clover, may require grazing to promote flowering and seed production in good spring seasons.

Definition of hardseededness

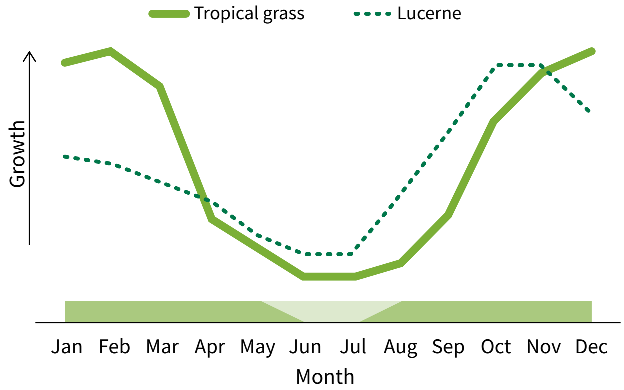
Hardseededness, sometimes called ‘seed coat impermeability’ is the main seed dormancy mechanism that regulates germination of pasture legumes. Hard seeds have an impermeable seed coat that prevents water entering and the seed imbibing. Seed softening is the process where the seed coat softens primarily in response to high temperatures and day-night temperature fluctuations. Moisture, or humidity, can also accelerate seed softening of some species. These conditions eventually cause the seed coat to split and the seed will germinate the next time it rains. This process can occur over a few weeks or many years.

Temperate perennial legumes

Lucerne is the most widely adapted temperate perennial legume in NSW and can be sown as a companion legume for tropical grasses on soils with higher water holding capacity. White clover is also an option in medium to high rainfall areas.

Lucerne has strong early spring growth, and in a tropical grass-lucerne mix, growth commences at least six weeks earlier in spring than a grass-only pasture. With autumn rainfall, lucerne can extend pasture growth later into autumn as well (**Figure 35**). While early spring growth benefits livestock production, the disadvantage is that lucerne can use soil water accumulated over winter, while tropical grass growth is slow. This can leave little or no stored soil water for tropical grass production until the pasture receives further rainfall (**Figure 36, Figure 37**).

Figure 35: Lucerne (···) has strong early spring growth compared to tropical grasses pastures (▬). A lucerne-tropical grass mixed pasture can provide at least six weeks additional feed in spring, compared to a grass-only pasture. Periods of production and soil water replenishment are indicated by ■ and ■ respectively. This figure does not account for growth and water use of temperate annuals such as ryegrass over the winter period



The extent that soil water is stored over winter can be manipulated by the winter activity rating of the lucerne cultivar; the higher the lucerne winter activity rating, the greater the winter growth, the more soil water used, and the less soil water stored. Conversely, lower activity rating lucernes have less winter growth and more soil water is stored. Good summer rainfall can replenish available soil water allowing the tropical grass to grow during the hottest part of the year when lucerne is less competitive and productive.

Approaches for establishing lucerne in tropical grasses

Since lucerne is a perennial species, it is not reliant on suitable conditions to regenerate each year. When grown in a mix with tropical grasses, it can be more productive than annual legumes and therefore able to fix more nitrogen. A challenge for sowing mixes of temperate and tropical perennial species is successfully establishing both pasture species aiming for an established pasture with approximately 50% tropical grass and 50% lucerne.

Establishment is typically successful when each species is sown at its optimum time. However, in the case of perennials with different growth patterns, the species that establishes first often monopolises resources, which can hinder establishment of the second species. A good option in many locations is to sow both species in spring when temperatures are suitable for both. Over time, the lucerne population will generally decrease, and the grass population will likely increase.

Figure 36: Lucerne commences growth about six weeks prior to digit grass. This provides feed for livestock in spring but can result in limited growth of digit grass later in spring (left) compared to pure digit grass (right) (Photo: S Boschma)

Figure 37: Lucerne cv. Venus growing in a pasture mix with digit grass cv. Premier in late-October, showing the early growth of lucerne compared with the tropical grass (Photo: S Murphy)

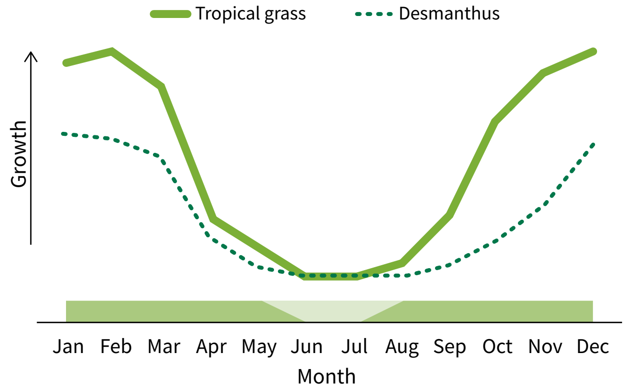
Tropical perennial legumes

Tropical legumes are widely sown in summer dominant rainfall regions. In NSW, they are most common on the high rainfall North Coast, although desmanthus has shown potential in North West NSW. In general, tropical legumes are not as well adapted to inland NSW conditions as the tropical grasses.

Tropical legumes are frost susceptible and have the same growth pattern as tropical grasses; growing for 6–8 months during the warmer months of the year (**Figure 38**). The length of their growth 'window' is dictated by temperature and the occurrence of frost. The grass and legume growing at the same time are directly competing for resources, but they can provide a more balanced grass-legume diet for livestock over the summer growing season. The winter period, when the pasture is inactive, allows soil water to accumulate (**Figure 38**).

Desmanthus grows best on medium to heavy textured soils in regions with high temperatures, long summers, and mild winters. Growth stops when frosts begin and recommences from the plant crown each spring. Desmanthus is tolerant of heavy grazing and drought (**Figure 39**). It is a short-lived perennial with plants living about three years and recruits readily from a soil seed bank (**Figure 40**). Desmanthus is susceptible to alfalfa mosaic virus, which can significantly reduce its productivity.

Figure 38: Desmanthus (---) grows at the same time as the tropical grasses (▬). This reduces the period this pasture produces feed for livestock (■), but it does allow for soil water accumulation during winter (■). Periods of production and soil water replenishment are indicated by ■ and ■ respectively. This figure does not account for growth and water use of temperate annuals, such as ryegrass, over the winter period.



In NSW, early flowering desmanthus cultivars should be sown to provide more opportunities for seed set. Thick swards of tropical grass restrict desmanthus growth. Livestock will selectively graze desmanthus, so high livestock numbers improve pasture utilisation, with rest periods to allow legume recovery. Strategic resting of the pasture is important to allow desmanthus to flower and recruit seedlings. Desmanthus does not cause bloat due to its condensed tannins.

Figure 39: Desmanthus-Bambatsi panic pasture being evaluated at Tamworth, northern NSW. Desmanthus holds its leaf during dry periods and has excellent drought tolerance (left). Desmanthus and Bambatsi panic pasture almost three weeks after 160mm rainfall in April, Tamworth, northern NSW (Photo: S Boschma)

Figure 40: Desmanthus can set large quantities of hard seed and recruits readily (Photo: S Boschma)

Establishing desmanthus in tropical grass pastures

Sow desmanthus with the tropical grass in spring. The grass sowing rate should be reduced to half that of a pure grass pasture to reduce competition between the grass and legume. Desmanthus seed needs to be scarified before sowing to ensure germination. Like all legumes, desmanthus seed should be inoculated with the correct rhizobia strain. Nodulation can be challenging to assess as nodules form on lateral roots, away from the tap root, and are easily dislodged (**Figure 41**). They are most easily seen in autumn.

It is important that desmanthus develops a seed bank. Some species/cultivars do not flower in their establishment year; therefore, it is essential that they set seed in the second year. Allowing desmanthus to set seed every 2–3 years will maintain a large seed bank. In NSW, seedling recruitment commonly occurs after Christmas, following good rainfall.

Animal health issues associated with legumes

Two common animal issues associated with livestock grazing temperate legume dominated pastures are bloat in cattle and red gut in sheep. These occur during periods where legume growth is high and lush, for example, in wet winter and spring periods. Pulpy kidney can also affect livestock and can be mistaken for bloat. Photosensitisation is another disorder than can occur with livestock grazing biserrula. This manual is not intended to provide advice on strategies to manage these risks. Consult a livestock advisor to better understand and manage the risks of legumes in grazed pastures or a veterinarian for advice on livestock health issues.

Figure 41: **(a)** Desmanthus nodules can be difficult to find and are easily dislodged when removing plants to inspect. **(b)** and **(c)** Nodules tend to form on lateral roots away from the tap root. (Photos: S Boschma)

(a)

(b)

(c)

Managing tropical pastures for production and persistence

Management for livestock production

Grazing principles

Tropical pastures are suited for grazing by both cattle and sheep (**Figure 42**) and can rapidly produce a large quantity of feed in favourable conditions. A challenge with tropical grasses is controlling peak growth with enough grazing pressure to maintain the pasture in a vegetative growth stage for as long as possible.

Figure 42: Sheep and cattle grazing a panic grass pasture near Manilla, northern NSW (Photo: S Boschma)

Feed quality is primarily reflected by the pasture growth stage. Young regrowth has the highest quality, which progressively declines as the plant matures and flowers (**Figure 43**). While there are differences in feed quality between species, these are more a reflection of relative plant maturity at any point in time. For example, if one species or cultivar matures faster than another, it will progress from the highest quality vegetative growth stage to lower quality reproductive stage at a faster rate.

Regular grazing is required to maintain a tropical pasture in a vegetative growth stage. In a study, feed quality was maintained for longer when growth was cut on two-week compared to six-week intervals (**Table 13**). Fertilising with nitrogen-based fertilisers at the start of the growing season can also increase crude protein percentage (**Table 13**).

During periods of peak growth, pastures with good soil moisture and fertility can grow 100kg DM/ha/day or more. To manage such growth, stocking density needs to be around 70 lambs/ha or 12 steers/ha, or a combination of these. Under these conditions, it is not possible to control growth in all paddocks. Effective grazing management focuses grazing pressure on some key paddocks by either combining mobs/herds or selecting a smaller paddock.

This will mean some paddocks will be ungrazed and the pasture can be left to flower, providing lower quality dry feed later in the season and over winter with supplementation. Alternatively, these pastures could be conserved as silage or hay, which are discussed later in the manual.

Figure 43: Guide to digestibility decline as tropical grasses mature (Source: Graham 2017 (MLA and NSW DRNSW), CC-BY-SA 4.0)

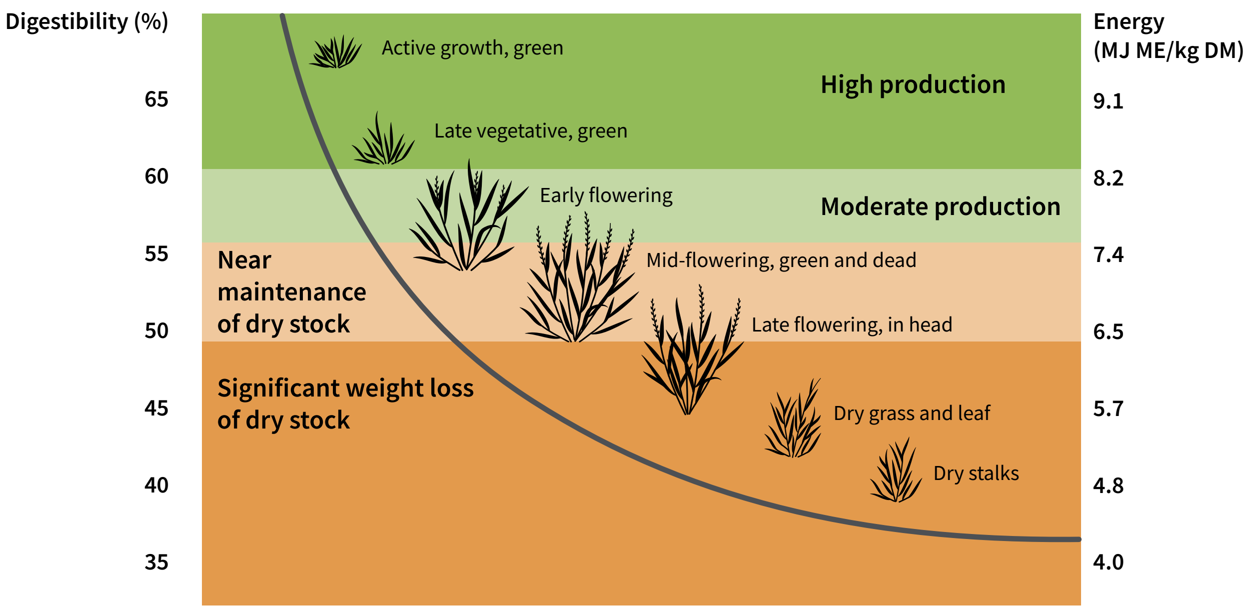


Table 13: Crude protein (%) and metabolisable energy (MJ ME/kg DM) of green leaves of digit grass unfertilised (-N) or fertilised (+N) with 100kg N/ha during the growing season at Tamworth, northern NSW. Forage quality is higher in fertilised regrowth. Both crude protein and metabolisable energy levels declined markedly from November to March in the unfertilised grass (Source: Boschma et al. 2015)

Month	2 weeks regrowth		6 weeks regrowth	
	-N	+N	-N	+N
	Crude protein (%)			
November	16	19	14	17
January	15	18	13	17
March	13	18	12	18
	Metabolisable energy (MJ ME/kg DM)			
November	9.5	9.6	9.1	9.3
January	9.1	9.5	9.2	9.2
March	7.1	7.7	7.2	7.8

Feed quality of tropical and temperate grasses

Tropical grasses have a lower feed quality compared to most sown temperate perennial grasses at the same growth stage. This is associated with greater lignification of the leaves of tropical grasses; a mechanism which minimises water loss (transpiration) and increases survival in hot summer conditions. When comparing the quality of temperate and tropical grasses for livestock production, it is important to remember:

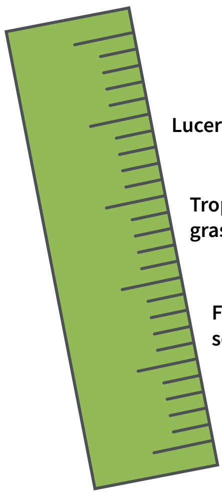
1. The relative performance of animals grazing temperate and tropical grasses of the same quality differs. While animal performance will be higher for a temperate grass with digestibility greater than 66%, performance can be greater when grazing a tropical grass with digestibility less than 66%. This difference is thought to be associated with the higher intake of green leaf of tropical grasses, due to their more upright structure and indeterminate flowering.
2. Tropical and temperate grasses grow at different times of the year, therefore, their relative quality is of little practical relevance. However, together as components of a feedbase, they complement livestock production. For example, tropical pastures can help fill the late summer–early autumn feed gap when temperate pastures are not actively growing and winter forages are not ready for grazing.

Other summer growing forage options

When considering the quality and role of tropical grasses in a grazing system over the summer period, they should be compared with other summer-growing species. Depending on the location, options include native perennial grasses, lucerne, and annuals such as forage sorghum, millet or cowpeas.

Native pastures dominated by summer-growing perennial grasses such as redgrass (*Bothriochloa macra*) and Queensland bluegrass (*Dichanthium sericeum*) can produce good quality herbage during the warmer months. However, they tend to mature quickly and only produce higher-quality forage for short periods, particularly following rainfall. Lucerne is a key summer-growing perennial legume in many areas and has a higher feed quality than tropical grasses. However, in pure stands, it has low groundcover and an increased risk of bloat. In summer, lucerne plants lose their leaves when they become water stressed. Forage sorghum generally has lower forage quality than tropical grasses under similar conditions. Additionally, it requires re-sowing each year and is generally not ready for grazing until about December, whereas tropical grasses can be grazed from October (**Figure 44**).

Figure 44: Well managed actively growing tropical grasses can have higher forage quality than forage sorghum and native perennial grass pasture, but less than that of lucerne



	Energy (MJ/kg DM)	Protein (%)
Lucerne	9.9–10.4	20–23
Tropical grasses	8.6–9.6	13–18
Forage sorghum	5.6–8.5	5–12
Native pasture	5.0–8.4	5–18

The role of tropical pastures in livestock systems

Matching livestock needs with pasture growth is a key factor in profitable grazing systems. It is a balance between providing good nutrition through pregnancy and lactation, and later for the growth of weaners and for breeders to recover body condition for joining.

In many areas of NSW, having a range of tropical and temperate pastures or forages provides the best opportunity, and the most cost-effective means to meet animal nutritional demands across the year (**Figure 45**). The proportion of tropical and temperate pastures and forages on a property will vary with location, enterprise type and other factors. For example, in southern NSW, tropical pastures will complement a largely temperate feedbase, whereas in northern NSW, tropical pastures will often be a larger proportion of the feedbase, complemented with temperate pastures and forages.

Figure 45: Sheep grazing digit grass in November at Tamworth, northern NSW. Digit grass is providing high quality feed whilst the cereal crop in the background is ready for harvest (Photo: S Baker)

Cattle production systems

Breeding cows require a large amount of moderate quality feed year-round. The quality and productivity of tropical grasses are well suited to grazing by breeding cows over the months the grasses are actively growing. This growth period will vary with location; ranging from six months or more in southern NSW to most of the year in northern NSW. Well managed and fertilised tropical grasses can meet the feed requirements for cows to achieve the condition scores required for joining and lactation (**Figure 46**). Standing dry tropical grasses can be cost effectively utilised with supplementation or temperate legumes for dry or lactating cows during dry periods or winter.

Tropical pastures provide excellent feed for young cattle growth from spring to autumn in many areas, with growth rates of 1–1.2kg/head/day common in yearling cattle (**Figure 47**). These pastures can support heifer growth to meet critical joining weights and be used to grow out cattle before finishing in feedlots or on winter forages.

Figure 46: Consol lovegrass pasture in December grazed by cows and calves in the Coonabarabran area, central NSW (Photo: S Boschma)

Figure 47: Heifers grazing digit grass that is actively growing following October rainfall in the Holbrook area, southern NSW (Photo: N Terlich)

Sheep production systems

Tropical grasses provide good nutrition for late pregnant and lactating ewes in autumn lambing systems. They can also supply moderate nutrition for weaned lambs throughout the growing season (**Figure 48**), including autumn, filling the feed gap while waiting for temperate perennial and annual pastures and forages to grow.

In spring lambing systems, the situation is reversed, as tropical grasses typically have insufficient quality to meet the needs of late pregnant ewes and insufficient growth for lactating ewes. However, in late spring they provide good nutrition for ewes to recover condition (**Figure 49**) and achieve moderate growth rates in weaned lambs.

The key to both lambing systems is having a balance of separate paddocks with tropical and temperate grasses, each containing 20 to 30% legumes to maintain feed quality.

Figure 48: Weaners grazing digit grass in the Gilgandra area, central NSW (Photo: R Freebairn)

Figure 49: Sheep grazing tropical grasses (Photo: B Kirsop)

Maintain soil fertility to maintain productivity

Good plant nutrition is essential to achieve optimum tropical pasture growth and quality for animal production. It is also important for ongoing production, effective water use, and persistence of established pastures. A pasture growing on fertile soil is more resilient to stresses like pests, disease, competition from weeds, drought and cold weather during winter. It will also respond quickly to rainfall, generate higher growth rates, producing more herbage of higher quality – all important contributors to animal production.

Fertilisers, particularly those that are nitrogen-based, increase pasture growth rates, annual production, and forage quality (**Figure 50**). However, nitrogen fertilisers are most effective when other nutrients, such as phosphorus and sulphur, are not deficient. Soil testing will identify nutrient deficiencies and soil constraints like soil acidity.

There are many fertiliser options available. Choosing a fertiliser and rate that will supply the desired amount of the deficient element is important. When deciding on a fertiliser type to use, it is important to assess:

1. What soil deficiencies exist
2. What elements individual fertiliser products contain in an available form
3. The relative cost of the deficient elements on an available unit basis
4. What is a sensible fertiliser rate to use?

Within a growing season, growth rates vary among grass species and are affected by soil fertility status and stored soil water. With fertility, including nitrogen, pasture growth rates in summer average about 80kg DM/ha/day but can be as high as 150kg DM/ha/day when growing conditions are favourable. When soil water is adequate, but tropical grass pastures lack nitrogen fertility, they produce about 35kg DM/ha/day during summer (**Table 14**). Once the pasture has used all stored soil water, growth will decline to less than 10kg DM/ha/day. Good soil fertility can also increase the pasture growing season length by at least a month compared to an unfertilised pasture.

Table 14: Average growth rates (kg DM/ha/day) of tropical grasses fertilised with nitrogen (N, 100kg/ha), phosphorus (P), and sulphur (S) were consistently higher than those fertilised with only P and S throughout the growing season

Season	N, P and S	P and S only
Early-spring	25	15
Late-spring	80	55
Summer	80	35
Autumn	40	25

Figure 50: Nitrogen fertilised and unfertilised digit grass with eight days of regrowth in March. During the growing season, 100kg/ha of nitrogen was applied (top) compared to no fertiliser (bottom). The fertilised grass produced a greater amount of higher-quality feed than the unfertilised grass (Photo: S Boschma)

Nitrogen

A tropical grass deficient in nitrogen will produce well below its potential dry matter production and feed quality will be well below optimum. A 10-year study where phosphorus and sulphur levels were maintained and either 0 or 100kg N/ha was applied annually found the nil-nitrogen digit grass pasture produced an average of 5.4t DM/ha annually, while the nitrogen fertilised pasture produced 9.4t DM/ha/year.

Nitrogen is generally supplied to a grass (herb or any non-legume) pasture from legumes, nitrogen fertiliser, or a combination of the two. Without regular addition of nitrogen, irrespective of the source, pasture productivity will decline over time (**Figure 51**). This is because nitrogen, and other nutrients, become bound in plant organic matter, making them unavailable for plant use. This phenomenon, known as pasture rundown, is widespread in areas of Queensland and is evident in older unfertilised tropical pastures in NSW.

Figure 51: Temperate annual legumes growing with tropical grasses provide opportunity for almost year-round feed. The nitrogen fixed by a well nodulated productive annual legume is available to the grass. In this picture taken in January, dark green foliage of digit grass is evident where temperate annual legumes grew the previous year compared to the surrounding areas without legumes (Photo: S Boschma)

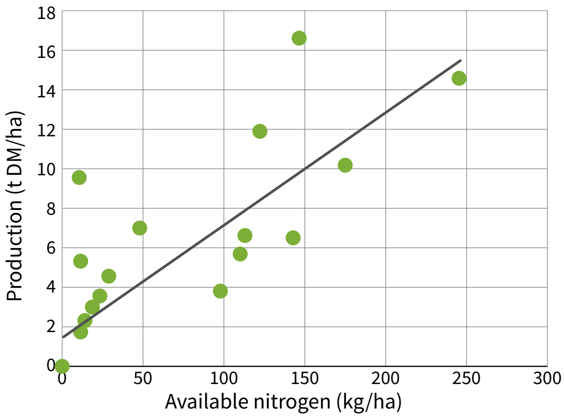
Sown tropical grasses reliably respond to summer rainfall when adequately supplied with soil nitrogen, typically showing a greater response than native pastures. Spring growth is usually robust when soil water is present, even in soils that have not received nitrogen fertiliser. This growth is due to mineralised nitrogen that has accumulated during the non-growing season, which includes winter and early spring.

To determine if nitrogen application is required, look for signs of deficiency in the grasses, such as paler green leaves, yellowing, and overall ill-thrift, particularly after rainfall. Comparatively darker green foliage of grasses around urine patches is also a sign that available nitrogen levels are low. Tissue testing and monitoring animal performance can also help guide the decision. If nitrogen deficiencies are observed or anticipated, applying nitrogen before a high-probability rainfall event is a good strategy.

Tropical grasses are responsive to increasing nitrogen fertility, although the response varies with species. As a rule of thumb, 43kg DM/ha can be produced per kg of nitrogen available to the pasture (**Figure 52**). This response varies with seasonal conditions; in dry years, the response will be less, and in wetter years, the response will be more evident until nitrogen levels are depleted.

Although growth responses can be observed at nitrogen rates over 100kg N/ha, applying more than 100kg N/ha as fertiliser is not recommended because it is unlikely to be economical in dryland environments. Nitrogen remaining in the soil at the end of the growing season will be available for winter growing species or be carried over for tropical grass growth in the following spring. However, during wet winter conditions, nitrogen could be leached below the root zone leading to potential environmental concerns.

Figure 52: Nitrogen increases pasture production. While the response varies with species and seasonal conditions, on average 43kg DM/ha is produced per kg of nitrogen available. The amount of nitrogen available includes both the nitrogen present in the soil and applied nitrogen



An annual application of 50–100kg N/ha can be highly economical, especially where legume growth is minimal or absent. Higher nitrogen rates are better suited to pastures grazed by livestock with higher nutritional demands, such as fattening stock or lactating cows, where the return on fertiliser investment will be highest. In contrast, dry cows on this pasture are unlikely to deliver the same return. A practical strategy involves a split application, applying 50–100kg N/ha in spring, with the option of a further 50kg N/ha later in the season if seasonal conditions are favourable. Before applying nitrogen, consider the following questions to ensure it is likely to be profitable:

1. Does the pasture have the capacity to respond? Is the species and the plant density suitable, and are weeds minimal?
2. What is the current soil fertility, including other deficiencies? If the soil has low sulphur and phosphorus, the response to nitrogen will be suboptimal.
3. Can the extra, higher quality feed produced be profitably used?

It is essential to apply nitrogen, particularly urea, ahead of a highly probable rainfall event. Without rainfall to wash broadcast nitrogen into the soil, losses of ammonia nitrogen can be as high as 30%. Nitrogen is available in a range of products. Application rates should relate to the percentage of nitrogen in the product. Organic forms of nitrogen in fertilisers, like animal manure, break down more slowly to produce available ammonia and nitrate. Some urea products are coated with urease inhibitors or other protective coatings to minimise nitrogen loss if follow-up rain is delayed or does not occur, but the cost is higher.

In drier western environments, summer rain can be erratic and less reliable. Maintaining productive temperate legumes with tropical grasses can also be difficult. In such situations, applying nitrogen in late winter or early spring ahead of a promising rainfall event will increase the likelihood that nitrogen will be available to support early spring and summer growth of the tropical pasture (**Figure 53**).

Long-term, the most sustainable strategy for improving nitrogen supply in grass pastures is to manage for a strong legume content. Legumes typically fix 15–25kg N/t DM produced. The majority of this nitrogen is potentially available for the pasture to use, with a small proportion removed as animal product, or lost during processes such as ammonia volatilisation, nitrification and denitrification. In a perennial pasture, legumes need to produce at least 4t DM/ha/year to supply 50kg N/ha/year for pasture use. Achieving this requires attention to species and cultivar choice, soil fertility, and grazing management.

Figure 53: Digit grass and Bambatsi panic stand at Collarenabri, North West NSW. This paddock is fertilised with nitrogen as legume growth can be inconsistent (Photo: R Freebairn)

Phosphorus and sulphur

Phosphorus and sulphur deficiencies can be addressed in either autumn to boost temperate legume production or in spring if the tropical pasture either contains no legumes or summer-growing legumes. Applying sulphur and phosphorus during the legume growth period will boost their production and maximise nitrogen fixation for later use by the tropical grass pasture. Phosphorus and sulphur are also important to achieve the best response to nitrogen fertiliser application. Phosphorus removal from soil in a grazed pasture is relatively slow compared to sulphur, and both are slower than nitrogen.

Lime

Many soils in central and southern NSW and lighter soils in northern NSW are acidic with pH_{Ca} <5.2. Regular monitoring of soil pH and aluminium levels is essential for long-term management and to guide decisions around pasture species selection and lime use. Acid soils should be tested in 5cm increments to a depth of at least 30cm to understand the extent of the issue. This identifies acidic subsoil layers that may not be evident in standard 0–10cm sampling.

The productivity of acidic soils can be improved by sowing acid-tolerant species such as digit grass, serradella or biserrula. Correcting soil deficiencies such as sulphur and phosphorus can also increase productivity.

Lime is the most effective way to correct soil acidity and reduce aluminium toxicity. It will enhance growth of companion legumes as well as the tropical grasses. Temperate annual clovers generally require $pH_{Ca} \geq 4.5$–5.0 for reliable establishment and persistence. Lucerne requires a soil $pH_{Ca} \geq 5.5$ in the surface and close to pH_{Ca} 5.0 in the subsurface to avoid aluminium toxicity and support strong nodulation.

While surface lime applications can improve topsoil conditions, lime has little impact at depth unless it is incorporated. This makes incorporation an important consideration where subsoil acidity is a problem. Even after liming, selecting acid tolerant species remains an important tool for maintaining productivity on these soils.

Livestock health issues associated with tropical grasses

Many valuable pasture plants can cause animal health issues under certain circumstances. Tropical grasses are no exception. They provide an excellent source of feed, but occasionally health issues may occur in certain situations (**Figure 54**). The main potential issues are summarised in **Table 15**.

In circumstances when issues occur or have potential to occur, management may need to be modified to minimise risk to livestock health and production losses. These problems can often be avoided by providing a range of pasture species for grazing and preventing livestock from grazing susceptible species for long periods of time. When sowing a pasture be aware of the possible livestock problems that may occur not only from the grass, but also the legume component which may have associated livestock health disorders. Consult a veterinarian or livestock advisor for advice on livestock health issues or production losses associated with tropical grasses.

Figure 54: Tropical grasses are suitable for sheep and cattle but occasionally health issues may occur under certain situations (Photo: S Baker)

Table 15: Some potential health issues associated with livestock grazing some tropical grass species. Note that these conditions, and others, can also be caused by a range of weeds

Health issue and livestock affected	Cause	Grass species
Hyperparathyroidism ('big head') can occur in horses and donkeys and occasionally nephrosis or hypocalcaemia in ruminants	High oxalate levels	Buffel grass, panic grass, purple pigeon grass, Kikuyu, setaria
Nervous ergotism ('staggers') can occur in sheep, cattle and horses	Stock eat flower heads affected by ergot fungus, *Claviceps paspali*	Paspalum
Nitrate poisoning can occur sporadically in cattle	Poisoning can occur grazing lush growth due to excessive nitrogen application. Most common from rapid growth following a protracted dry period. Serious toxicity occurs spasmodically after rainfall, fertiliser application and invasion of pasture by army worms.	Kikuyu
Photosensitisation can affect cattle, sheep and goats and rarely horses	Saponins produced in the plant cause secondary photosensitisation where livestock skin becomes sensitive to bright sunlight. Severe skin damage may result and death due to liver failure in extreme cases. Young animals are more susceptible.	Bambatsi panic, panic grass

Management for persistence

The fundamental principles of grazing management that are applied to other pastures are equally relevant for tropical pastures. This includes matching stocking rate to pasture growth to maintain the pasture in the vegetative growth stage and maintaining good soil fertility and at least 70% groundcover.

During periods of peak growth, a grass pasture can be heavily stocked with short rest periods. The duration that tropical pastures can be grazed before resting varies with the pasture species, overall pasture condition, and seasonal conditions. Rest periods are important to allow plants to replenish their reserves, and for some species, to provide opportunities to set seed and recruit new plants. If the pasture contains a perennial legume, for example lucerne, rest periods need to be longer.

Pastures commonly contain a mix of species, including different grasses and legumes, each with varying palatability. When paddocks are grazed for long periods, unpalatable species are seldom eaten, while palatable ones are continuously grazed. This causes the reserves of palatable species to become depleted with little chance for natural recovery or seed set. Conversely, less palatable species gain a competitive edge over the more palatable ones and will gradually dominate the pasture over time.

In pastures containing annual legumes, it is important aerial flowering species set seed every 2–3 years. Destocking or reducing stock density when the annual legumes are flowering will provide an opportunity for them to set seed.

An important aspect for many soils and terrains is that maintaining good pasture groundcover levels protects the soil surface and improves rainfall capture. Low groundcover can lead to large water losses, and soil water, like good soil fertility, is critical for effective pasture growth.

Managing temperate legumes in a tropical pasture

Tropical grass-temperate annual legume mixes require grazing management to ensure the ongoing persistence of both components. The critical periods are during the shoulder seasons in autumn and spring, when both components are growing. These times are important to prepare the pasture for good productivity of the next component, that is, late summer-early autumn, prior to the autumn break to encourage annual legume regeneration, and late winter-early spring in preparation for regrowth of the tropical pasture.

In late summer to early autumn, the perennial grass component of the pasture needs to be grazed more intensively to reduce the bulk to approximately 3t DM/ha and open the canopy. This provides space and light for the annual legume to regenerate (**Figure 55**). A tropical pasture that has not been grazed, even with moderate groundcover, can reduce light penetrating the canopy by more 50%. It is not always possible to graze every tropical grass paddock to this level, but aim to have the paddocks with temperate legumes well grazed by late autumn. These target paddocks can change from year to year. If grazing is not an option, mulching or slashing (avoid forming windrows of cut material) or cutting hay may be options. Conserving excess feed as hay or silage is discussed in a later section.

Figure 55: Grazing the tropical pasture to remove the bulk and open the canopy allows light to enter encouraging temperate legume regeneration (Photo: R Freebairn)

In winter and spring, when growth of temperate annual legumes is high, grazing is needed to reduce their dry matter to a maximum of 3.5t DM/ha. Excessive growth creates a damp and shaded environment, which can smother the tropical grasses as they attempt to regrow in spring (**Figure 56**). Plant losses of tropical grasses have occurred following these conditions (**Figure 57**). If grazing pressure cannot be applied, baling the legume as hay could be an option to remove the bulk, allowing the grass to grow, however, the legume may not recover sufficiently to set large quantities of seed (**Figure 58**).

Figure 56: Excessive temperate legume can smother tropical grasses. Careful management is required to reduce the bulk but still allow the legume to flower (Photo: R Freebairn)

Figure 57: Large biomass of subterranean clover in spring has killed grasses and reduced growth of a native pasture. The same can occur in tropical grass pastures (Photo: S Boschma)

Figure 58: Serradella and subterranean clover in a tropical grass pasture were cut and baled as hay in October. While subterranean clover will still set seed, the serradella is unlikely to recover sufficiently to set a large quantity of seed. In this pasture, both legumes had large seedbanks and regenerated with good seedling densities the following autumn (Photo: R Freebairn)

Management in cold environments

Tropical grasses can be productive in tableland environments, with some good examples of their long-term persistence and productivity. Maintaining these grasses over time can be particularly challenging in higher-altitude areas. Their productive growth period is shorter due to a prolonged frost period from autumn to spring, but this can be complemented by a productive temperate legume component. Careful paddock selection is crucial when choosing where to sow tropical grasses in these environments. Paddocks with a northern aspect, higher in the landscape will be warmer than those with a southern aspect located at the bottom of a valley.

Tropical grasses are more vulnerable in colder tableland environments, especially above 800m elevation. Persistence in these environments is generally limited to 5–7 years without favourable conditions and careful management. In an experiment at Orange on the Central Tablelands (1,000m above sea level), digit grass, Bambatsi panic, paspalum and Kikuyu persisted four years in a low-lying paddock (**Figure 59**). Only paspalum persisted seven years, with a small number of plants of digit grass and Kikuyu also surviving. Likewise, at Glen Innes on the Northern Tablelands (1,070m above sea level), these same species persisted well in the first 2–3 years, however, by year five, only paspalum and Kikuyu persisted, along with a small number of digit grass and Bambatsi panic plants.

Paspalum and Kikuyu are often considered transitional species between tropical and temperate zones and are among the most cold-tolerant tropical grasses. This cold tolerance enables these species to persist in environments that experience regular frosts and lower mean annual temperatures.

In these cooler environments, management needs to favour the requirements of the tropical grasses rather than well adapted companion temperate legumes. Critical periods for management are at the beginning and end of the perennial grass growing season. In spring, it is important to ensure that legume growth does not result in extended periods of total foliage cover. This is especially crucial during favourable winter-spring seasons when annual legume growth is vigorous and the growing season is longer (**Figure 60**). Prolonged coverage can smother the early grass regrowth, leading to plant death.

At the end of the tropical grass growing season, in late summer-early autumn, graze the pasture to open the grass canopy to encourage temperate legume regeneration. Tussock grasses, like digit grass and Bambatsi panic, should maintain a height of 30–40cm with bulk around the plant crown. This cover helps insulate the crown and can raise its temperature by about 2°C and protecting it from extreme temperatures.

Figure 59: Tropical grass evaluation experiment conducted at Orange on the Central Tablelands with snow. Digit grass, Bambatsi panic, paspalum and Kikuyu persisted four years. After seven years, only paspalum had survived (Photo: N Munday)

Figure 60: Balansa clover in October is showing huge growth following a wet winter at Orange. At that time, the legume was about 9t DM/ha and 60–70cm tall, higher than a gum boot (as shown). Total legume biomass production during the winter period was approximately 13t DM/ha (Photo: N Munday)

Management during and after drought

Drought is a stressful time with many decisions associated with the farm business, including reducing stock numbers and whether to supplementary feed. During these times, pastures are often overgrazed resulting in reduced ground cover and increased soil erosion. Also, when rain does fall, water runoff increases, resulting in less available water for pasture growth. Overgrazed pastures recover more slowly from dry periods, have greater perennial plant losses, and more bare ground for weeds to grow, resulting in less total pasture growth. Maintaining at least 70% groundcover and 1.5t DM/ha on tropical pastures during dry periods helps avoid these problems. In extended droughts, groundcover and residual biomass will naturally decline over time. However, maintaining as much groundcover as possible will allow the pasture to regrow quickly following rainfall (**Figure 61**).

Some species and cultivars are more drought-tolerant than others. In inland NSW, digit grass and Bambatsi panic showed excellent drought tolerance during the 2017–19 drought, while panic grass and Rhodes grass were less tolerant.

After an extended drought, grazing management is again key to supporting pasture recovery. If rain falls during warmer months, tropical grasses can respond quickly, even to small rain events (5mm) on lighter country. Where possible, allow the grasses to regrow to at least 2t DM/ha before grazing. This will provide an opportunity for the grasses to replenish root reserves, supporting long-term persistence and productivity. Allowing pastures to flower is also important after a long period of stress, such as drought. Upon flowering, most grasses have recovered their reserves.

Figure 61: Tropical pasture recovery in November, four weeks after drought breaking rainfall (Photo: R Freebairn)

Degraded or thin swards of tropical grasses of the more persistent species can recover and thicken in most areas of NSW if good grazing management is practised. Seedling recruitment can increase the plant density of grasses, such as digit grass (**Figure 62**). The recommended plant density of tussock grasses like digit grass is at least 4 plants/m^2. For these grasses, monitoring recruitment and destocking or maintaining low stock numbers can allow the seedlings to mature. Strategic herbicide use to reduce problem broadleaf weeds (like galvanised burr) may also be required. Addressing soil fertility and maintaining companion legumes will also be important for longer-term pasture recovery and productivity.

Figure 62: Digit grass can recruit from seed set the previous year. Not all of these seedlings will survive, but recruitment offers the opportunity to thicken stands if plants are lost (Photo: S Boschma)

Soil fertility affects how well tropical pastures can respond after drought. Depending on the duration of the drought, levels of mineralised soil nitrogen may have increased. This can support pasture growth for several weeks following rainfall, but for sustained pasture growth and quality, good soil fertility is essential—particularly while moisture and temperature conditions remain favourable (**Figure 63**).

Wet winters following drought can result in large legume biomass. These can increase the risk of livestock health issues such as bloat, red gut and pulpy kidney. Legumes may require management in late winter-early spring to ensure there is sufficient biomass for seed set without smothering the tropical grass in spring. See 'Managing temperate legumes in a tropical pasture' section for further detail.

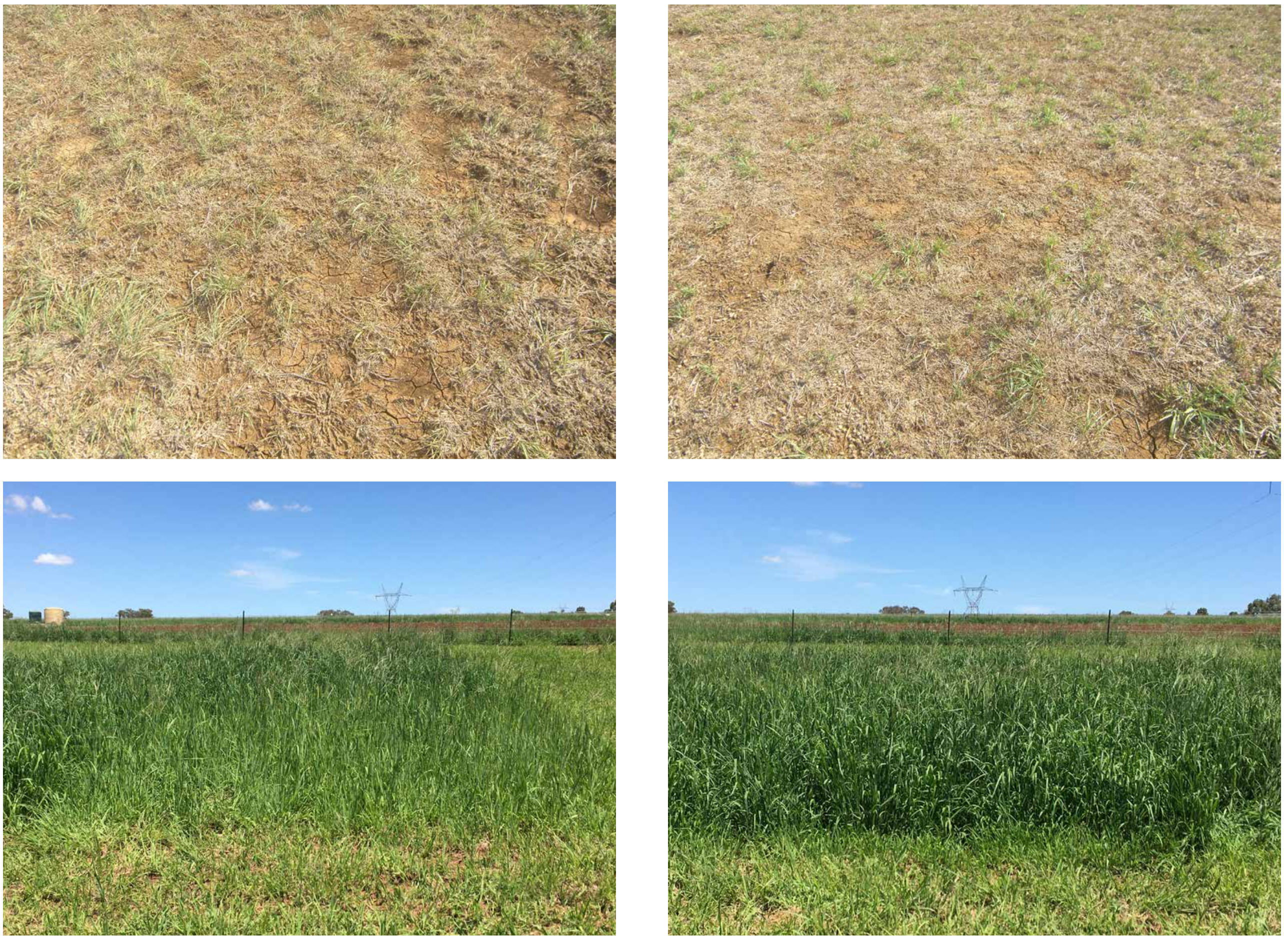
Figure 63: Digit grass with a seven-year history of annual nitrogen fertiliser application of 0 (left) and 100kg/ha (right) in January 2020 near the end of the 2017–19 drought (top row), and six weeks later (bottom row) after receiving 256mm of rainfall (February 2020) (Photos: S Boschma)

Nil nitrogen fertiliser

100kg/ha nitrogen fertiliser

Near the end of the 2017–19 drought

6 weeks after good rainfall in February 2020



Management after fire

Tropical grasses, especially those with a large bulk of material (e.g. more than 4.0t DM/ha) tend to be highly flammable and burn hot. All litter is generally burnt, leaving the soil surface bare, increasing the risk of soil erosion from post-fire storm events.

Tropical grasses are generally tolerant of fire and recover quickly if sufficient rainfall is received. Both digit grass and Bambatsi panic are fire tolerant. Rhodes grass also recovers well and there is no long-term damage to panic grasses after fire. Kikuyu can survive severe bushfire due to the below ground rhizomes (**Figure 64**). Buffel grass is also highly fire tolerant.

Tropical grass regrowth can commence within days after a fire, but ongoing growth depends on rainfall and the levels of stored soil moisture (**Figure 65**). During recovery, it is desirable to delay grazing for at least 3–4 weeks after rainfall, then rotationally graze to allow the pasture to fully recover (**Figure 66**).

Figure 64: Kikuyu regrowth two weeks after being burnt near Bega, South Coast (Photo: S Baker)

Figure 65: Digit grass recommencing growth three days after rainfall following fire. All litter had been burnt, leaving the ground bare (Photo: R Freebairn)

Figure 66: Digit grass which has fully recovered three months after fire (Photo: R Freebairn)

Pests and diseases associated with tropical grasses

There are many pests and diseases that can impact tropical grasses, however, most are not a significant problem or occur infrequently. Warm and humid conditions typically favour fungal diseases which are more frequently seen in coastal and higher rainfall areas. Pasture dieback is the most significant condition impacting tropical grasses causing the death of grasses. **Table 16** lists some of the more common pests and diseases. For further information contact a local agronomist.

Table 16: Some pests and diseases that can affect tropical grasses (Source: Cook et al. 2020)

Pest or disease	Cause and symptoms	Main grass species impacted
African black beetle and other scarab beetles	Scarab beetle larvae, including African black beetle (*Heteronychus arator*) larvae feed on plant roots. In severe infestations pastures become patchy and can be rolled back like carpet. Adults feed on young plants favouring the stems close to ground level, often damaging the growing points and can cause plant death. Older plants can survive but are weakened.	Many species including Kikuyu, paspalum, Rhodes grass
Armyworms	Both common armyworm (*Leucania convecta*) and fall armyworm (*Spodoptera frugiperda*) caterpillars can cause significant defoliation, often resulting in death of young plants. Plants may regrow if stems are not eaten. Fall armyworm favours maize and sorghum but can also impact pasture grasses.	Many species including setaria, Rhodes grass, Kikuyu
Black spot	A fungal disease caused by *Bipolaris* spp. Leaves have black spots and turn yellow. Infected leaves are unpalatable to livestock but neither plant growth nor persistence is affected.	Kikuyu
Buffel blight	The fungus *Pyricularia grisea* causes oval shaped brown spots on leaves. Leaves turn yellow then die. Plants have reduced ability to photosynthesis resulting in reduced production.	Buffel grass
Ergot	The fungus *Claviceps paspali*, causes a dark sticky exudate on the seedhead. Staggers can occur in livestock, particularly cattle, that consume the infected seedheads.	Paspalum
Kikuyu yellows	A fungus like organism (*Verrucalvas flavofaciens*) causes affected Kikuyu plants to turn yellow. Spread by water borne spores, usually moves down slopes.	Kikuyu
Leaf spots	Several fungi species can cause spots, blotches or lesions on leaves. Affected leaves can turn brown and die. Does not result in plant death.	Many species including setaria, Kikuyu, creeping bluegrass
Pasture dieback	A condition involving pasture mealybug (*Heliococcus summervillei*). Symptoms include leaf discolouration, stunted and unthrifty plants and ultimately plant death. Areas of dead grass are colonised by broadleaf weeds and legumes.	Most species sown in NSW
Rust	Caused by a fungus (*Puccinia* spp.) which produces orange/brown spores on grass leaves. Typically occurs in more humid conditions. Does not result in plant death.	Many species, including forest bluegrass and creeping bluegrass
Spider mite	Multiple species occur in Australia. Mites are hard to see with the naked eye and spin a fine web that covers grasses. Rarely causes plant death.	Many species

Utilising excess forage produced by tropical perennial grasses

In periods of high growth, it can be difficult to keep a tropical pasture in the vegetative growth stage to maintain forage quality for animal production. There are two main options to utilise forage that is surplus to livestock needs:

1. **Conservation**. Making hay or silage can be an effective method to conserve surplus feed and maintain pasture quality.
2. **Allow feed to senesce and graze during winter with supplements**. Dry standing feed provided by frosted pastures at the end of the growing season can be an effective 'standing haystack' in the paddock for use over the winter months. This feed will have low quality, and livestock will require supplementation or a good temperate legume or annual grass content to increase pasture utilisation and prevent animal weight loss.

Conserve as hay or silage

Making hay or silage offers a way to store surplus forage to supplement livestock during 'out of season' production, improve drought preparedness, increase enterprise flexibility or provide marketing opportunities (**Figure 67**, **Figure 68**). The choice whether to make hay or silage is individual and some advantages and disadvantages of both are provided in **Table 17**.

Figure 67: Silage being stored in a pit (Photo: S Boschma)

Figure 68: Hay made from digit grass (Photo: R Freebairn)

Table 17: Some of the advantages and disadvantages of hay and silage (Modified from Kaiser et al. 2005)

	Hay	Silage
Advantages	■ Simple and easy to store ■ Efficient to transport with lower costs on a dry matter basis ■ Lower transport costs per unit of protein, metabolisable energy, and neutral detergent fibre due to higher dry matter content ■ More contractors are equipped to make hay ■ Baling costs are lower per tonne ■ More market opportunities available.	■ Higher quality feed test results compared to hay ■ Less exposure to weather damage (pit) ■ Unaffected by the type of storage and storage surface (pit) ■ Good silage is free of weed seeds; weed seeds can be killed during silage fermentation ■ A good fodder conservation option when consumed on the same farm it is produced.
Disadvantages	■ Can be exposed to weather damage whilst curing in the paddock ■ Generally lower feed test results compared to silage ■ Degrades faster if stored unprotected outside; hay is best stored in a shed.	■ Care is required to get the process right; excluding oxygen is essential to ensure silage will store and not waste ■ Fewer market opportunities ■ Wrapped silage bales tend to be damaged during handling; exposure to oxygen causes spoilage ■ Not easily transported; best made and used on property Silage contains a lot of water, therefore: ■ Transport costs are higher on a dry matter basis compared to hay ■ Higher delivery cost based on protein, metabolisable energy, and neutral detergent fibre on a dry matter basis ■ Baling cost per tonne is higher.

The most cost-effective hay or silage is made from high-quality pasture as it can be used to achieve higher animal performance (**Figure 69**). Baling hay from low-quality tropical grasses can also be worthwhile. For example, baling tropical grasses after flowering will produce low quality hay, but open the pasture to allow legume regeneration in autumn (**Figure 70**). The conserved grass is useful to feed out with lush crops such as lucerne to reduce bloat risk.

To produce the highest quality silage, tropical grasses should be cut when they are at a vegetative growth stage. Delaying cutting to when grasses are flowering generally produces more silage, however, quality will be lower and not as suitable for animal production. The optimum time to harvest is a compromise between quality and quantity. The ideal time is when forage quality is acceptable and dry matter yields are high enough for it to be economical. This typically occurs when the pasture is in the late vegetative growth stage and is commencing stem elongation in preparation for flowering. Additional benefits from harvesting at this stage include faster wilting and drying, and higher pasture regrowth potential.

Tropical grasses are more difficult to ensile than temperate grasses because they have low water-soluble carbohydrate levels. They also have higher fibre content. Traditionally, Kikuyu is the tropical grass most commonly conserved as silage, but the principles for conserving tropical grasses are similar across all species. The best quality Kikuyu silage is made from young, leafy growth that has 4–5 new green leaves. This is usually achieved after about 25–35 days of regrowth (under good growing conditions) and reaches a height of approximately 25–30cm. Metabolisable energy and protein levels decline if harvest is delayed after this period (**Table 18**). Cutting at this growth stage also gives the best potential for pasture regrowth. These principles are also the same for hay making.

Figure 69: Tropical grass hay can be higher quality than average cereal hay (Photo: R Freebairn)

Figure 70: Hay made from digit grass in full flower will be lower quality, but can still be worthwhile (Photo: R Freebairn)

Table 18: Effect of pasture growth stage on quality and potential yield of Kikuyu silage (Kaiser et al. 2004)

Growth stage	Approximate days regrowth	Metabolisable energy (MJ ME/kg DM)	Crude protein (%)	Potential yield (t DM/ha)
Vegetative	25–35	9–10	15–20	2.0–3.5
Late vegetative	40–50	8–9	11–15	2.5–5.0
Flowering	>50	6	6–10	3.0–8.0

Tips for making high quality silage from tropical grass pastures such as digit grass:

1. Fertilise at least four weeks before cutting. There may be issues with elevated levels of nitrate if grasses are cut for ensiling too soon after nitrogen fertiliser is applied.
2. Cut when the pasture is vegetative or commencing stem elongation.
3. A rapid wilt of the cut grass to 35% DM is important to concentrate water soluble carbohydrates and improve fermentation. This is a little higher than recommended for temperate forages.
4. Apply a commercial silage inoculant. They are a cheap insurance to ensure suitable bacteria are present for effective fermentation.

TopFodder™ silage courses cover all aspects of silage making, storing and feeding. Contact NSW Local Land Services for information when the next course may be held or to express interest in attending. For a copy of the manual go to: **tocal.nsw.edu.au/publications/field-crops-and-pastures/successful-silage**.

NSW Department of Primary Industries and Regional Development have a range of tools that can be used to assist with silage production. These can be found at **dpird.nsw.gov.au/agriculture/pastures-and-rangelands/silage**.

Dry standing feed

Often, it is impossible to utilise all tropical grass growth, and there will be a bulk of dry standing feed at the end of summer (**Figure 71**). This effectively forms a ‘standing haystack’ that can be used during winter. Livestock require supplementation to make use of this dry pasture without weight loss.

Provided the standing tropical grass material is fairly open, temperate legumes can regenerate and supply much of the high protein-high energy supplement needed by livestock (**Figure 72**). Without good temperate legume or annual grass growth, additional supplements will be necessary for livestock to make the most of the pasture. See a veterinarian or livestock officer for advice on supplementation.

Figure 71: If allowed to senesce in autumn tropical grass pastures can provide a large bulk of feed for use during the winter months with supplements (Photo: S Baker)

Figure 72: When the tropical pasture is open, temperate annual legumes can regenerate providing quality feed and improve utilisation of the sensed grass over the winter months (Photo: R Freebairn)

Appendix 1 – Tropical grass seedling identification

MA Brennan, SP Boschma and CA Harris

Seedling identification

Distinguishing between sown tropical species and annual grass weeds at the seedling stage in an establishing pasture can be difficult. Following are photos and descriptions of some seedling characteristics that can be used to identify tropical grass species and common summer-growing annual grass weeds.

Characteristics such as colour and hairiness can be useful for identifying grass seedlings, noting that these can change as plants develop. The descriptions in this section focus on the seedling stage, emergence and the following six weeks. The photographs are to assist with identification, but it should be noted that growing conditions such as temperature, sunlight, nutrition and available moisture may change the physical appearance of seedlings at similar stages. For example, seedlings can appear compressed when moisture is limiting or elongated under particularly moist conditions. The characteristics described below can be seen either with the naked eye or a magnifying lens with a 10x power magnification.

Seedling characteristics

The basic leaf structures of a grass seedling include the sheath, blade, tip (sometimes called apex), collar, ligule and auricles. These are shown in **Figure A1.1**. Each leaf consists of a sheath, the portion of the leaf that encircles the stem, and a blade, which is the flat expanded portion of the leaf. The leaf blade has an upper and lower surface, margin and tip. The junction of the sheath and the blade is referred to as the collar region and usually includes a ligule and sometimes auricles. The ligule is an outgrowth on the inner surface of the leaf blade in the collar region. The outgrowth can be membranous (thin and soft like a membrane) or hairy. The shape, colour, and margin of a ligule are usually consistent and useful when identifying characteristics for a species. The auricles are appendages that may be found wrapped around the stem in collar region. They can also be membranous or have hairs.

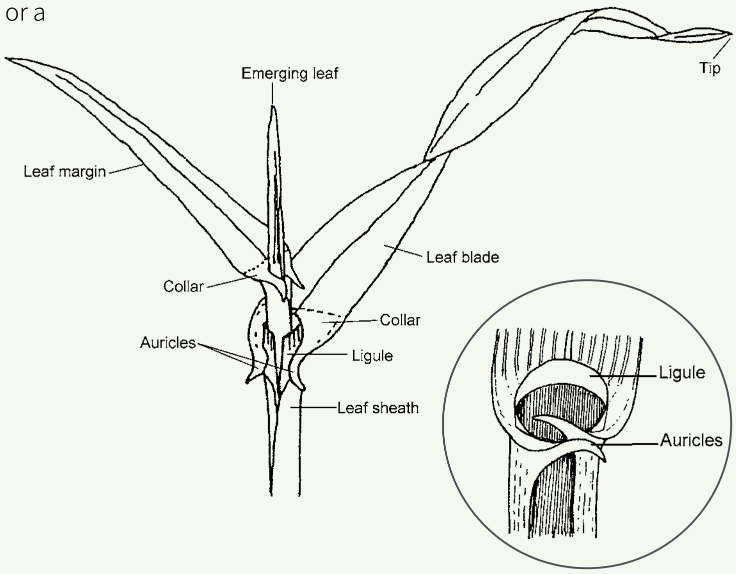


Figure A1.1: The plant features used to assist the identification of grass seedlings [Modified from Moerkerk (1998) and Jacobs et. al. (2008)]

Perennial grasses

Angleton grass

Figure A1.2: Angleton grass cv. Floren has a membranous ligule and long hairs on the top of the leaf blade near and at the edge of the collar

Figure A1.3: Angleton grass seedlings can appear compact in marginal growing conditions

Leaf: Sheath is hairless but has distinct long hairs on the margin of the upper side of the leaf blade towards the collar (usually visible after the 3-leaf stage) (Figure A1.2).

Ligule: Distinct and membranous (Figure A1.2).

Auricles: Not distinct, but there may be long sparse hairs on the edge of the collar (Figure A1.2).

Other features: Seedlings can appear compact in marginal growing conditions (Figure A1.3).

Bambatsi panic

Figure A1.4: A leaf blade of a Bambatsi seedling showing the white mid-rib, ligule with a fringe of minute hairs and long hairs along the leaf margin at the collar

Figure A1.5: A Bambatsi seedling showing the blue-green colour as the seedling matures

Leaf: The leaf blade is predominantly hairless, but sparse long hairs on leaf blade margin near the collar may be evident (Figure A1.4). As the seedling matures the leaf blade changes from a pale green to a blue-green colour. A distinct white mid-rib colouration on the leaf blade can be seen as the seedling matures (Figure A1.5).

Ligule: Short and membranous with a fringe of minute hairs (Figure A1.4).

Auricles: No distinct auricle but has long hairs along the edge of the collar (Figure A1.5).

Creeping bluegrass

Figure A1.6: Creeping bluegrass seedling compressed in stressed conditions showing blue-green colour

Figure A1.7: Creeping bluegrass seedling elongated in moist conditions and showing distinct red colour at the base of the seedling

Leaf: There are no visible hairs on the sheath or blade up to 3-leaf stage. Leaves are blue-green in colour (**Figure A1.6**).

Ligule: A short papery membrane with a few hairs on the edges.

Auricles: Not distinct.

Other features: After the 3-leaf stage there may be some sparse hairs at the base of the plant. A distinct red colour may be visible at the base of the seedling (**Figure A1.7**).

Digit grass

Figure A1.8: Digit grass seedlings in moist conditions showing the broad first leaf.

Figure A1.9: Digit grass seedling showing hairs on the underside of the leaf and base of the plant

Leaf: Noticeable hairs on leaf sheath. The first leaf is broad with a rounded tip (**Figure A1.8**). Leaf blades are mostly hairless on the upper side, but some fine hairs may be detectable with a hand lens. The underside of the leaf blade is covered with fine hairs becoming less hairy to hairless as the seedling matures.

Ligule: Small, membranous and rounded.

Auricles: Not distinct.

Other features: Noticeable hairs at the base of the seedling (**Figure A1.9**).

Forest bluegrass

Figure A1.10: Forest bluegrass seedlings are brighter green with a red base in moist conditions

Figure A1.11: Forest bluegrass seedlings are blue-green when establishing during cool nights but still have a red base

Leaf: Sheath smooth without hairs. Leaf blades long and narrow tapering to a point at the tip and mostly hairless.

Ligule: Short and membranous.

Auricles: No distinct auricle, but there may be sparse hairs at the collar region (detectable with a magnifying lens).

Other features: Colour of seedling varies with growing conditions. In moist conditions seedlings will usually be light green with a slight red-purple colouring at the base of the seedling (Figure A1.10). When establishing under cool conditions seedlings will generally be blue-green in colour, but will still have a purple-red base (Figure A1.11).

Kikuyu

Figure A1.12: Kikuyu seedling showing folded leaf blade

Figure A1.13: Kikuyu seedling showing whitened leaf sheaths

Leaf: Sheath has some hairs. Leaf blade is light-green and slightly folded with hairs on the lower surface becoming less hairy to hairless as the seedling matures (Figure A1.12)

Ligule: Not distinct.

Auricles: Not distinct but can have a membrane extending down the leaf sheath.

Other features: Leaf sheaths tend to whiten on older seedlings and stolons are white and fleshy (Figure A1.13)

Lovegrass

Figure A1.14: Consol lovegrass seedling showing the narrow and tapering of the leaves

Figure A1.15: The collar region of a Consol lovegrass seedling showing sparse hairs

Leaf: Sheath may have some short fine hairs. Leaf blade is long, narrow and tapering (Figure A1.14). Blade is predominantly hairless, sometimes with a few hairs on margin of leaf near the collar region (Figure A1.15). The leaf blade colour can be variable from blue-green to green and slightly rough on both sides to touch.

Ligule: A short rim of hairs which can be seen with a hand lens.

Auricles: Sparse hairs detectable with a hand lens (Figure A1.15).

Other features: Base of the seedling may have some short fine hairs and becomes hairier as plant matures.

Panic grass

Figure A1.16: A panic seedling showing distinct red-purple colour at the base of the plant

Figure A1.17:The leaf sheath of panic seedlings have short hairs. The upper side of the leaf blade is smooth

Leaf: Sheath has short fine hairs. Short fine hairs may also be present on the underside of the leaf (detectable with magnifying lens). The upper side of the leaf blade is smooth. Leaves are often arranged in pairs opposite each other on the stem. Leaves of Gatton seedlings have a distinct mid-rib (Figure A1.16)

Ligule: Membranous.

Auricles: No distinct auricles, but fine short hairs at the collar region.

Other features: Base of the seedling is a distinct red-purple colour (Figure A1.16, Figure A1.17)

Purple pigeon grass

Figure A1.18: A purple pigeon grass seedling in the field showing the narrow leaf tip

Figure A1.19: Purple pigeon grass seedlings can have a red base

Leaf: Sheath may have fine hairs that are usually only visible with hand lens. Leaf blade is hairless and sharply narrows to a pointy tip (Figure A1.18).

Ligule: Short and membranous fringed with hairs that are visible with a hand lens.

Auricles: Not distinct.

Other features: A reddish base may be visible (Figure A1.19).

Rhodes grass

Figure A1.20: The leaf blades of a Rhodes grass seedlings have a slight twist and curve downwards and the seedling has a distinct red-purple base

Figure A1.21: A Katambora Rhodes grass seedling showing a membranous ligule and fine hairs on the leaf sheath

Leaf: Sheath is covered with fine hairs. The leaf blades are flat and curved downwards with a slight twist (Figure A1.20). The leaf blades are also covered with fine hairs that disappear as the seedling matures.

Ligule: Small and membranous (Figure A1.21).

Auricles: No distinct auricle but has long sparse hairs in the collar region.

Other features: Seedling has a distinct red-purple base. Tiller bases are distinctly flattened.

Setaria

Figure A1.22: The leaf blades of a setaria grass seedlings are smooth and leaf sheath may have red-purple venation

Figure A1.23: Larger setaria seedlings have distinctive flattened bases

Leaf: Leaf sheath can show red-purple venation. Leaf blades are smooth and hairless, slightly folded with a mid-rib (Figure A1.22). New leaves may have a crinkle nearer the leaf sheath.

Ligule: Small indistinct membrane may be evident.

Auricles: No distinct auricle.

Other features: Larger seedlings have distinctly flattened bases (Figure A1.23).

Some common summer annual grass weeds

Barnyard grasses *Echinochloa* spp.

Figure A1.24: A barnyard grass seedling showing the red-purple colour at the base of the seedling

There are two species of this annual grass weed: awnless barnyard grass (*Echinochloa colona*) and barnyard grass (*Echinochloa crus-galli*).

Leaf: Leaf blades are long, tapering to a point (Figure A1.24) and predominantly hairless.

Ligule: Not distinct.

Auricles: Not distinct.

Other features: Seedling base is hairless and may be a red-purple colour (Figure A1.24). Awnless barnyard grass often has a red base while barnyard grass does not. As the plant matures purple-red bands are often seen on the leaf blade of awnless barnyard grass particularly when the plant is stressed. The tiller base is distinctly flattened.

Liverseed grass *Urochloa panicoides*

Figure A1.25: The first leaf of a liverseed grass seedling to emerge is short and broad

Figure A1.26: Hairs on the leaf margin and sheath of a liverseed grass seedling. This photo also illustrates the wave like nature of the leaf margin

Leaf: Sheath hairy. First leaf to emerge is short and broad (Figure A1.25). Leaf blade has a distinct wavelike pattern along the margin with long hairs (Figure A1.26).

Ligule: Membranous with fringe of hairs.

Auricles: No distinct auricles, but hairy at the collar region.

Other features: Very vigorous seedling and will germinate in early spring if present in the seed bank.

Stink grass *Eragrostis cilianensis*

Figure A1.27: The leaf blades of stink grass seedlings have glands along the margins

Figure A1.28: The base of stink grass seedling may be a red-purple colour

Eragrostis cilianensis

Leaf: Sheath may be a red-purple colour. Leaf blades are smooth with glands present along the leaf margin (Figure A1.27). Some sparse fine hairs may be visible on the underside of the leaf blade.

Ligule: A fringe of short hairs.

Auricles: Not distinct, but hairs can be found at the collar region.

Other features: Seedling base may be a red-purple colour (Figure A1.28).

Appendix 2 – Companion legumes for tropical grass pastures

Table A2.1 summarises some temperate annual, temperate perennial, and tropical perennial legumes that may be suitable for sowing as companion species with tropical grasses. It includes key information such as soil and rainfall suitability, maturity range, and notable agronomic or management traits.

Use this table as a starting point to help identify legume species that may suit your environment and pasture objectives. Look for species that match your soil pH and texture, annual rainfall, and grazing system requirements. Traits such as hard seed levels, pest resistance, and persistence under grazing should also be considered.

Note: this is a summary only. More detailed and current information about specific cultivars, regional adaptation, and management practices should be sourced.

NNSW = northern NSW

SNSW = southern NSW

Table A2.1: Characteristics of some common temperate annual, perennial, and tropical legumes used in NSW

Legume	Description	Soil range	Minimum rainfall	Maturity	Other
Temperate annual					
Arrowleaf clover (*Trifolium vesiculosum*) 	Deep-rooted, erect growth, aerial seeding legume. Highly palatable, suitable for grazing, hay, and silage	pH_{Ca} 5.0–7.5; moderate to high fertility. Avoid alkaline clays, saline or those prone to waterlogging	400mm (SNSW) 500mm (NNSW)	Range of maturities. Earlier cultivars suit drier environments	Long growing season, but needs spring moisture. Very hard seed; scarification improves germination
Biserrula (*Biserrula pelecinus*) 	Deep-rooted, aerial seeding, hard-seeded legume. Persistent after establishing a seed bank. Drought tolerant	Light-textured soils; pH_{Ca} 4.5–7.5. Tolerates aluminium, but sensitive to high levels of manganese. Avoid soils prone to waterlogging	375mm (SNSW) 525mm (NNSW)	Early-mid-maturity and mid-maturity cultivars available	High seed production and persistent once seed bank is developed
Balansa clover (*Trifolium michelianum*) 	Aerial seeding, hard-seeded, self-regenerating legume	Suited to acid to neutral soils; pH_{Ca} 4.5–7.0. Tolerates waterlogging and is mildly salt tolerant	350mm (SNSW) 650mm (NNSW)	Range of maturities available	Early growth is slow but rapid over winter and spring

Legume	Description	Soil range	Minimum rainfall	Maturity	Other
Bladder clover (*Trifolium spumosum*) 	Semi-erect, early maturing, aerial seeding, hard-seeded legume	Suits wide range of soil types pH_{Ca} 5.0–8.5. Susceptible to waterlogging and salinity	350mm (SNSW) 450mm (NNSW)	Early to mid-maturity (similar to Dalkeith subterranean clover)	Susceptible to a range of insect pests. High seed yields and high levels of hard seed
Gland clover (*Trifolium glanduliferum*) 	Semi-erect, hard-seeded legume	Suited to soils with pH_{Ca} 4.5–8.0. Grows well on light textured soils. Moderately tolerant of waterlogging	375mm (SNSW) 550mm (NNSW)	Early maturity	Resistant to redlegged earth mite, aphids and clover scorch
Rose clover (*Trifolium hirtum*) 	Hairy, hard-seeded, self-regenerating aerial seeding annual	It suits a wide range of soils, especially acid and light textured soils	400mm (SNSW) 650mm (NNSW)	Early to mid-maturity	Tolerant of redlegged earth mite. Sensitive to heavy grazing at flowering. Regeneration is unreliable without management to maximise seed production
Barrel medic (*Medicago truncatula*) 	Small-seeded, aerial seeding legume with prostrate to semi-erect habit	Suited to neutral to alkaline soils. Not well adapted to very light textured soils, waterlogging or moderately saline soils	275mm (SNSW) 400mm (NNSW)	A range of different maturities are available from early-mid through to mid-late maturity	More persistent in low rainfall areas than subterranean clover. Susceptible to a range of insect pests. In addition to maturity, hard seed characteristics should be considered when selecting a cultivar
Burr medic (spineless) (*Medicago polymorpha* var. *brevispina*) 	Trailing prostrate, aerial seeding legume. Has spineless pods (unlike naturalised burr medic)	Suited to mildly acid red-brown sandy soils to red clay loams with pH_{Ca}>5.2. Tolerates waterlogging and mild salinity	275mm (SNSW) 400mm (NNSW)	Early-mid maturity	High seed yield and high hard seed levels. Persists well in low rainfall areas

Legume	Description	Soil range	Minimum rainfall	Maturity	Other
Snail medic (*Medicago scutellata*) 	Erect, aerial seeding legume. Identifiable by large snail shell-like pods	Best suited to heavy textured neutral to alkaline soils	400mm (SNSW) 500mm (NNSW)	Early to mid-maturity	Good hard seed levels. Best in short pasture phases or mixes in lower rainfall areas
Yellow serradella (*Ornithopus compressus*) 	Deep-rooted, hard-seeded, aerial seeding legume	Suited to a wide of soils. Performs well in light acidic soils; pH_{Ca} 4.2–6.5	400mm (SNSW) 450mm (NNSW)	Range of maturities from early-mid to late	High seed production and persistence
Pink serradella (*Ornithopus sativus*) 	Deep-rooted, hard-seeded, aerial seeding legume	Suited to a wide of soils. Performs well in light acidic soils; pH_{Ca} 4.2–6.5	350mm (SNSW) 400mm (NNSW)	Range of maturities from early-mid to late	Slightly less acid tolerant than yellow type. Strong regeneration
Subterranean clover (*Trifolium subterraneum*) 	Prostrate, hard-seeded legume. Buries seed (except for bracycalycinum types which tend to leave a higher proportion of burrs on the soil surface)	Broad range of soils – sand to clays; pH_{Ca} >4.5. Sensitive to waterlogging and salinity	450mm	Early to very late. Early maturing types better suited to drier regions	Bloat risk in some cultivars. Many cultivars available
Woolly pod vetch (*Vicia villosa*) 	Aerial seeding legume with twinning habit	Suited to a wide range of soil types (loams to cracking clay soils), but has done well on light loam soils; pH_{Ca} 5.0–8.0. Requires well drained soils. Not tolerant of waterlogging.	550mm (SNSW) 650mm (NNSW)	Early to mid	Suited to short pasture phases and green manuring. Less hard seed than other vetches. Bloat risk and other livestock disorders

Legume	Description	Soil range	Minimum rainfall	Maturity	Other
Temperate perennial					
Lucerne (*Medicago sativa*) 	Deep-rooted, long-lived perennial legume. High quality fodder species	Broad soil range from slightly acidic to alkaline that are well drained; pH_{Ca} 5.2–7.5. Susceptible to waterlogging	375mm (SNSW) 400mm (NNSW)	Perennial. A range of winter activity ratings available	Drought tolerant. Grazing-adapted types available. Requires careful rotational grazing. Bloat risk and other livestock disorders. Winter growth activity differs among cultivars
White clover (*Trifolium repens*) 	Prostrate perennial with stolons. High feed quality	Suits a wide range of soil types. Relatively tolerant of acid soils (pH_{Ca}>4.5, with aluminium 20%)	700mm (SNSW) 775mm (NNSW)	Perennial. Can recruit from a soil seed bank	Not suited to dryland tropical areas unless irrigation is available. Often included in temperate perennial systems. Can cause bloat
Tropical perennial					
Desmanthus (*Desmanthus* spp.) 	Deep-rooted upright, perennial legume	Suited to medium to heavy textured soils with a neutral to alkaline pH	500mm+	Perennial. Recruits readily from a soil seed bank	Best suited to NNSW. Persistent under grazing. Drought tolerant. Susceptible to alfalfa mosaic virus which causes production losses

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Notes

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