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Leucaena in southern inland Queensland

Producer Demonstration Site

Demonstrating the productivity and value of newly-established leucaena in selected areas of the Darling Downs

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Abstract

This project set out to show graziers in southern inland Queensland where leucaena would grow, how to grow it, varieties to use, what companion grasses to use, and how to manage it. It also set out to confirm site selection criteria, cultural requirements, row spacing, animal management and performance including stocking rates.

Established demonstration sites were monitored for an additional 3 years. This has shown that, in general, leucaena in 5-8 m rows wide with vigorous grass between the rows, will carry at least 2 AE per ha over about 170 days from late October until late May. In cooler and drier years, lower stocking rates can be expected. Steers on well-established leucaena pasture will average 0.8 kg live weight gain / day. Animal production during peak growing periods will vary from 1.0 to 1.3 kg live wt. gain / day but drop to 0.5 kg/day at season's end when grass quality and leucaena availability decline.

Leucaena in this region will be of greatest benefit when grown in preferred sites, providing a very reliable, drought-tolerant, long- lasting summer-growing forage system that can replace annual summer growing forage crops and supplement winter growing oats (to the extent of reducing the area required).

Executive summary

This project is a continuation of the PDS, Leucaena on the Downs (BNBP.0256), which demonstrated that leucaena can be a reliable and suitable summer growing legume in pasture systems in southern inland regions which have suitable climate, soils and topography. That PDS concluded that leucaena requires at least 550mm of summer dominant rainfall and calcareous soils with a plant available water holding capacity (PAWC) of at least 130 mm. It can tolerate moderate frosts (down to -4°C) before losing it leaves but higher intensity frosts will knock it back to ground level, making recovery slow in the coming spring. It thrives with plenty of moisture (but not wet feet), high temperatures and high soil fertility, particularly phosphorus (P).

The current project was designed to collect additional animal production data to gain confidence in its performance, to continue monitoring the effects of cool weather and frosts on its growth and regeneration in this region, and to evaluate its capacity to fulfil the role of annual forage sorghum and to complement winter forage crops.

The project found that:

- Leucaena is the most productive summer-growing legume option for soils and locations to which it is well suited.
- Producers who have knowingly established it in less than ideal soils and locations have accepted lower production and stocking rates. However, they suggest it is still the best legume option they have for some land types e.g., for sandy loam soils with low PAWC.
- It will tolerate wet soil conditions for up to3 weeks as long as the soils internal drainage is adequate. However, it died out in waterlogged soils with poor internal drainage (tea tree country associated with shallow melon-holed brigalow soils) after eight weeks.
- Leucaena and grass pasture mixtures on well drained sites in the very wet year of 2011, produced as much as would be expected from fully irrigated conditions. Stocked at almost 2.2 AE/ha for 196 days, one paddock produced 364 kg live weight /ha.
- Low production in the very dry spring and cool summer season of 2009/2010 showed leucaena's reliance on high temperatures and soil moisture for growth. Animal production and stocking rates reverted back to expectations from a good grass paddock – 113 kg/ha compared to over 340 kg/ha in the following 2 seasons.
- Even with these limitations, producers can generally plan on achieving an average of 0.8 kg live weight gain per day for 180 days at stocking rates of 1.5-2 AE per ha.
- In 2011 & 2012, the flood plains near Dalby commonly received heavy frosts (to - 10°C). Leucaena was knocked back to it crown and recovered so slowly that it was not fit to graze until early December (moisture was not limiting).
- There was no significant difference between the two commonly grown varieties, Cunningham and Tarramba.
- Wonder Graze, the latest released variety, is showing definite advantages over the other varieties, such as quicker establishment, quicker early growth and perhaps higher dry

matter yields. It may even have higher tolerance to frosts. More observations are needed to confirm this.

- There was no advantage from planting leucaena in twin rows. Sowing single rows with good quality planting equipment into the right soil conditions and good quality seed gave reliable plant populations and higher dry matter yields at lower seeding rates.

- The best time to plant companion grass in the mixture was immediately after sowing the leucaena, but leaving about 1 m either side of the planted leucaena row. In a prepared seed bed where weeds are controlled, sown grass seed will only germinate after the next rain and by then the leucaena has a distinct competitive advantage. Early grass growth rates are quite low for several weeks.

The best grazing management system is to rotationally graze paddocks. In the growing season, at least 6 weeks spell after grazing is required. Grazing heavily will help keep the shrubs down to a manageable height so that mechanical trimming is not required. However, persistent heavy grazing will reduce individual LWG.

Psyllids were prevalent in all years on all varieties including the new “wonder graze”. However, damage has not been severe enough to justify chemical treatment.

Key recommendations

- Leucaena is an excellent summer-growing legume to include in any grass pasture grown calcareous soils on undulating landscapes where average annual rainfall exceeds 550 mm. Choose any grazing variety on the market and plant as early as possible in the season.

- Check seed germination and seedling vigour before sowing. Treat it as a (summer) crop until properly established. Keep up soil fertility requirements, particularly soil phosphorus (P). Therefore, prior planning should investigate the soil’s fertility, its plant available water holding capacity (PAWC) and to know where heavy frosts are likely to occur.

- It is not worth planting small areas of leucaena based pastures (<20 ha) because of the need to maintain in cattle the special animal rumen fauna required by to remove risk of sub-optimal animal performance. It is vital to ensure that cattle grazing leucaena have those correct rumen micro-organisms to fully utilise the nutritive value of the leucaena.

Leucaena is expensive to establish but not that much more costly than establishing other mixed pastures. Its greatest advantage is that it can be sown as a crop, because of its big seed, with as much reliability and confidence as establishing a good stand of grain sorghum.

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1 Background

This project follows on from a PDS, BNBP.0256, which showed that leucaena could be successfully established and appeared to be a productive legume option for southern inland Queensland pasture systems. One year's animal production data was obtained from 4 sites, two in Millmerran and one each in the Kaimkillenbun and Chinchilla districts. As one year of data is not sufficient to give an accurate assessment of productivity, this project was undertaken to further evaluate and demonstrate leucaena's productivity and role in the region.

As well as the inner Downs and western Downs areas, leucaena is now been successfully grown in more western regions such as Surat, Meandarra, Roma and Goondiwindi. It is prudent to have reliable data available to inform graziers about locations where the plant is best suited (soils, topography, frosts and temperature) and what they can expect from a mixed leucaena/grass pasture in terms of animal production.

An accurate assessment of the area established is not available, but it is estimated that at least 5,000 ha exists in the Condamine river catchment and about the same amount in the western regions of southern Queensland.

2 Project objectives

1) Work with local producers to assess the persistence and productivity of established leucaena in several areas of the Darling Downs (e.g. Millmerran, Chinchilla and Bell), including the impacts of frosts and cold weather.

2) Collect production data (growth rates and stocking rates) from at least 3 producers on different soil types in different areas of the Darling Downs.

3) Compare cattle productivity (growth rates and stocking rates) between leucaena and forage sorghum on two properties in different areas of the Darling Downs.

4) Test the viability of introducing forage crops using zero till techniques in between the rows of leucaena.

5) Investigate a forage production system using leucaena that does not need oats for the late May/early June to September period.

6) Record other observations as opportunities arise on (a) establishment of leucaena in paddocks with a history of long term use of residual herbicides; (b) grazing techniques; and (c) returns from different classes of animal.

7) Produce an updated fact sheet on "Leucaena in southern Queensland" for producers.

3 Methodology

3.1 Co-operators and sites

Over the three year period of this project, observations were taken from the 4 original sites from project BNBP.0256 (2 at Millmerran, one each at Kaimkillenbun and Chinchilla), as well as from other graziers near Meandarra, Brymaroo and Bell. Animal live weight gain (LWG) data were obtained from the two Millmerran properties. In particular, John and Sue Moffatt of Bringalilly, Millmerran gave the most detailed data including both plant and animal yield. They expanded their area of leucaena to over 100 ha including some elevated light brigalow/cypress pine country which proved unreliable for forage crop production.

At Charley's Creek north of Chinchilla, owned by Darryl and Kaylene Wonka, edible leucaena dry matter yields were measured which helped verify photo standards developed to estimate leucaena yields at other sites. They have also supplied stocking rate data. Their country is flat brigalow land with shallow melon holes to 20 cm deep. There are isolated patches of tea tree which is much more prone to waterlogging.

At Captain's Mountain, Millmerran, owned by Craig Antonio, pasture yields and some animal production data was collected. Craig has increased his area of leucaena to about 200 ha with a substantial area of the new variety, Wondergraze.

Brett and Rana Haager, of Kaimkillenbun, planted leucaena on flat, light sandy loam country and on elevated light brigalow/soft-wood soils. Although still surviving, the leucaena on the light soil country is unproductive (low soil moisture holding capacity, low soil fertility, severe frosts and excessive wildlife grazing), while the elevated paddock of 15 ha is still going well. The light soil area was sown to show graziers that leucaena was not suited to these types of soil on country prone to heavy frosts. This site hosted a field day and supplied grazing data.

3.2 Dry matter presentation yields of leucaena pasture

Dry matter yields were initially measured by cutting plots from both Cunningham and Tarramba pastures at Millmerran and Chinchilla. Only edible material was taken. Photos were taken immediately adjacent to these plots and details such as height, row width and row configuration were recorded. From this, photo standards were developed. They have been tested on several occasions by estimating yields using the photo standards and then checking those estimates by physically cutting and weighing samples. Although not completely accurate, they are close enough for the work undertaken in this project and have been used to estimate stocking rates. This has been very useful for graziers to work how many animals of a particular size the paddock will carry to achieve a particular weight in a given time.

3.3 Animal data

Accurate live weight gains have been recorded by the 2 Millmerran co-operators, who are steer fatteners, from over the period of the project. The other two co-operators were not able to provide this data but have been able to provide stocking rate information.

3.4 Varieties and planting configurations

Timing of cutting the demonstration sites was done to measure differences between the older varieties, Cunningham and Tarramba. Such factors as cool season tolerance, insect

susceptibility, length of growing season, yield as relating to row configuration (twin rows 1 m apart V single rows), row width from 5 to 8 m apart (from outside row to outside row) and planting rate were compared.

The cutting data was from an average of 3 randomly selected sites in each variety, all planted in the same paddock, each site being 3 m of row long.

3.5 Publicity

Several field events and discussions were conducted specifically on leucaena while presentations were also made at regional field days which were focussed on related issues (e.g. pastures, cattle production, use of irrigation water by mining companies). As well, articles on the project have been published by MLA's journals and newsletters. Information has also been given to State Government staff in the Downs and the south west.

4 Results and discussion

4.1 Varietal differences

Much has been made of differences existing between varieties in terms of yield, length of growing season, cool temperature tolerance and insect susceptibility. Comparisons of Cunningham and Tarramba showed superior yield from the former, particularly at Chinchilla (Table 1). However, there was little difference between the varieties with respect to other attributes.

In the very wet year of 2011, both varieties produced a phenomenal amount of seed at the expense of leaf growth. Both varieties stood in saturated soils at Chinchilla for more than 3 weeks without significant adverse effects. However, one area of about 5 ha that was originally tea tree country did die out because of the soil's poor internal drainage and water logging continuing for 8 weeks or more.

Table 1. Dry matter yields of edible leucaena (kg/ha) during the PDS.

Site	Date	Cunningham	Tarramba
Moffatt, Millmerran	24/11/2009	488	464
	29/3/2010	1571	1026
	1/12/2010	1400 *	1200 *
	26/10/2011	645	715
Antonio, Millmerran	4/12/09	521	278
	13/4/10	1043	NA
Wonka, Chinchilla	4/2/09	2405	1313
	30/3/10	4408	2316
	9/11/2010	2787	1322
	3/2/2011	1500 *	900 *

* Estimated using photo standards.

From limited observations made on several properties in different areas, it would appear that Wondergraze, a new variety, has some yield advantage over the others, is more shrubby than Tarramba, has quicker earlier growth, but is just as susceptible to psyllids.

4.2 Animal production

Table 2 shows the production figures received from John and Sue Moffatt, Bringalilly. Production was very high in 3 years out of the 4 recorded. The low production in 2009/10 was caused by low summer temperatures following a cold dry winter and spring. The grazing period in 09/10 was reduced by 50%, to 100 days, at a lower stocking rate.

Table 2. Animal production data from the Bringalilly site

Year	LWG/ha	LWG/head *	Stocking rate (AE/ha) and grazing period
2008/9	196 kg	1.01	3.1 for 50 days
2009/10	114 kg	0.8	1.5 for 119 days
2010/2011	364 kg	0.88	2.2 for 196 days
2011/2012	342 kg	0.71	3.8 for 207 days

*These are weighted averages accounting for the large number of young stock introduced in autumn.

The final two years of measurement have been very good for forage growth. The site has well-drained brigalow soil and the paddocks responded as if they were irrigated.

In all years, the LWG per head varied with growth stage of the leucaena and grass and the age of the steers. Live weight gains were lower in autumn, probably because the quality of the companion grass had deteriorated. Young animals and those freshly brought in from other properties did not gain as quickly as larger animals or those brought in from other parts of the property. In general, settled-in yearling or older steers in summer gained around 1.2 kg or more a day while young steers in autumn gained from 0.3 to 0.5 kg/day.

Table 3. Grazing periods and stocking rates at others sites.

Location & year	length of grazing (days)	Stcoking rate (AE/ha)
Millmerran - 2008/09	145	3.0
Millmerran - 2009/10	89	1.2
Bell - 2009/10	177	3.1
Chinchilla - 2009/10	177	2.5
Chinchilla - 2010/11	160	4.0

Currently (July 2012), the Bringalilly site is still being grazed at the rate of 1 AE/ha and will continue to do so for at least another month (unless a very severe frost wipes all the leaf off the paddocks).

4.3 Twin rows V single rows

At the Bringalilly site, growth from a single-row configuration was measured against twin rows (rows planted about 1 m apart with the outside rows being 6-7 m apart). There was always more edible material from single rows and this was at the same plant density as in each row of the twin-row configuration. This was probably because there were twice as many plants in the same area competing for resources. Therefore, if the planting equipment is good and the soil preparation and seed quality and treatments are as recommended, single rows are preferred.

As a side issue, scarified seed over 18 months old was planted on one paddock and the vigour of the seedlings were noticeably weaker than those from fresh seed planted in the same paddock. This means that it is preferable to use fresh seed.

In summary, while these factors are important, the major decision is site selection. Assuming establishment is successful, productivity and persistence of leucaena-based pasture will largely depend on the depth/texture/fertility of the soil and the degree to which the site is away from severe frost zones.

4.4 Publicity and communication

Leucaena has received much publicity from various sources for some years now. The main avenue used by this project has been via field days, discussions at grazier meetings, discussions with professional pasture people from DEEDI (now DAFF Qld), and news stories through MLA's newsletters and magazines, e.g., Feedback magazine, March 2012, page 24, "Piling on the pounds with leucaena".

Over the last three years, field days specifically on leucaena have been held at Millmerran and Meandarra. Leucaena has been one subject at several field days at Chinchilla, Brymaroo, Kaimkillenbun, Quinalow and Peranga.

It is now a matter of helping individual graziers with site selection as the required land preparation and planting technology are well known.

4.5 Comparisons with annual forage crops

These observvations and inferences are absed on comments from graziers as the project was not able to directly compare productivity of forage crops with leucaena pastures.

Over the 3 years of the project at Bringalilly, the area of summer forage crop went from 100 ha to none in 2012. John's comment is that they don't need it as leucaena is a permanent system that reliability produces at least 2 times as much animal production per ha as forage sorghum.

At Charley's Creek forage sorghum is still planed because of the surity of forage it provides them. They also need its hay for yard feeding. They concede that leucaena is a far easier and less costly alternative.

At Dalby Downs, forage sorghum and maize are grown for silage which is fed to stud bulls. On most proerties with leucaena, oats as winter forage is still used to finish off steers that have not made the grade from leucaena, but two graziers spoken to recently suggest that oats is rapidly losing its once crucial place in their feeding programmes. It is now the back-up forage.

4.6 Grazing methods

Graziers now suggest there is no advantage in trying to "save" some leucaena for winter feed. Recently, three graziers indicated they deliberately graze their leucaena paddocks hard, for some time at least, to utilise all the leaf material and to knock down the tall plants to managable heights (1.2 to 1.5 high) in their rotational system. Animal live weight gain is sacrificed at this time to get the material down.

The most common grazing technique is rotating leucaena on a two weeks on and 6 to 8 weeks off during the growing season. Those with small areas have stock in continuously during the grazing period.

It is still important to emphasise the need to make sure cattle have the necessary rumen micro-organisms before commencing grazing.

5 Success in achieving objectives

5.1 Collecting production data by working with grazier co-operators

All co-operators have contributed significantly to the data collection. All this data gives a greater understanding on the value of the pasture when giving recommendations on site requirements to individual graziers.

5.2 Production data

This project followed on from BNBP.0256 which showed graziers the techniques required to pick sites, establish the pasture as well as preliminary data on productive potential. This project

showed what could be expected over different years with varying climatic conditions. Because it costs about $350 / ha to establish, people have to be sure about potential returns before investing.

Fortunately, a normal year was followed by a abnormally cool summer season which limited growth to about half of what was expected. That was followed by a cold, frostly winter and an abnormally wet summer year which caused flooding and water logging in flat areas but gave almost irrigated conditions on well drained sites. The final 2011/12 seasonhas been excellent in some regions but dry in others.

Putting all that together, realisticl expectations can be provided.

5.3 Comparisons with annual forage crops

Of the four original co-operators, three grew forage sorghum before introducing Leucaena pastures. Two still do. One uses it to produce forage for breeders and for hay-feeding stock in yards and the other because they are still "hedging their bets". The two Millmerran properties don't grow any forage sorghum. Both these properties turn off steers headed for Japan or feedlots and contend that leucaena offers more reliable forage and is twice as productive. Bringalilly experience is that it costs as much to grow forage sorghum each year as it does to establish leucaena and it is a once-only expense.

Oats is still grown by all four major co-operators, but at a much reduced area. Oats is now the back-up to leucaena rather than the main way of finishing cattle for market. Notably, oats is grown in areas on the property which are too frosty for leucaena.

5.4 Variations to recommended practices

The Charley's Creek, Chinchilla site is flat brigalow country prone to water logging in very wet years. Two of the three years under review were very wet and inter-row grasses did not establish well. Instead, the owners have sown annual forage sorghum between the rows of Tarramba as the bulk source of forage. This has worked satisfactorily but the recommendation is still to establish a water loving grass (bambatsi) instead of annual cropping. This was brought home in 2011 summer when it was too wet all season to plant the forage. The small amount of bambatsi present flourished.

In the Cunningham paddock at Charley’s Creek, the configuration is a single row planted 3.5 m apart. There are patches of brigalow soils (interanlly well drained) mixed with poorly drained tea tree soils. The wet years have favoured the Cunningham dramatically in the brigalow soil where yields have been extremely high with 4,400 kg DM/ha being masured in February 2010 from a bare start in September 2009.

In the poorly drained parts the leucaena has been killed out. For the last two seasons, the owners have planted early oats in the flood prone sections of the paddock and are feeding the oats and leucaena together. Again, this has worked well, but it would be better to plant the very wet areas with a water tolerant grass (e.g., bambatsi) and be able to make better use of the leucaena when it is in its prime.

This site has shown the potential of leucaena under good conditions and have even suggested that it should be grown in 3 m rows as a complete hedge and grow grass or forage crop in other

parts of the paddock as a normal practice. This may have merit in special cases such as their badly flood-prone paddock.

5.5 Develop tools for graziers to use - fact sheet and photo standards.

A draft fact sheet has been produced.

Photo standards have been developed and also appear as a separate appendix 8.2.

6 Impact on the beef industry; now and in 5 years time

6.1 Immediate impact

That leucaena is a viable and productive option, for beef producers with suitable land in specific parts of southern inland Queensland, is bemoing incraesingly accepted. In general, producers are increasingly aware of how to grow it and fears asscoaued with establishment failure are diminishing. Its limitations are also increasingly recognised.

Fore suitable sites, data and obseravtions to date suggest it is the best summer growing legume option now available. It is a long term pasture (30 or more years probable) with the potential to increase beef production to around 300 kg LWG per ha in good seasons.

However, in cool, dry years, it has produced only about 110 kg LWG per ha which is about similar to well grown grass pastures. However, no nitrogen is needed to boost the protein content of the pasture when lecucaena is present.

Leucaena and grass, planted in late spring or early summer into good soil moisture, is commonly ready for a first graze in the following autumn.

6.2 Impact in 5 years.

The area sown to leucaena is likley to increase greatly over the next 5 years. There is a potential expansion of leucaena into western areas where there is excess water being made available from mining operations (gas producers). Some plantations already exist.

Assistance from officers from government agencies and producer groups such as the Leucaena Network will help growers restrict its potential to become a weed and encourage its adoption into its preferred sites.

Varieties with more cool tolerance may see this legume being even more productive and beinmg sown further south than now considered possible. Other traits such as insect resistance, low levels or nil seed production and more compact growth characterists may help it adoption to more humid coastal regions without it being deemed to be a weed risk.

In the wet season of 2011, leucaena showed its worth as a spunge for water as it reduced water runoff down to a minimum. It will gain a place for controlling seepages and reducing salt outbreaks as it has done in the Brymaroo district. Many growers have stated that runoff water from leucaena paddocks over the last two very wet years has been so low that farm dams in those catchments have gone dry. That would appear to be a function higher water usage by the pasture and very high levels of ground cover encourages greater water infiltration into the soil.

With the coming of carbon trading, leucaena as a fast growing leguminous shrub stands as potentially a source of income to graziers. Because it is a legume, it has the ability to assist pasture systems to sequester more carbon than a grass-only pasture because it will increase plant and soil nitrogen.

7 Conclusions and recommendations

7.1 Conclusions

This project has successfully shown graziers that leucaena can be a reliable and productive summer growing legume for pastures in specific locations of southern inland Queensland. More producers are now area that it can be readily established, will give cattle good live weight gains, will tolerate dry conditions and light frosts, and will persist for many years. The oldest stand of leucaena (Tarramba) in this part of Queensland is at Charley's Creek, Chinchilla which was established in 1994 and is still going very strongly.

Care must be taken to limit its spread into unwanted areas and graziers should do their bit to destroy it when they see it in environmentally sensitive places; road sides, creek and river banks, national parks etc. This project was well publicised throughout it life and the results distributed to local producers and agency officers.

The work done by co-operators was considerable and very much appreciated, an outstanding contribution being made by John and Sue Moffatt.

Support during the project was also given by DEEDI (now DAFF Qld) staff on the Darling Downs. That was very much appreciated.

7.2 Recommendations

Leucaena has been shown to be suitable to a large area of southern inland Queensland, but site selection has to be done carefully. It will thrive on the fertile calcareous soils of the uplands of the Darling Downs and the elevated brigalow soils of Western Downs, Maranoa and Wandoan.

When planning a plantation, graziers should consider each site’s soil type, soil depth, plant available water holding holding capacity, internal drainage, fertility (particularly phosphorus) and landscape position (needs elevated sites where frost is not likely to be severe).

It is best to rotationally graze the forage. As a guide, to gain full benefit from the pasture, it is suggested that 20 ha of leucaena would be a minimum, but there are producers on the Downs making good use of smaller areas.

Leucaena, where suited, is the best available legume for summer growing pastures in the region.

Group discussing the new variety "wondergraze", 20/07/2012 at Moffatts, Millmerran. Plenty of leaf retained on the plants despite night temperatures as low as -3°C.

8 Appendices

8.1 Photos of leucaena after heavy rain associated with flooding

Pic 1: Leucaena standing in water on brigalow soils. Note sedges growing in water logged soils. The leucaena survived.

Pic 2 Cunningham killed by 8 weeks of waterlogging, Charley's Ck, Chinchilla 2011

Pic 3: Severely frosted leucaena 11/10/2011- flood plains Kaimkillenbun. It survived but regrowth was slow

Pic 4: Best yield measured: Cunningham in 3.5 m rows - 4400kg DM/ha from Sept. to February

Pic 5: Feb 2011. Cunningham suffering from severe waterlogging set extraordinary amounts of seed. These plants survived but some on tea tree country nearby did not.

Pic 6. Moffatt's young steers after overwintering on leucaena, August 2011

8.2 Photo standards used to estimate yields of leucaena. Yields are eatable material only

Tarramba Twin rows with 5.5 m between outside rows Yield = 437 kg DM/ha Alluvial flats	

Tarramba Twin rows Row width 7.3m centre to centre Ht 1.9m average Y= 477 kg DM/ha Undulating basaltic soils	
Tarramba Twin rows - width 7.3 m centre to centre Ht av. 2.3 m Yield = 975 kg DM/ha Basaltic clay soil	

Cunningham Single row 6.25 m apart Ht 2.3 m Y = 1650 kg DM/ha Brigalow clay soil	
Cunningham Twin rows @ 7.0 m centre to centre Ht. = 2.0 m Y=1490 kg DM/ha Brigalow clay soils	

Cunningham @ 3.3 m wide & 2.5 m tall Y = 2405 kg DM/ha	
Tarramba Twin rows 6.5 m centre to centre Ht = 2.4 m Y = 1313 kg DM/ha	

Cunningham Single rows Width = 3.6 m Ht = 3.0 m Y = 4280 kg DM/ha	

Tarramba Twin rows 6.8 m centre to centre Ht = 3.2 m Y = 2316 kg DM/ha	

Tarramba Row width = 6.3m Ht = 2.2 m Y = 715 kg DM/ha