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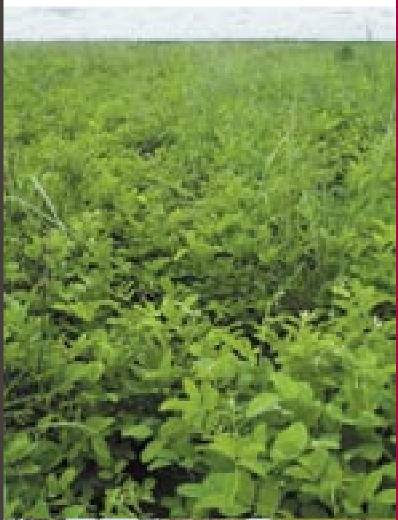
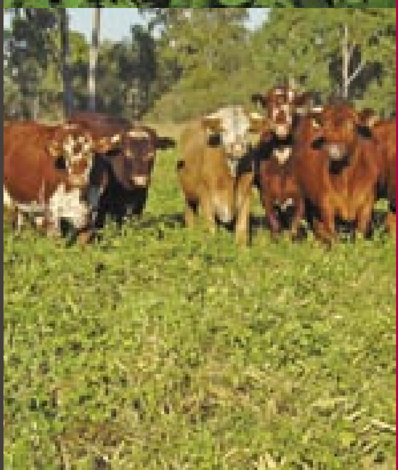
The Butterfly Pea Book

a guide to establishing and managing butterfly pea pastures in central Queensland





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The Butterfly Pea Book

a guide to establishing and managing butterfly pea pastures in central Queensland

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The Department of Primary Industries and Fisheries seeks a better quality of life for all Queenslanders – a quality of life supported by innovative world-class food and fibre industries, by responsible and ecologically sustainable use of natural resources and by capable and self-reliant rural communities.

Our business is about:

- innovative science and commercial uptake of new technology by food and fibre industries
- sustainable use of natural resources
- food safety and protection against imported pests and diseases
- market-driven and ethical food and fibre production and
- capable rural communities achieving prosperity and selfreliance through successful rural businesses.

This publication is designed to offer a comprehensive guide to establishing and managing butterfly pea in central Queensland to project members, primary producers and other interested parties for improved decision making to promote profitable and sustainable central Queensland farming systems.

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Foreword

Butterfly pea is a productive and persistent legume adapted to a range of soils and climates in tropical and subtropical Australia but adoption by growers was low after the cultivar Milgarra was released in 1991. The area planted in Queensland is now increasing each year. This occurred as a result of R&D by researchers, extension staff and farmers with financial assistance from funding bodies.

Major reasons for the increasing popularity of butterfly pea include:

- **The technology met a need.** For many years central Queensland's graziers have needed a persistent legume that could produce quality pastures to finish cattle at a younger age and meet market specifications whilst restoring soil fertility.
- **The technology worked.** Butterfly pea can be established quickly to produce a high quality, productive pasture on soils previously considered difficult to establish.
- **A team approach was used.** The butterfly pea technology was successfully incorporated into an agronomy package developed by farmers and scientists working together.
- **Champions** from the farming and scientific communities constantly and enthusiastically promoted butterfly pea and its management.
- **The R&D was done in partnership.** The practical experience of farmers, technical skill of scientists and support of industry funding bodies ensured that solutions to integrating butterfly pea into farming and grazing systems were developed.
- **High quality, cheap seed** is readily available.

This book attempts to compile relevant information on butterfly pea to allow graziers and farmers to determine whether butterfly pea is suited to their enterprise and to use best management practice for establishing and managing butterfly pea pastures. Much of the information is directly relevant to central Queensland graziers and farmers but will also apply to other parts of subtropical Australia.

Acknowledgements

The enormous contribution made by Stuart Coaker of *Lindley Downs* Springsure, to the practical development and extension of butterfly pea in central Queensland is acknowledged. Some of that experience is captured in these pages. Many farmers including those who provided trial sites as part of the Central Queensland Sustainable Farming Systems project (CQSFSP) are acknowledged for adding their practical experience to the pool of knowledge.

Some of the photographs used in this book were supplied by David Sasse, Springsure (dsasse@bigpond.com) and Arthur Mostead, Canberra (www.amphotography.com.au). Their support of this publication is acknowledged.

Research by DPI&F and CSIRO, and industry funds provided by GRDC (Grains Research and Development Corporation) and MLA (Meat and Livestock Australia) were an essential part of the development of butterfly pea.

The review and comment by Dick Jones (ex-CSIRO Brisbane), John Hopkinson (ex-DPI&F Mareeba) and others was appreciated. The contribution of fellow authors, editing by Rod Collins and layout by Tonia Grundy and Heather Lees made this book possible.

Maurie Conway

DPI&F Emerald

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1 Introduction

Maurie Conway and John Doughton

Tropical pasture legumes have two major purposes:

- To provide high quality forage for animal production either as a pure legume pasture or in association with perennial or annual grasses
- To improve soil nitrogen status and prevent soil fertility decline, a major constraint to profitability in grass-only pastures and cereal cropping.

The important feature of legumes used in agriculture is their ability to fix atmospheric nitrogen, which becomes available in the soil to other plants as the legume decomposes. Harvesting pulse (grain legume) crops such as chickpea, mungbeans and soybeans removes a significant proportion of the fixed nitrogen in the grain. However most of the nitrogen produced by forage legumes stays in the paddock despite grazing by animals and volatile losses from dung and urine.

The system of using a pasture phase in a cropping rotation is known as ley farming. Soil fertility decline is a major constraint to cereal production and one that can be reversed by the use of ley pastures. Butterfly pea is a successful ley legume when established into cultivation paddocks with low soil nitrogen levels. These paddocks can be returned to farming once the soil fertility has improved (usually 3-5 years).

In the dryland, mixed farming systems of Queensland, ley legumes are almost always used for animal production rather than green manure crops, even where improving soil fertility is an important aim, as water is frequently more limiting than nitrogen.

Arthur Mostead Photography

Department of Primary Industries and Fisheries technical officer Maurie Conway examines a twining butterfly pea stem

Changes in relative values of cereals and beef, together with a demand to finish beef cattle at a younger age to meet both export and domestic markets, has induced farmers to invest more resources into their beef enterprises. Over the last decade, strong beef prices have made the beef industry more attractive to producers who have the land, know-how and infrastructure for both cropping and beef production. The development of ley legumes such as butterfly pea has allowed mixed enterprises to move from a cropping to a beef focus, whilst providing the flexibility to return to cropping easily in the future.

Butterfly pea – the plant

Butterfly pea (*Clitoria ternatea*) is a perennial, summer-growing legume, which performs best on fertile soils with high water holding capacity. It is palatable and has high nutritive value, with a higher leaf nitrogen percentage and lower acid digestible fibre than most other tropical legumes. In central Queensland – butterfly pea has emerged as a well adapted legume for the heavy-textured cropping soils of the region. The cultivar Milgarra is the only variety released in Queensland to date. The following description of this cultivar is summarised from Oram (1992):

Milgarra is a perennial, summer growing legume with fine, twining stems 0.5–3 m long. The leaves are pinnate, with 5–7 leaflets on petioles 1.5–3 cm long. Single flowers 2–5.5 cm long are borne in the leaf axils on pedicels 4–9 mm long, and range in colour from deep blue to blue-mauve to white. Seed pods are typically flattened and 4–13 cm long, with 8–11 seeds per pod. The seeds are 4.5–7 mm long, 3–4 mm wide and range in colour from olive brown to black.

As Milgarra is a composite of a number of different lines, it is usual to see variations in growth habit (i.e. erect or prostrate) as well as flower colour (i.e. blue, mauve or white) throughout a paddock. This variation does not affect the performance of the pasture.

Arthur Mostead Photography

Examples of flower colour variants

Desirable features

Butterfly pea has a number of features that make it suited to both the central Queensland climate and as a pasture phase in a cropping system:

- vigorous, summer-growing legume
- easy and relatively inexpensive to establish
- prolific seed producer – large numbers of new seedlings can establish over time with appropriate management
- perennial – usually does not require re-sowing
- productive, responds to rain and grows vigorously during hot wet summers
- adapted and persistent on fertile soils with high water holding capacity
- suited to ley and permanent pastures
- competitive with weeds and grasses once established
- tolerant of periodic heavy grazing and prolonged dry periods
- improves soil fertility (total nitrogen and soil organic matter)
- non toxic – does not cause bloat
- Heliothis tolerant and largely unaffected by other insects or diseases
- highly palatable and digestible, and high in protein
- produces excellent weight gains in cattle (between 0.75 and 1.3 kg/head/day)
- more frost tolerant than most tropical legumes and regenerates quickly in warm weather
- easy to kill in subsequent crops using commercially available herbicides
- used for grazing, hay and seed production.

David Sasse

Steers in a butterfly pea paddock at Lindley Downs, *November 2000*

Comparison with other pasture legumes

Butterfly pea has advantages as a ley or permanent legume over other commercially used legumes suited to clay soils in central Queensland. A comparison is shown in Table 1.

Table 1. *A comparison of the features of various legumes suited to the clay soils of central Queensland*

Crop	Establishment	Persistence (years)	Productivity
Butterfly pea	Easy	5-10	Medium
Leucaena	Can be difficult	More than 25	High
Lablab	Easy	1-2	High
Lucerne	Can be difficult	1-2	Low

Lablab can be very productive but rarely persists for longer than 1-2 years. The expense of frequent replanting is a deterrent for more extensive use of lablab. In central Queensland, lucerne does not persist on most clay soils and will only be productive and persistent for an extended time (3-5 years) on deep well-drained fertile soils (e.g. alluvials).

Leucaena is a tree legume, and is primarily suited to long-term permanent pastures on fertile soils. Butterfly pea is faster and less risky to establish than leucaena. It also has a much shorter time to the first grazing and is easier to remove when rotating back to cropping. Some soils well suited to butterfly pea, such as shallow open downs soils, may be too shallow for leucaena.

History

Butterfly pea has its origins in Central and South America, although it is now widely distributed throughout the semiarid and subhumid tropics, including Central and South America, the Caribbean, and parts of Africa, Asia and Australia. Many countries have used it for human consumption, ornamental purposes and animal production.

In Australia, naturalised plants are found along creeks, roadsides and in home gardens from coastal central Queensland to the Northern Territory and northwest Western Australia. Milgarra has been the only cultivar released for grazing purposes in Australia.

Butterfly pea was trialed extensively in pasture species evaluation experiments conducted throughout northern Australia from the 1940s to the 1990s (Hall, 1985). Hall recognised its potential as a useful pasture species in the 1980s at *Milgarra*, a property south of Normanton in northern Queensland.

David Sasse

Stuart Coaker of Lindley Downs *at Springsure investigated the use of butterfly pea as an alternative ley legume species*

The cultivar Milgarra was registered by the Queensland Department of Primary Industries and Fisheries in 1991. By combining a composite of 21 introduced and naturalised lines over three generations, Milgarra was developed after these selections were evaluated in field experiments in northern Queensland (Oram, 1992). Following the release and seed increase of Milgarra, adoption was low despite some promotion by the seed industry in north Queensland.

Developing a technology package for butterfly pea

In 1993, Stuart Coaker (*Lindley Downs,* Springsure) was keen to return some farming country with fertility run-down to pasture. Stuart had previously planted considerable areas to lucerne but was frustrated when stands thinned and became non-viable after two

years or less. He conducted numerous trials and supported many others to help develop knowledge and experience on establishing and managing butterfly pea. Other farmers learned from his research and added their experience to the expanding pool of knowledge on butterfly pea. At the same time, Meat and Livestock Australia (MLA) funded the Legumes for Clay Soils project, which evaluated a number of promising legumes adapted to clay soils on sites from Clermont to Roma. Butterfly pea was one of the legumes included in the project and information on establishment, production and persistence was collected.

In 1997, the Central Queensland Sustainable Farming Systems project (CQSFSP), funded by the Grains Research and Development Corporation (GRDC), recognised the potential of butterfly pea and began the process of developing an integrated package to enable producers to better utilise this legume. Grazing sites were planted to gather data on establishment, grazing management, animal weight gain and soil nitrogen accumulation. A video was developed and made available to interested producers. Trials to determine row spacing, seeding rate and weed control measures to better establish butterfly pea were conducted. Techniques to control butterfly pea in a subsequent crop at the end of a ley phase were developed. Data on organic matter and total nitrogen accumulation were collected.

The combination of farmer, extension and research inputs has resulted in widespread adoption of butterfly pea and has seen the area planted increase exponentially since 1996. Only drought throughout much of central Queensland has slowed its rate of expansion.

The future

When the price relativity between beef and grain inevitably changes, it is likely that productive butterfly pea pastures will be returned to cropping. Improved crop yield and quality is likely to be observed due to improved soil fertility from the legume ley. As land cycles between grazing and cropping, the ley system utilising butterfly pea and crops is likely to contribute to a sustainable production system.

David Sasse

Butterfly pea field day at Lindley Downs, *January 2001*

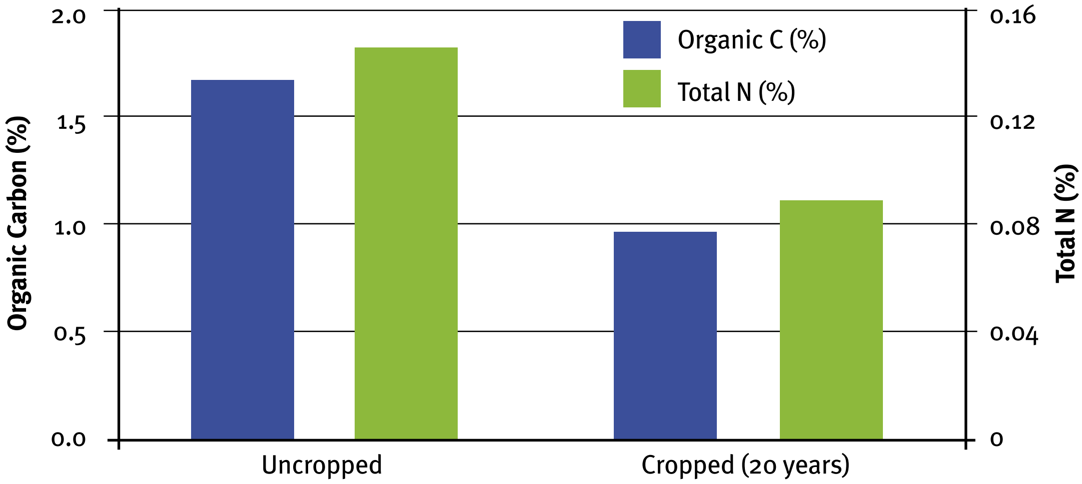
2

Butterfly pea as a ley legume rotation

John Doughton

Until recently, a key element missing from dryland farming systems in central Queensland has been a well-adapted ley legume for rotation with field crops. Ley legumes are pasture species planted into old cultivation to restore soil nitrogen (N) and organic matter levels. After three to five years, the pasture is removed and the area returned to cropping.

Figure 1. *Soil fertility decline in central Queensland under cropping*



Source : DNRM

In common with all regularly cropped areas, central Queensland has experienced fertility decline (Figure 1) which has continued unabated since extensive farming developed in the region in the late 1940s. In southern Australia, this problem has been managed using subterranean clover, medics and lucerne as rotational leys to restore soil organic matter and fertility. Unfortunately, these legumes have not been successful in central Queensland in a fertility-building role. Only lucerne has been considered an option in the region, however it rarely persists for more than three years under dryland conditions (with rapidly declining productivity).

Lablab is a highly productive but short-term forage legume that has been used to restore soil fertility but must be re-planted every one or two years. Leucaena is a popular browse shrub in central Queensland however it is unsuitable as a ley legume because it needs to be productive for longer than a ley pasture to be cost-effective, and also requires land to be cleared before cropping can recommence. Other legumes, such as Siratro, have failed as ley legumes in the region due to either poor production or persistence. A good ley legume, the key to sustainable and profitable farming in central Queensland, has therefore been elusive.

Nitrogen fertiliser has been used to maintain soil nitrogen fertility under cropping. However the application of nitrogen can be a high-risk strategy in the highly variable rainfall environment of central Queensland. This is particularly the case on the shallow soils that are fairly common in the region. Also, uneconomic rates of nitrogen fertiliser are required on some soils just to maintain total soil nitrogen levels. Hence fertility decline can continue under cropping even where nitrogen fertiliser is applied.

In 1997, staff in the Central Queensland Sustainable Farming Systems project (CQSFSP) recognised the potential of butterfly pea as a ley. Following a short period of research and development, the estimated area of butterfly pea planted in central Queensland has rapidly expanded, increasing from less than 500 ha in 1996-97 to 30 000 ha in 1999-2000, about 50 000 ha in 2002, and to 100 000 ha in 2004. The availability of butterfly pea as a viable ley legume for rotation with grain crops will have a positive impact on the future sustainability of grain farming systems in central Queensland.

How does butterfly pea work as a ley legume?

The main benefit from a ley legume is its capacity to fix atmospheric nitrogen in root nodules, with this nitrogen being distributed through the plant. Legumes have a significantly higher nitrogen concentration than grasses and therefore make good grazing forage for cattle. Additionally, legume residues decompose more rapidly than grass residues. Soil microbes which carry out plant decomposition prefer the low fibre, high nitrogen diet provided by legumes, particularly legume leaves.

Rapid decomposition of legumes and high turnover of microbial populations results in legume plant material being rapidly transformed into plant available nutrients. These include nitrogen, phosphorus and zinc – elements that often become deficient in central Queensland as a result of fertility decline brought about through cropping.

The rapid recycling of nutrients from legumes to the soil can make a soil appear more fertile than it actually is, based on its soil organic matter content. Additional nitrogen fixed in the legume adds to the total soil bank and is also rapidly made available as a result of legume decomposition. This release of nitrogen into the soil can result in a quite marked rise in plant available nitrogen in the soil. This is particularly the case with a warm, wet spring where microbial decomposition of plant residues can be very rapid.

As available soil nitrogen increases, for example in the second year of a butterfly pea ley, legumes tend to utilise this nitrogen rather than fix atmospheric nitrogen through their root nodules. This results in a recycling of nutrients from the soil into butterfly pea, suppressing the amount of nitrogen fixed and reducing the rate of increase in soil nitrogen levels.

At this stage weeds can invade the legume stand to take advantage of the higher soil nitrogen levels. A solution to this problem is to introduce a suitable grass into the ley after one or two years of good legume growth. Grass has the capacity to utilise excess available soil nitrogen and store it in stems and roots where it is less likely to be decomposed by soil microbes. Such long-lived organic residues become soil humus or organic matter, leading to an organic matter increase, which by definition, is also an increase in soil fertility. With grasses using excess available soil nitrogen, legume plants are forced to again fix nitrogen rather than simply take it from the soil. This adds more fixed nitrogen to the system, allowing more organic matter accumulation.

Ideally, a ley pasture should commence with a pure legume stand to fix maximum nitrogen and then gradually increase in grass content to allow this nitrogen to accumulate in grass residues and build up organic matter. Naturally, as the grass component of the pasture increases and the legume component decreases, the amount of nitrogen that can be fixed per hectare will decrease.

The grass sown should also be compatible with a re-cropping phase. Ideally, the grass species chosen should be a less competitive introduced species or a native species that will provide minimal problems in returning to cropping. However, in practical terms it is better to select a grass species that is well adapted to the soil and climate and then select the most suitable method of removal at the end of the ley. Grasses considered to be compatible with butterfly pea in central Queensland are listed in Chapter 4.

Another factor affecting nitrogen accumulation in the ley is the vigour and bulk of the butterfly pea pasture. Quantities of nitrogen fixed by legumes are closely related to how well they grow. Vigorous legume pastures will produce high levels of dry matter and fix significant quantities of nitrogen whereas drought-stricken or diseased legumes that produce low dry matter will fix little nitrogen. Often two good years of legume growth can fix more nitrogen than five or more poor growth years. This is important for judging when a ley has produced most of its benefit (and thus when it may best be terminated and re-cropped).

Other issues also come into this decision including the relative returns from grazing and crops as well as the amount of stored soil moisture at the time of pasture removal. Good

stored soil moisture is essential for ensuring both a good kill from spraying out a ley with herbicide and the opportunity to re-crop quickly.

Ideally, a butterfly pea ley should be sprayed out and zero-tilled into cropping. This minimises nitrogen losses by preserving organic matter and retaining more of the nitrogen accumulated throughout the ley. Nevertheless, some problems may be encountered in the transition from ley to cropping that may require cultivation.

Cultivation of a nitrogen-rich ley can produce more available nitrogen than a crop can use. This excess can be lost through denitrification or leaching. Ideally, if cultivating out of a successful legume ley, it is useful to plant crops with a high nitrogen requirement such as grain or forage sorghum or cotton to help minimise nitrogen losses.

Properties of butterfly pea in a ley

What makes butterfly pea such a useful ley legume?

Suited to heavy clay cropping soils in central Queensland

Butterfly pea grows well on the better quality cropping soils in central Queensland. These include open downs soils and the heavier alluvial and brigalow soils. This adaptation makes butterfly pea an ideal complementary ley species to rotate with field crops commonly grown on these soils.

Perennial – does not require re-sowing

As a self-regenerating perennial species, butterfly pea stands can be long-lived without the requirement for re-sowing as is the case with lablab. This reduces costs and management input to maintain a stable and productive pasture.

Self-regenerating from seed – populations increase over time

Perennial stands of butterfly pea can increase in density as a result of annual regeneration from seed produced by the existing plant stand. This provides increased competition for weeds and allows swards to thicken over time under appropriate management.

Competitive with weeds and grasses once established

With recommended planting rates, row spacing and weed control at establishment, dense and productive swards of butterfly pea can be achieved. These are quite competitive with weeds and, with minimal management input, can be maintained in this condition. Poor establishment practice in butterfly pea can leave a legacy of sub-optimal production and ongoing weed problems.

Fine stems allow possibility of zero-till in a subsequent cropping phase

When plant populations are adequate, butterfly pea does not produce large woody stems and roots. The plant is easily killed with herbicides and subsequent crops can be planted through ley residues using a zero-till planter in most cases.

Frost tolerant in central Queensland, regenerating quickly in warm, wet weather

This feature makes butterfly pea well adapted to most parts of central Queensland. Established plants have good frost tolerance, and although butterfly pea slows its growth considerably in winter and loses leaf due to frost, it re-grows rapidly with rain and the onset of warmer weather.

Weed control at establishment is relatively easy

The keys to successful establishment developed for butterfly pea (see Chapter 4) ensure successful stands of the legume can be established if certain weed control practices are followed (see Chapter 5).

Removal of butterfly pea as a weed in crops is easy

When re-cropping butterfly pea leys, it is important that the legume itself does not become a weed in the newly sown crop. Management practices to prevent this occurrence have been successfully developed (see Chapter 5).

Productive with high quality forage

Butterfly pea forage quality is high (see Chapter 7) and, being a tropical legume with adequate fibre content, it does not produce bloat in cattle.

Provides excellent weight gains in cattle

Butterfly pea has demonstrated that it can produce quality forage and high weight gains in grazing cattle so that the ley phase contributes significantly to the income of the whole system (see Chapter 6).

Recovers from periodic heavy grazing

Grazing management is important in the management of first-year stands, however experience has shown that established, healthy stands can recover well from short periods of heavy grazing.

Multipurpose – hay, seed, grazing

Butterfly pea has successfully produced hay crops (see Chapter 7), seed crops (see Chapter 8) and is suitable for grazing cattle, both with and without grass. This provides additional options for diversity in the income stream from the legume.

Production unaffected by common insect pests

Heliothis causes minimal damage in the crop. Some pods can be attacked, however little damage is seen, even in crops where heavy populations of heliothis are present on alternative hosts within the crop.

Builds soil fertility

Initial studies indicate that butterfly pea builds soil fertility, although more research is needed to determine the amount of soil nitrogen increase in different situations. Although the relative amount of soil nitrogen increase compared with other ley legume options such as lablab and lucerne is yet to be determined, butterfly pea has many other features that make it a suitable ley legume for central Queensland. It also reduces risk of using nitrogen fertiliser that may not provide responses in every year due to moisture limitations.

Farming systems and butterfly pea

Butterfly pea adds a further dimension to farming systems in central Queensland. Recent work by the Central Queensland Sustainable Farming Systems project (CQSFSP) has shown that grain farming can be profitable on shallow soils while native soil fertility is being exploited. However, when fertility declines and nitrogen fertiliser becomes necessary to maintain yields, the additional costs of this fertiliser and the uncertainty of responses to nitrogen in the highly variable rainfall environment of central Queensland places the farm business in jeopardy.

On these soils, butterfly pea has a role in providing a lower risk income from grazing and a capacity to improve soil fertility without the need for financially risky fertiliser applications. With fertility accumulation, opportunities then become available to reintroduce a cropping phase without the risks associated with fertiliser inputs. The capacity to manage soil fertility levels through different phases of a farming system is vastly different from past farming systems that have been characterised by continuous fertility decline and nutrient deficiency problems. Maintenance of soil fertility allows greater advantage to be taken of better-than-average seasons and ensures optimum water use efficiency to maximise crop yields.

Butterfly pea should have a marked impact on the sustainability and profitability of farming systems at the more marginal end of the soils spectrum. As fertility continues to decline over time, butterfly pea rotations will allow cropping of these soils on a regular basis. It will avoid the need to return these soils to permanent pasture through a lack of economically viable options for fertility restoration. This will be a major benefit to the region as central Queensland has large areas of shallow soils, including soils which have saline and sodic subsoils.

CQ Sustainable Farming Systems project trial results:

Measuring soil fertility at *Lindley Downs*, Springsure

Butterfly pea is a legume, giving it the capacity to convert atmospheric nitrogen (N) to soil nitrogen, and over time should increase the amount of soil nitrogen present. This is important in central Queensland farming systems where the inclusion of butterfly pea in the rotation should allow soil nitrogen levels to be maintained. This provides an alternative to nitrogen fertiliser application, which is often risky due the variable rainfall patterns in central Queensland.

This work sampled butterfly pea pastures of different ages to identify changes in soil nitrogen levels compared with a natural grass pasture, to determine if butterfly pea pastures can improve soil fertility.

What was done?

In March 1999, soil and plant sampling was conducted at *Lindley Downs*, Springsure, to determine total nitrogen levels in soils with different cropping / pasture histories.

The soil was a self-mulching black to brown cracking alkaline clay overlying basalt. It was generally low in total nitrogen, organic carbon, sulphur and zinc and high in phosphorus and potassium with a pH greater than 8.5 throughout the profile.

Sampled sites were all within 2 km of each other. The soil at each site was physically very similar with soil depths of 0.5–1.0 m. Cropping / pasture history was the major difference among sites.

David Sasse

Butterfly pea establishing in pasture at Lindley Downs, *Springsure*

Site 1 was an undisturbed Queensland bluegrass pasture (*Dichanthium sericeum*), located on a stockroute / roadside and selected to represent pre-settlement fertility levels. Sites 2-8 were grazed prior to the 1950s and have been farmed since — almost 50 years. In the early years (1950–60s), wheat was the main crop; later (1970–80s) sorghum was the dominant crop with other crops such as sunflower also grown. During the 1990s, ley pastures (butterfly pea and purple pigeon grass) were progressively established across the farm.

Ten soil samples (0–10 cm) were collected from each site in March 1999 and individually analysed for total N. Within each butterfly pea / grass pasture, five samples with dominant butterfly pea pasture and five samples with butterfly pea / grass mix were selected.

What happened?

Table 2. *Average total soil N from 10 surface soil samples taken from various sites at* Lindley Downs

Site	Pasture type/age	Planting date	Plant material present at sampling	Total soil N 0-10 cm (kg/ha)	Proportion of Site 1 (%)	Plant dry matter (kg/ha)
1	**Undisturbed Qld bluegrass**	Undisturbed Qld bluegrass pasture	Qld bluegrass	**1208**	100	7050
2	**BFP/grass pasture ley - 7 years**	Butterfly pea planted 14/4/93	BFP + PPG + Qld bluegrass	**1050**	87	2550
3	**BFP/grass pasture ley - 4 years**	Butterfly pea planted 23/1/95	BFP + PPG + Qld bluegrass	**1207**	100	4400
4	**BFP/grass pasture ley - 3 years**	Butterfly pea planted 10/3/96	BFP + grass	**667**	55	2150
5	**BFP/grass pasture ley - 2 years**	Butterfly pea planted 3/2/97	BFP + PPG	**1022**	85	2900
6	**BFP/grass pasture ley - 1 year**	Butterfly pea planted 10/2/98	BFP + PPG	**1028**	85	8850
7	**Grass only ley - 7 years**	Purple pigeon grass planted in 1992	grass only	**806**	67	2100
8	**Continuous cultivation**	Cultivation	nil	**564**	47	nil

BFP = Butterfly pea
PPG = Purple pigeon grass (*Setaria incressata*)

What did we learn?

Although this sampling process has limitations, it nevertheless indicates some trends:

- 50 years of continuous farming has reduced the total N levels in the top 10 cm of soil by more than 50% (at the time of sampling total N levels were 47% of the original Queensland bluegrass level).
- Legume / grass pastures are effective in rebuilding total N and restoring soil fertility.
- The quantity of dry matter produced by the pasture over time, especially the legume component, has a greater impact on how quickly total N is rebuilt, than the number of years of ley pasture growth.
- A grass only ley pasture (which will often have some native or introduced legumes) can restore some N and organic carbon but usually at a slower rate than a productive legume / grass ley.

Further work is required to better quantify these effects on the soil types where crops and ley pastures will be successful.

Acknowledgements

Results from this trial have been compiled by Maurie Conway (DPI&F Emerald). The project is grateful for the co-operation and assistance of Stuart Coaker of *Lindley Downs*.

3 Climate and soils

Maurie Conway and Rod Collins

Climatic requirements

Butterfly pea is a summer-growing legume and is most productive on deep, fertile soils when temperatures are warm. With appropriate management on suitable soils it can be persistent and productive in 650-1250 mm (26-50 inches) rainfall areas.

Productivity of butterfly pea is strongly influenced by the length of the growing season, which in turn is affected by availability of soil moisture and then by low autumn temperatures. Rainfall becomes more reliable but more distinctly confined to a summer wet season in areas north of central Queensland. The effect of low temperatures during spring and autumn limiting growth increases in areas further south and west of central Queensland. The growing season becomes too short for viable production due to these temperature effects south of the Qld/NSW border. In western Queensland, low rainfall and temperatures are likely to significantly shorten the growing season.

As a general rule:

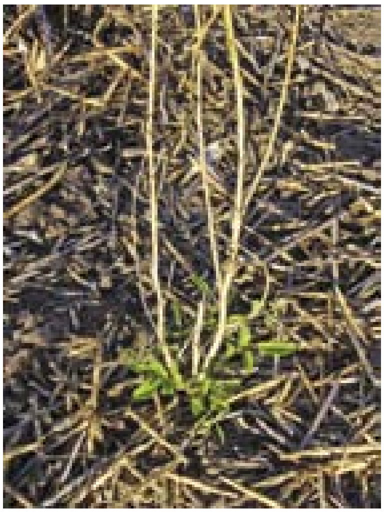
- Spring growth will be slow until average temperatures reach 21°C.
- During summer, maximum growth occurs when temperatures reach 27°C or greater and soil moisture is non-limiting.
- In inland central Queensland and southern Queensland, production will effectively finish when autumn average temperatures reach 15°C.
- In northern and coastal Queensland, soil water rather than autumn temperature defines the end of the productive season.

Table 3. *Indicative regions /districts where butterfly pea will be productive if planted on suitable soils*

Region / District	Median rainfall (mm)	Autumn temperature limitation to growth[1]	Potential forage production[2]	Months of potential high growth
North Queensland				
Peninsula - Cooktown, Coen, Laura, Chillagoe	850-1700	1	high	6
Gulf - Burketown, Normanton, Croydon, Georgetown, Mt Surprise	700-900	2	high	5
Dalrymple - Charters Towers, Lyndhurst, Mingela	650-750	3	high	5
North & Central Coast				
Burdekin - Ayr, Bowen	900-1100	2	high	6
Whitsunday - Prosperine, Mackay, Sarina	1000-1750	2	high	6
Capricornia - St. Lawrence, Marlborough, Yeppoon	800-1100	2	high	5
Central Queensland				
Central Highlands - Nebo, Clermont, Emerald, Springsure	570-670	3	high	5
Dawson/Callide - Theodore, Moura, Baralaba, Biloela	650-700	3	high	5
Central Western Queensland				
Alpha, Blackall, Tambo	450-550	3	low	4
Wide Bay-Northern Rivers coastal				
Bundaberg, Gympie, Maryborough, Nambour, Lismore	1100-1600	3	med-high	5
South coast hinterland				
Burnett - Monto, Eidsvold, Gayndah, Kilkivan, Goomeri	700-850	4	med	4
Lockyer - Gatton, Esk, Ipswich	750-950	4	med	4
Condamine Catchment				
Darling Downs - Clifton, Dalby, Jandowae, Millmerran	650-750	5	low-med	4
Western Downs - Chinchilla, Miles, Wandoan, Taroom	600-700	5	med	4
Maranoa - Roma, Injune, Mitchell, Surat	500-600	5	low	4

[1] Autumn temperature limitations: 1=nil; 5=high

[2] Forage production: high >4000 kg/ha/year; med 2000-4000 kg/ha/year; low 500-2000 kg/ha/year



Butterfly pea shooting from the crown after frost damage

Frost

Almost all tropical legumes are susceptible to damage from frost. Erect plants usually suffer less damage from light to mild frost than prostrate (low growing) plants but severe frost will damage tropical legumes regardless of plant form.

Butterfly pea plants with woody stems will recover, but young succulent seedlings can be killed by frost. Butterfly pea retains its leaf longer than most tropical legumes when frosted (3-7 days). Leaves die and fall gradually after frost rather than turn to parched paper and fall quickly as does lablab leaf. Its ability to tolerate light frost and retain its leaf for longer after mild frost means butterfly pea will provide feed for longer into winter.

Soil requirements

Soil type

Butterfly pea grows on a wide range of soil types. High plant available water capacity and reasonably high fertility are the most important soil characteristics if maximum production is to be achieved. On soils known to be low in phosphorus, experience suggests that phosphorous fertiliser at rates similar to those used for dryland crops should be applied at planting. Soils with minor to moderate limitations to plant available water (e.g. sodic and/or saline subsoils, shallow soils) will still grow productive stands of butterfly pea, although the total forage yield will reduce as the limitations increase in severity.

Suitable central Queensland soils

Butterfly pea can be very productive on self-mulching, medium to heavy grey and black cracking clay soils with medium to high fertility, such as brigalow and open downs soils. In the past, such soils were considered to be difficult to establish pastures in. Butterfly pea also does well on red basaltic soils, clay loams and highly fertile alluvial loams. It can be persistent and productive (depending on soil depth and fertility) on brigalow/eucalypt soils. Butterfly pea fails to persist in arid areas or on soils with low plant available water capacity, such as infertile red and yellow duplex, sandy grey and yellow earths, and coarse granite sands. Table 4 summarises soil types found commonly in central Queensland and their suitability for butterfly pea. In general, soils with a high water holding capacity and reasonable fertility will be able to support a productive and persistent butterfly pea pasture with correct management.

Table 4. *Common central Queensland soil types and their suitability to butterfly pea pasture*

Dominant vegetation and sub-types	Dominant soils	Potential production and persistence
Brigalow		
1. Softwood scrub	Loamy clays	high
2. Scrub	Heavy clays	moderate – high
3. Dawson gum/Poplar box	Duplex	low – moderate
Alluvial flats		
1. Coolibah	Heavy clays	moderate – high
2. Blue gum	Loamy clays – heavy clays	high
3. Brigalow	Heavy clays	high
4. Poplar box	Duplex or hardsetting loam	moderate
Downs		
1. Open grassland	Heavy clays	moderate – high
2. Open woodland	Medium – heavy clays	low – moderate

The actual production from and persistence of a butterfly pea pasture will also be affected by factors such as rainfall, plant population and grazing management.

Subsoil salinity and sodicity

On some central Queensland soils, the productivity and persistence of butterfly pea pastures is affected by the levels of subsoil salinity and sodicity and the depth at which these constraints occur. These constraints affect production and persistence by restricting the plant available water capacity (PAWC) of the soil, with the impact on butterfly pea being greatest in years where there are extended dry periods. Butterfly pea grown on a soil with a low PAWC (<100 mm) will have much lower forage production and persistence compared to a soil with a high PAWC (>180 mm).

Field observations suggest that butterfly pea is productive and persistent on soils with subsoil sodicity and/or salinity levels that are considered acceptable for cropping. Accepted threshold levels for cropping soils are an exchangeable sodium percentage (ESP) of less than 15%, and electrical conductivity (EC) levels of less than 0.8 dS/m. On soils suited to productive butterfly pea pastures (e.g. some brigalow clays), these levels are often not exceeded until depths of 60 to 90 cm. However, when these levels are exceeded or occur closer to the surface, production and persistence of a butterfly pea pasture is reduced.

How long will a butterfly pea pasture last?

With good management, butterfly pea will persist indefinitely on fertile soils with high plant available water capacity. On soils with minor limitations or where grazing places continual pressure on butterfly pea plants, stand life can be reduced to three to four years. On soils with significant limitations to plant available water capacity (such as sodic and/or saline subsoils) or that are relatively infertile, effective stand life can be one to three years depending on the severity of the limitations.

Butterfly pea pasture will maintain a high plant population and tolerate periodic heavy grazing with recovery periods as part of grazing management. With appropriate management, butterfly pea will coexist with aggressive grasses such as buffel grass.

David Sasse

An example of the clay soils of central Queensland which are well suited to butterfly pea pastures

4 Planting and establishment

Maurie Conway

Keys to successful establishment

- Ensure good subsoil moisture prior to planting.
- Plant into moisture as soon as you can get onto the ground after planting rain between January and March.
- Inoculate the seed with Group M (Siratro) inoculum.
- Plant as shallow as possible into moist soil, preferably 2.5 to 5 cm deep. Seedling emergence is reduced at depths >6 cm.
- Plant in narrow rows (20-30 cm) and use presswheels or a roller to ensure good seed/soil contact.
- Plant at 7-10 kg/ha.
- Manage weeds and grasses to reduce competition for soil moisture.

Timing

Butterfly pea grows best under warm, moist conditions therefore growth in early spring and late autumn will usually be slow. The safest time to plant butterfly pea is after rainfall and when the probability of follow-up rain for emerging seedlings is highest. In central Queensland long-term weather records and grower experience suggest January to March as the most reliable time.

Seedling butterfly pea plants are particularly sensitive to competition for soil moisture from weeds and grass, regardless of when they emerge. Reducing competition will ensure better and faster establishment. Seedlings will only establish amongst mature plants after good rain and when there is low grazing pressure and low weed and/or grass competition present. Fast growing spring weeds are extremely competitive for moisture against slower establishing butterfly pea seedlings. Good post emergent weed control (e.g. using Spinnaker® herbicide) is essential for establishment during spring. Rainfall is more variable in spring, and warm temperatures in October/November combined with low soil moisture can result in young seedlings suffering moisture stress.

Planting in spring will give a long growing season but should only be considered if:

- it is past the date of the last frost
- the soil temperature is at least 16°C and rising (butterfly pea is slower to establish when soil temperatures are low)
- there is good subsoil moisture and sufficient planting rain
- excellent weed control is achieved.

Butterfly pea will be damaged by frost (see page 17). If planting in late summer or early autumn, allow at least 10 weeks for seedlings to mature and develop woody stems before the first frost. In central Queensland, mid-March is the end of the planting window in frost-prone areas, whereas the planting window can be extended to mid-April if the risk of frost is low.

Studies conducted previously in cultivated paddocks show that soil surface temperatures can reach greater than 60°C, and depending on air temperature fluctuate by up to 40°C during the day (Conway, unpublished data). However, soil temperatures drop rapidly as soil depth increases. Seed left on or near the surface can suffer reduced seedling establishment whereas seed planted into the soil is less likely to be affected by temperature extremes. The impact on surface soil temperature and moisture from leaf litter increases as the quantity of litter increases. The impact is short term (2-4 hours to 1-2 days), but significant.

Results from constant temperature trials

Butterfly pea was germinated at a range of temperatures from 8°C to 44°C in a laboratory trial investigating the effect of temperature on germination. Total germination was low at 8–12°C, increasing rapidly past 16°C and reaching a maximum at 24–28°C before rapidly declining. Above 40°C, no seed germinated. The proportion of dead seed was highest between 8–16°C and 28–40°C. The speed of germination increased as temperatures rose from 8–28°C, was highest at 32°C, but declined between 36–40°C.

What does it mean?

Total germination and speed of germination were highest in the range of 24–32°C. Outside this range, total germination was lower and the speed of germination was reduced. Very early and late season plantings may suffer from poor establishment when soil temperatures are too low. Similarly, seed lying on the soil surface may not germinate properly in the middle of summer when temperatures are high.

McDonald, C.K. (2002). *Germination response to temperature in tropical and subtropical pasture legumes. 1. Constant temperature.* Australian Journal of Experimental Agriculture **42:** 407–419.

Planting options and machinery

There are a number of different methods used to establish butterfly pea, varying according to the condition of the paddock to be planted and the machinery available. Regardless of the method used, good seed/soil contact will ensure quick and even establishment. Best establishment is achieved when seed is planted shallow into soil moisture and a roller or presswheels are used. If seed is broadcast on the surface rather than planted, a roller is preferable to harrows for improving seed/soil contact. Harrows may assist to cover seed but leave the soil fluffy and likely to dry out quickly. Poor establishment can result from seed lying on the soil surface if follow-up rain does not fall immediately after germination, as seedlings will die if the soil dries out before roots can establish.

Planting into cultivation

This method can produce good results as it is easier to ensure good seed/soil contact and therefore quick and even establishment. The relatively large seed size of butterfly pea allows it to be sown using normal crop planting machinery, such as air seeders, combines and precision planters. Planters should have presswheels, or a roller should be used at planting to improve seed/soil contact. The success of this method relies on good weed control in the fallow prior to planting to ensure adequate subsoil moisture levels and minimal weed competition at planting. Spraying weeds rather than cultivating will maximise the amount of soil moisture stored in the fallow.

Seed that has been scarified or seed with a low hard seed content is preferred to ensure a quick and even establishment. Seed should be planted at 2.5 to 5 cm into moist soil as emergence is reduced if planted deeper than 6 cm. Narrow rows (20–30 cm) are preferred as they provide increased competition with weeds, less competition with other emerging butterfly pea plants and maximise total dry matter production. Once row spacings exceed 50 cm, weed management becomes difficult and dry matter production is likely to be reduced.

Planting at 7-10 kg/ha and applying Spinnaker® according to label directions will maximise dry matter production and ensure weeds are controlled during establishment. Planting at a higher rate (10-15 kg/ha) can increase the established plant population and help control weeds but should not be considered as an alternative to applying Spinnaker® when weed populations are moderate to high. Spinnaker® should not be applied when grass seed is planted at the same time as the butterfly pea. Applying Spinnaker® may not be necessary when soil moisture and temperatures are high and weed seed populations are very low.

Broadcasting into native or improved pasture using herbicides and minimum till

Good establishment is possible in native or improved grass pastures in a low cost operation that reduces the competition and direct broadcasts butterfly pea seed. Broadcasting seed into grass pasture without reducing competition from existing plants is rarely successful, as established grass will normally out-compete butterfly pea seedlings for soil moisture.

To maximise establishment, reduce competition from existing grass or weeds as much as possible by either grazing, slashing or burning after spring rain and then spraying out the regrowth of grass and weeds. Although seed can be spread at the same time as spraying, better results can be expected if a second spray is used before the seed is broadcast. This achieves a better kill of the existing pasture and improves soil moisture storage. Seed can be spread using a fertiliser spreader, roller drum, or similar machinery. Establishment can be improved by using a roller or covering harrows behind the spreader where possible. This will bury some seed and maximise seed/soil contact.

Select butterfly pea seed with a high hard seed content (see “Seed treatment” later in this chapter) to ensure multiple germinations. This means that some seed will survive if there is little follow up rain after planting. This method is cheap and effective if competition is low at planting.

Planting with a crocodile planter

Sowing with a crocodile planter into native pastures is often only successful on self-mulching open downs soils and when grass competition is low. Success is dependent on follow up rain and low grass/weed competition during establishment. Reducing competition by grazing, slashing or spraying will improve seedling survival.

Planting using a roller drum seeder during blade ploughing

Large areas have been planted with butterfly pea using a roller drum seeder during blade ploughing. Some seed may be buried too deep using this method so planting rates may need to be adjusted to achieve the desired plant population. Establishment studies have found that 50% more seed will emerge from 6 cm than from 9 cm and 50% more from 9 cm than 12 cm (Conway, unpublished data). Again, select seed with a high hard seed content. Success of butterfly pea establishment using this method varies enormously and is dependent on factors including amount of follow up rain, the proportion of grass that is killed or re-establishes, the rate of subsequent grass growth, and grazing management.

Butterfly pea seed spread via dung

Butterfly pea seedlings geminating in dung heaps is a common sight in established stands as cattle readily eat seed pods. Cattle will successfully spread butterfly pea seed in established stands in a wet summer season. Nil or lenient grazing, good soil moisture, and low grass and weed competition are required to ensure establishment. While this will assist to establish plants throughout the paddock, it is likely to be a slow and unreliable planting technique.

Planting rate – a guide

The recommended rate for most situations is 7-10 kg/ha but successful establishment will be affected by:

- seed quality (normal & hard seed percentage, seed viability)
- planting conditions (soil moisture, soil tilth, seed/soil contact)
- weed competition.

Table 5. *Expected establishment (plants/m^2) under good conditions at various planting rates*

Rate (kg/ha)	seed/ha	seed/m^2	Emergence (67%) (plants/m^2)	Establish (67%) (plants/m^2)
1	23 000	2.3	1.5	1.0
2	46 000	4.6	3.1	2.0
4	92 000	9.2	6.1	4.1
6	138 000	13.8	9.2	6.1
8	184 000	18.4	12.3	8.2
10	230 000	23	15.3	10.2
15	345 000	34.5	23.1	15.5

Table 6. *Plant population guide (plants/m^2)*

	Low	Medium	High	Excellent
BFP/grass pasture	‹ 1	1 - 5	5 - 10	› 10
BFP sward only	1 – 5	5 - 10	10 - 20	› 20

But I don’t want to plant more seed than I have to!

Planting rate is often a compromise between planting enough seed to achieve the desired plant population and spending as little as possible on buying seed. So:

- If seed quality is high and planting and weather conditions are ideal, lower rates will achieve a good population.
- If seed quality is low and planting and weather conditions are poor, higher planting rates are unlikely to fix the problem.

What’s the best approach?

When planting into good quality soils with a weed-free fallow period, a planting rate of 7–10 kg/ha will most likely give a thick even stand which can be grazed earlier.

When using a low cost approach to planting ensure that you kill or significantly reduce competition (existing grass and weeds) and plant when it is wet and hot (January–March) as butterfly pea is likely to be growing fastest.

Planting at lower rates (2-4 kg/ha) will be cheaper in the short term but requires time and careful grazing management to enable the plant population to increase. Table 5 shows the expected established plant population at different planting rates under good establishment conditions, assuming 67% of the seed emerges and 67% of the emerged seedlings successfully establish. Note that both the expected emergence and establishment rates can vary according to a number of seed and environmental factors including seed quality, soil moisture and temperatures at planting as well as seed/soil contact and the degree of hardseededness. A guide to plant populations can be seen in Table 6.

Factors affecting establishment and survival

Flooding

Field observations suggest that butterfly pea tolerates or recovers from short-term flooding better than many tropical pasture plants. Most butterfly pea plants die when covered by floodwaters for more than 12-36 hours. While plant numbers will decline, butterfly pea has demonstrated that some plants will persist and continue to grow even when standing in shallow water for up to 2-6 weeks on soils that drain slowly. Butterfly pea will not persist on non-draining waterlogged soils.

Where soil seed levels are high, seedling regeneration after flooding can be spectacularly high in established stands. To achieve successful establishment from seed ensure low grazing pressure and weed competition following emergence.

Fire

Temperature and duration of the fire (governed by fuel load, air temperature, humidity, soil moisture and wind) will largely decide survival of butterfly pea after fire. A hot fire can kill plants completely. Cooler fires may kill some stems or all above ground material in which case the plant may re-shoot from surviving stems or from the plant base. Fire destroys litter and reduces cover, increasing the establishment of both butterfly pea seedlings and weeds.

Seed treatment

Inoculation

Inoculation is required for effective nodulation of the roots by *Rhizobium* bacteria, which produce nitrogen for plant use. Effective inoculation can increase the rate of establishment, resulting in faster growth and higher nitrogen content. For inoculation of butterfly pea, use Tropical group M - suited for siratro. Butterfly pea can nodulate using native *Rhizobium* strains but many of these strains result in slower nodulation and less effective nitrogen fixation.

To ensure optimum inoculation, check the expiry date on the packet as old inoculant is less effective. Ensure the inoculant is kept cool (i.e. in the fridge) until you are ready to use it. As the inoculant contains living bacteria, it will die if exposed to high temperatures. Only inoculate the amount of seed that you can plant within 12 hours and store any inoculated seed out of direct sunlight.

When to scarify BFP seed?

Hardseededness in legumes prevents all seeds germinating on the one rainfall event, with multiple germinations helping to ensure survival. Hardseededness occurs because the seed coat is impermeable to water. Butterfly pea's hard seed percentage varies with each seed lot (<10% to >65%), giving differences in germination percentage between seed lots. The percentage of hard seed is determined by a seed test, and should be requested when buying seed.

When to scarify seed? – a rough guide

If the HARD SEED content is HIGH (greater than 40-70%), seed is suitable for sowing into rough seed beds e.g. blade ploughing. Consider mechanically scarifying seed prior to planting into cultivation or increase planting rate.

If the NORMAL SEED content is HIGH (greater than 40-70%) and HARD SEED content is LOW (less than 20-40%), seed is suitable for planting into cultivation and mechanical scarification of seed is not essential.

Mechanically scarifying hard seed ensures a faster emergence by damaging the seed coat to enable moisture to enter the seed and start the germination process. This maximises the number of seeds that germinate immediately after planting, whereas hard seed that is not mechanically scarified will germinate over a number of rainfall events. At the time of printing, scarification of butterfly pea seed cost $1.00-$1.50/kg.

The decision to mechanically scarify seed will depend on the hard seed content and the planting situation.

Germination tests – what do they tell you?

Normal percentage is the percentage of seed that will germinate and produce normal seedlings when watered. Generally the higher the number the better the seed quality.

Abnormal percentage is seed that germinates but the seedlings are abnormal and unlikely to survive under field conditions. Nil or a low number is acceptable.

Fresh percentage is seed that is alive but ungerminated (dormant). Most tropical grasses are dormant after harvest varying from about three months for Rhodes grass to 7-18 months for purple pigeon grass. A low number is desirable if the seed is to be planted soon.

Hardseed percentage is seed that is alive but will not germinate until the seed coat is fractured and water can enter to begin the germination process. In nature the seed coat can fracture from repeated hot/cold cycles. Mechanical scarifying seed fractures the seed coat and ensures quicker germination. A high number means the seed is suitable for planting where multiple germination events are desirable.

Dead percentage is seed that did not mature or has died during storage. High dead percentage may indicate poor harvest or storage conditions and that quality of the whole sample is declining.

Pure percentage determines the percentage that is seed versus litter, trash, other seeds or dirt. A high number is preferred.

Planting grass with butterfly pea

The most productive and stable pastures are a legume/grass mix because:

- a legume/grass pasture will normally produce more dry matter (and increased animal production) than a legume-only pasture.
- grasses use nitrogen as it is fixed by the legume ensuring the legume continues to fix nitrogen.
- competitive grasses minimise invasion by broadleaf weeds.

Invading native grasses (or grasses establishing from a previous pasture) can provide sufficient plants for a legume/grass pasture. Where there are low weed seed populations and no pre or post-emergent chemical that will kill grass seedlings is applied, a low rate of grass seed (0.5–1 kg/ha) can be planted with the butterfly pea seed. Grasses with the ability to spread will fill gaps in the pasture. A thick well-established butterfly pea stand will impose significant competition to establishing small-seeded grasses. For best results when planting grass into an established butterfly pea pasture:

- plant when the chance of good soil moisture and follow up rainfall is high (January – March). Plant at other times only if competition for soil moisture is low and there is sufficient moisture to allow small seedlings to grow.
- plant adapted species and ensure good soil/seed contact
- plant shallow (1 cm) or on the surface into a firm seedbed with a roller or presswheels. Some soil coverage is an advantage but planting too deep will result in nil or low emergence.

Planting rate

Planting 2 kg/ha (either a single species or a mix of species) is sufficient when high quality seed is placed on the surface or incorporated into the top 1 cm of soil and rolled firmly to ensure good seed/soil contact. This allows the seed to begin germinating before the soil surface dries. The planting rate can be varied depending on the following factors:

- **seed quality**. Frequently high quality seed will also have high vigour, meaning a higher proportion of seedlings will emerge at a faster rate. A small amount of high quality seed can achieve the same number of established plants as a large amount of low quality seed.
- **degree of soil / seed contact** achieved (firmness of the seed bed) and quality of the subsequent rolling.
- **soil moisture** present and the competition for this moisture from the existing butterfly pea and weeds.
- **desired grass population** and how quickly you want to achieve that density. Increase the planting rate if a high plant population is desired quickly.

Selecting a grass species

Consideration needs to be given to many factors when deciding which grass to include in the pasture mix:

- **climate** - rainfall, temperature, risk of drought, frost and floods.
- **soil type** - soil fertility, drainage and soil texture (clay or sandy soils).
- **length of pasture phase –** reliability and ease of establishment are important for short term pastures (2-4 years) whereas in long term pasture (greater than 4 years) persistence may be more important.

Grasses considered suitable for planting with butterfly pea in central and southern Queensland:

Bambatsii *(Panicum coloratum var makarikariense* cv. Bambatsii*)*

- adapted to clay soils
- tolerates drought, flood, frost, high salinity
- establishment is difficult (particularly on heavy clay soils) and slow unless planted into a firm, shallow seedbed with press wheels following
- productive when grown on fertile soil
- very persistent even on low fertility soils.

Bambatsii will grow on clay, clay-loam and loam soils but is particularly well adapted to Brigalow clay and downs soils. The seed is small and smooth and poor establishment will occur when planted too deep.

Bambatsii is second only to buffel for drought tolerance and persistence. It will tolerate inundation from flood waters for 1-2 days but will survive for 1-2 weeks if stem and leaves are above water.

Buffel grass (*Cenchrus ciliaris* cv. Americian, Gayndah, Biloela, Bella and Viva)

- the most drought tolerant of commercially available grasses
- adapted to and persistent on light textured soils
- persists but is slow and difficult to establish on heavy clay soils
- responds quickly after small falls of rain.

Buffel grass establishes and persists on clay loam, loam, sandy loam and red earth soils and grows best on moderate to high fertility soils. It is not suited to downs, Coolibah or low fertility forest soils.

Buffel seed is fluffy and can bridge during planting so check the planter regularly to ensure that blockages do not occur. Pelleted seed can make it easier to plant but will be more expensive.

Creeping bluegrass (*Bothriochloa insculpta* cv. Hatch and Bisset)

- stoloniferous, semi prostrate, spreads through runners (Bisset mainly) and seed
- productive on highly fertile soils but more persistent than most other species on low fertility soils
- requires greater than 700 mm annual rainfall and individual plants will die during drought. Unsuited to western areas except in favourable soil moisture conditions.

Seed is expensive so consider planting at low rates (100-500 g/ha) as part of a mix. Cultivar Hatch will only spread from runners during prolonged wet weather or when trampled into the soil whereas Bisset will more readily put down roots at each node.

Hatch is taller and more productive if fertility and moisture allow, while Bisset has finer leaves and is often shorter.

Floren bluegrass (*Dichanthium aristatum* cv. Floren)

- tufted perennial
- establishes on heavy cracking clay soils
- good seedling vigour and will establish in existing pasture
- persistent on low fertility soils
- productive on high fertility soils
- high drought tolerance
- moderate tolerance of flooding and saline soils
- very palatable and is preferentially selected by stock in any pasture.

Floren is preferentially grazed and is more drought tolerant than other bluegrasses (Queensland or creeping bluegrass). It will establish and persist on bluegrass downs and brigalow soils. Seed is expensive so consider planting at low rates (0.1-0.5 kg/ha) as part of a mix.

Green panic (*Panicum maximum* var trichoglume cv. Petrie)

- productive and palatable but will only persist on high fertility soils
- shade tolerant
- only moderate drought tolerance but responds quickly to rain.

Best suited to fertile scrub soils but will grow on fertile clay, loams and sandy loams. Green panic is a good indicator of high soil fertility and will frequently be the first grass to disappear once fertility declines.

Purple pigeon grass (*Setaria incrassata* cv. Inverell)

- easier to establish on heavy clay or hard setting soils than most other grass species
- palatable only on highly fertile soils or when growing in a productive legume mix
- strong competitor for weeds
- produces good hay and seed yields where soil fertility is sufficient
- if soil fertility declines to low levels, leaf and stems will be much less palatable, dry matter yields reduce and plants will decline to single stems or disappear
- only moderate drought tolerance
- does not tolerate flooding but seedlings establish readily after flooding or rain.

The seed of purple pigeon grass is larger so it can be planted deeper into soil moisture rather than on to the soil surface. This enables more plants to establish even on heavy clay soils. Ensure that the seed is at least 12 months post harvest as purple pigeon grass seed has a long dormancy period and may not reach maximum germination for 18 months.

Queensland bluegrass (*Dichanthium sericeum*)

- one of the first tropical grasses to germinate and grow in spring so has first use of the water, nitrogen and space
- productive and adapted to open downs, Brigalow and alluvial clay soils
- palatable and nutritious, especially when young
- fails to persist in drought and declines under heavy grazing
- will frequently recolonise clay soils once the initial high fertility has declined and nitrogen-loving grasses decline or disappear
- an Australian native
- seed is expensive and frequently difficult to obtain.

Queensland bluegrass seed is fluffy and does not flow well so plant as for unpelleted buffel grass.

Rhodes grass (*Chloris gayana* cv. Katambora, Callide, Finecut and Topcut)

- establishes very quickly and provides good coverage from seedlings and runners on suitable soils
- more salt tolerant than other grasses
- poor drought tolerance, and will not survive flooding
- requires moderate to high fertility to persist and will grow on clay, loam, duplex and scrub soils.

Rhodes grass is a tufted summer-growing perennial which roots readily at the node and provides excellent ground coverage when fertility is high. While it is more tolerant of cooler climates, it only tolerates heavy grazing when fertility and soil water are high.

Butterfly pea planted into sorghum stubble

5 Weed management

Vikki Osten and Megan McCosker

Competitiveness and in-crop weed control

Butterfly pea is a poor to intermediate competitor with weeds. Under warm and wet conditions butterfly pea competes quite well, but under dry and/or cooler conditions it competes poorly. Since optimal growing conditions can never be guaranteed, weed control (especially during the establishment phase) is an important issue. Trials have been conducted in central Queensland to determine butterfly pea competitiveness by examining the impacts of planting rate and row spacing on establishment and biomass production in the presence and absence of weeds. Other trial work has concentrated on determining the most cost-effective weed control options for the establishment phase and for mature stands.

The message for weed management during the establishment phase...

The cost-effective planting rate for butterfly pea is 7 kg/ha sown on narrow rows (26 cm) with weed free conditions. Spinnaker® (700 g/kg imazethapyr) at 140 g/ha applied no closer than 2 weeks to planting will provide these desired weed-free conditions.

Butterfly pea competitiveness

The following provide a summary of the research results:

- **Establishment was significantly reduced by both wide row spacing (60 cm) and uncontrolled weeds.** Where weeds were present, the average weed population was 18/m^2. Wide rows reduced the establishment by 30% compared with the narrow rows (26 cm). Uncontrolled weeds reduced legume establishment by 13%.
- **As planting rate increased, dry matter production (t/ha) increased, however both row spacing and weed pressure had influence.** On a narrow row spacing, dry matter production was 25% more than that of the wider rows. Planting similar populations on narrow rows reduced the competition within the row compared with those planted on the wide rows.
- **Individual plant dry matter production was reduced at the high planting rate (15 kg/ha) and was adversely affected by uncontrolled weeds.** This dry matter reduction was due to increased intra-row competition between butterfly pea seedlings. Competition from weeds reduced the dry matter of individual plants by approximately 60%.
- **Weeds had the greatest effect on dry matter production of butterfly pea with overall yield of unweeded plots reduced by 43%.** At planting rates of 15 kg/ha, the difference in yield between weeded and unweeded plots was not significant. However, at the

15 kg/ha on narrow rows

7 kg/ha on narrow rows

7 kg/ha on wide rows

4 kg/ha on wide rows

4 and 7 kg/ha planting rates, the weed-free treatments had 128 and 86% more dry matter production, respectively, than their equivalent unweeded treatments, highlighting the need for good weed control when establishing butterfly pea.

- **Weed control options should be used in normal to dry seasons if butterfly pea is to establish and invigorate in the first 12 months.** However, the need for chemical weed control may be negated if high (15 kg/ha) planting rates are used. The choice between using herbicide or an increased planting rate will be determined by the associated costs and the potential weed population.

Weed control options during establishment

Trial work addressing in-crop weed control for the establishment phase has concentrated on the use of the "legume friendly" herbicides belonging to Group B – Spinnaker®, Flame® and Broadstrike®. Results from this research included:

- Butterfly pea was most severely affected by Spinnaker® when applied very close to or at planting. Under a normal growing season, the legume was unable to compensate.
- Pre-plant applications of Spinnaker® made at least 2 weeks prior to sowing were well tolerated as were those applied 7 days post-emergence.
- There was no effect from Spinnaker® when butterfly pea was planted dry (as opposed to planting after rain), provided the recropping interval to planting was at least 14 days.
- Crop oil (e.g. Hasten®) was not added to the post-emergence applications. Past experiences have shown Hasten® tends to cause severe stunting and yellowing of legumes, which may or may not recover depending on ensuing seasonal conditions.
- The spectrum of weeds controlled from seed by Spinnaker® (in these trials) included:
  - sweet summer grass (*Brachiaria eruciformis*)
  - barnyard grass (*Echinochloa colona*)
  - liverseed grass (*Urochloa panicoides*)
  - caltrop or yellow vine (*Tribulus terrestris*)
  - black pigweed (*Trianthema portulacastrum*)
  - boggabri (*Amaranthus mitchellii*)
  - native jute (*Corchorus trilocularis*)
  - native rosella (*Abelmoschus ficulneus*)
  - a spurge (*Euphorbia vachellii*)
  - bladder ketmia (*Hibiscus trionum*)

Spinnaker® damage to butterfly pea

- Selecting increased planting rates (in lieu of using Spinnaker®) to control weeds during establishment permits the opportunity to use Spinnaker® at a later date, e.g. the following year after the butterfly pea has been grazed and the stand is open and vulnerable to weed competition. This approach should not be considered when planting into paddocks with high weed populations.

Recent farmer experience suggests that Spinnaker® can be applied immediately post-plant as long as follow-up rain is not received. This approach has been successful in drier than average seasons, however there is a greater risk of crop damage should rain fall in the 2 weeks following planting. If rain falls within this period, the emerging butterfly pea plants will suffer severe stunting and yellowing between the veins on leaves. Prolonged ideal growing conditions are needed if the plants are to recover fully.

Some growers have also encountered antagonism in pre-plant tank mixes containing Spinnaker® and 2-4,D amine products, although more research is required to fully explain this.

An off-label permit allowing the use of Spinnaker® in butterfly pea has been approved by the Australian Pesticides and Veterinary Medicines Authority (formerly known as the

National Registration Authority). The details of this permit for Spinnaker® (PER5304) use in butterfly pea in Queensland and the Northern Territory are:

Directions for use:

Crop: BUTTERFLY PEA (*Clitoria ternatea*) AND LEUCAENA (*Leucaena leucocephala*)

Pest: MANY BROADLEAVED AND GRASS WEEDS FROM SEED AND IN THE EARLY GROWTH STAGE.

Rate: 200–400 mL/ha.

Critical use comments:

- Apply either pre-plant at least 2 weeks prior to planting (no closer than 2 weeks prior to planting) or post emergent when the legume is at least 7 days old and weeds are very small.
- Do NOT add crop oil to any application.
- Use the higher rate for longer term weed control.
- Apply only ONE application per legume crop during the establishment phase.

Withholding period:

DO NOT HARVEST FOR AT LEAST 14 DAYS AFTER LAST APPLICATION.

Note that this permit will expire on 31 March 2005. The 240 g/L liquid formulation has now been replaced by a more concentrated granular product (700 g/kg). The rates specified in the permit are equivalent to 70-140 g/ha of the granular product.

Weed control options for established stands

More recent trial work has focused on chemical weed control in established butterfly pea pastures (12–24 months old). In particular the work has targeted spring/summer applications to stands which have been moderately grazed. Bare ground (amongst butterfly pea plants) provides ideal opportunity for weeds to take advantage, particularly during late winter – early spring when the legume is not as active and therefore much less competitive. This window of weed management becomes critical when unseasonal winter and early spring rains are received.

Currently no herbicides are registered for use in established butterfly pea stands. The following information has been generated from local research trials and does not constitute recommendations. The chemicals assessed, either alone or in mixes, included glyphosate, Ally® (metsulfuron methyl), Blazer® (acifluorfen), Basagran® (bentazone), Buctril® (bromoxynil), Buticide® (2,4-DB), Broadstrike® (flumetsulam), and Brodal® (diflufenican). Results showed that mature butterfly pea (i.e. with woody stems) is quite tolerant to glyphosate (500 mL/ha) and glyphosate plus metsulfuron methyl at very low rates (3 g/ha). While some initial effects were quite visible, the butterfly pea tended to recover rather quickly with only slight biomass reductions evident. This herbicide-induced biomass reduction would still be significantly less than reductions caused by uncontrolled weeds. The application of metsulfuron methyl at low rates will also impact on butterfly pea germinations, but this effect will be confined to the early part of the season while herbicide residues are still active. Recent farmer experience suggests that seedling butterfly pea plants are susceptible to low rates (<800 mL/ha) of glyphosate.

Terminating a butterfly pea pasture

A butterfly pea pasture that has been productive for two to three years will have produced many seeds, a percentage of which will be hard seed that can stay dormant for a number of years before germinating. New seedlings will continue to establish annually for several years and may pose problems for subsequent cropping phases. The butterfly pea may become a summer germinating perennial weed within the farming system. It is only likely to be a problem in winter crops if mature plants are permitted to survive over the autumn, or if the winter season is very mild.

Termination of the legume phase is not overly difficult. A common scenario is that the pasture will have been grazed with little green material remaining. Trial results have shown that, provided some green matter is present, applications of glyphosate with either metsulfuron methyl (e.g. Ally®), fluroxypyr (e.g. Starane®) or 2,4-D (e.g. Amicide 625®) have been successful in controlling young butterfly pea plants. The glyphosate has proven to be useful in assisting with the removal of any grasses. However, at the time of printing none of these products were registered for the control of butterfly pea in a fallow situation.

Plants that survive a herbicide application and reach maturity in the fallow can be controlled by cultivating 4-6 weeks later. Blade ploughs tend to leave seeds on the surface, tyne implements bury some of the seed while disc implements bury most seed. Because of the seed size, little or no seed will emerge when buried at 10–15 cm deep, but subsequent cultivations over the next few years may bring seed back to the surface.

Butterfly pea as a summer fallow weed

Once mature plants are controlled, seedlings will become weeds during the fallow. Small seedlings are easily controlled using the herbicides listed above. Applications of metsulfuron methyl may also provide some residual butterfly pea control prior to planting wheat. Atrazine applied prior to planting sorghum will also provide residual control. Neither product was registered for butterfly pea in summer fallows at the time of printing.

Butterfly pea as an in-crop weed

Wheat presents as the best cropping option following a legume ley. Should any butterfly pea seedlings emerge during late autumn – early winter, in-crop wheat herbicides such as metsulfuron methyl (e.g. Ally®), MCPA and 2,4-D (e.g. Amicide 625®) used to target common winter weeds are also likely to be effective against young butterfly pea plants. Chickpea grown later in the rotation may require simazine for the control of volunteers. Balance® herbicide may also be an option but its efficacy on butterfly pea has not been evaluated (generally herbicides designed for use in legume crops are ineffective on legume weeds).

Since few in-crop herbicide registrations exist for sunflower, controlling butterfly pea in this crop will be difficult. Sunflower should be considered late in the rotation sequence once butterfly pea seed banks have depleted.

Whether sorghum is the first crop or a later rotation choice, the use of Starane® or atrazine or both to control other common summer weeds will also control young butterfly pea plants. Both are registered for use in-crop. Several trials have been conducted locally to address butterfly pea as a weed in sorghum. The highlights of these trials include:

*Black pigweed (*Trianthema portulacastrum*) infestation in a butterfly pea paddock*

- Minimise butterfly pea impact by planting into a clean (weed-free) seed bed.
- Use atrazine, preferably applied prior to the planting rain at rates of at least 3 L/ha (50% active ingredient product) and prior to the emergence of the butterfly pea.
- If applying atrazine post-emergent to the butterfly pea seedlings, add Starane® to the mix (minimum rate 400 mL/ha).
  Note: Starane® should never be applied prior to secondary root development in sorghum.
- If relying on Starane® alone, use a minimum of 700 mL/ha and apply before the butterfly pea reaches a height of 12-15 cm. (See note above).
- Keep sorghum row spacing as narrow as possible, and strive for a competitive crop population (>50 000 plants/ha).

6 Grazing management & animal production

Maurie Conway

Grazing management aims to maintain a balance of legume and grass while allowing animals to select a diet high in leaf and young stem for optimum animal performance. Over time a legume/grass pasture is the most productive in terms of both animal and plant production. As a short-term forage (6-18 months), lablab is more productive than butterfly pea.

Plant production and persistence

Butterfly pea can flower within six weeks of planting and under ideal growing conditions can be grazed within 12 weeks of planting. In most cases it will be 14–20 weeks (or longer depending on rainfall and temperature) before the plant is sufficiently mature to withstand grazing without risking plant death.

Butterfly pea seedlings are very palatable and will be selectively grazed. In the first year delay grazing until some seed is set. This provides seed for future establishment and enables the plant to develop a woody frame that can produce large numbers of growing points and rapidly respond to rainfall events in summer. Established butterfly pea has a well-developed tap root and is more drought tolerant when growing on deeper soils. Reduced productivity of butterfly pea in soils with low plant available water capacity or in low rainfall areas will result in lower animal production.

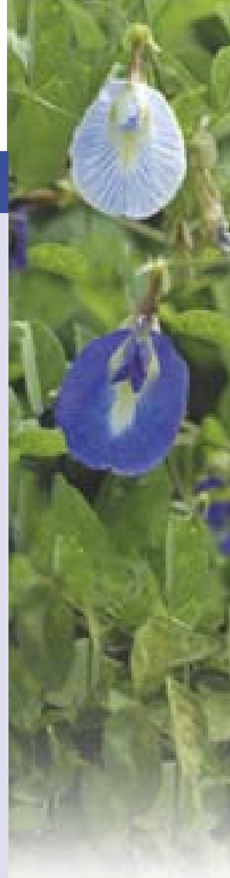
Mature plants are tolerant of periodic heavy grazing but prolonged periods of continuous heavy grazing may significantly reduce plant numbers. Resting for seed production is a useful management strategy in older stands, especially if stand density is declining. In well-managed pastures, individual plants eventually die but new plants establish from the soil seed bank to make up for this loss. It is far cheaper to restore a butterfly pea pasture through natural reseeding than to have to re-cultivate and re-sow. Under hot, dry conditions, pod shattering is normal and seed can be thrown up to three metres enabling limited spread to occur.

Observations of palatability by those who have planted butterfly pea vary from 'eaten but not relished' to more commonly, 'extremely palatable and selectively grazed'. Grazing in a rotational system is more likely to maintain a higher plant population and to maximise dry matter production than year-round grazing pressure. Plants can drop leaves after frosting or in hot, dry conditions and limited grazing of fallen leaf by cattle can occur.

Animal production

Animal production will be highest when plants are growing rapidly, enabling animals to select a diet high in leaf and stem. This occurs from late spring to mid autumn, but as shown in Tables 7 and 8, satisfactory gains can also be obtained in late autumn and late winter.

The benefits of using butterfly pea in conjunction with a grass are outlined in Chapter 2. Butterfly pea is a more nutritious feed than grass both in terms of protein and energy. The higher the percentage of butterfly pea in a mixed pasture, the higher the overall pasture quality and the greater the probability of increasing the protein in the associated grass. To finish animals quickly, use a lighter stocking rate so that the animals can selectively graze the highest quality growth with the best potential for high liveweight gain.



CQ Sustainable Farming Systems project trial results:

Grazing trial summaries

Measurements of liveweight gain on butterfly pea were made on several farms within central Queensland as part of the Central Queensland Sustainable Farming Systems project.

Ross Maclean, *Coolum*, Baralaba

A grazing trial at *Coolum* was located on a self-mulching clay soil, where Coolibah was the dominant tree species. The paddock had been cropped since 1948, mainly to sorghum and wheat, and had moderate limitations to plant growth because of its sodic subsoil.

The pasture was planted on 10 February 1998 to Milgarra butterfly pea at 7 kg/ha using a conventional combine planter. Grass seed comprised of a mixture of 1.2 kg/ha finecut rhodes grass, 0.7 kg/ha Queensland bluegrass, and 0.1 kg/ha Bisset bluegrass was spread on the soil surface in strips using a drum seeder following a combine planter. Grazing commenced in October 1998 and measurements of animal weight gains were recorded over the next three years. Variable costs associated with each group of steers and the income generated were also recorded and used to calculate gross margins for each grazing period.

Animal liveweight gain

Liveweight gain by steers grazing the butterfly pea / grass pasture was excellent especially during the summer months (see drafts 1, 2, 4 and 6 in Table 7). During autumn 1999 (draft 3), low weight gains were recorded following heavy grazing during summer (October-February).

Visual observation of the pasture indicated that butterfly pea can be grazed heavily yet maintain an adequate plant population. At the end of the trial period (April 2002), there were sufficient butterfly pea plants present for the paddock to continue as a productive grass/legume pasture.

Table 7. *Liveweight gain (LWG) and economic returns from grazing butterfly pea at* Coolum *1999 - 2002*

	Draft 1	Draft 2	Draft 3	Draft 4	Draft 5		Draft 6	Draft 7	Draft 8
	steers	steers	steers	steers	steers	heifers	steers	heifers	heifers
Date in	15/10/98	12/01/99	21/04/99	11/01/00	4/04/00	11/05/00	11/01/01	15/01/01	12/02/02
Date out	12/01/99	12/02/99	16/06/99	30/03/00	20/07/00	28/06/00	28/02/01	21/05/01	11/04/02
No. of days on feed	**89**	**31**	**56**	**79**	**107**	**48**	**48**	**126**	**58**
Stocking rate (/ha)	**2.4**	**1.5**	**1.5**	**1**	**1.5**	**2.5**	**1.2**	**1.9**	**1.3**
LWG (kg/day)	**0.91**	**0.87**	**0.16**	**1.1**	**0.65**	**0.69**	**1.1**	**0.53**	**0.83**
Av. weight in (kg)	257	361	430	539	212	232	273	225	291
Av. weight out (kg)	338	388	439	625	282	265	326	292	339
Av. weight gain (kg)	81	27	9	86	70	33	53	67	48
Price ($/kg)	**$1.25**	**$1.25**	**$1.25**	**$1.55**	**$1.55**	**$1.55**	**$1.45**	**$1.45**	**$1.40**
Variable cost ($/ha)	$771	$677	$806	$681	$509	$899	$508	$604	$509
Interest ($)/head @ 5%	$9	$3	$6	$7	$7	$6	$3	$10	$4
Total var. costs ($/ha)	$780	$680	$812	$674	$517	$905	$511	$614	$513
Gross Income ($/ha)	$1,014	$727	$823	$782	$676	$1,027	$606	$783	$593
GROSS MARGIN ($/ha)	**$234**	**$48**	**$11**	**$101**	**$160**	**$122**	**$95**	**$169**	**$80**

Doug Howard, *Bindaree*, Moura

The *Bindaree* grazing trial was located 15 km south of Baralaba on self-mulching black and grey cracking clay soils. The trial paddock of 12 ha had been planted to forage crops (mostly oats) for more than 10 years. An adjacent area of grass, mainly buffel, but with small areas of bambatsii was left undisturbed and provided the grass component of the trial. Treatments included butterfly pea only (100% of the paddock); butterfly pea and grass (50% each); and grass only (100%).

Butterfly pea (10 kg/ha) was planted (20 January 1999) using a conventional combine planter on 46 cm (18”) spacings (no press wheels). Establishment was excellent, assisted by 20-25 mm of rain soon after planting. Observed establishment was higher in the wheel tracks of the tractor, suggesting the use of presswheels may have helped improve establishment. Measurements of liveweight gain were made over the duration of the trial.

Liveweight gain in 2000

All pastures were stocked at 1.8 steers/ha (average liveweight 205 kg). Table 8 shows the average daily gain.

Liveweight gain in 2001

The pastures were stocked at 3.3 steers/ha (363 kg liveweight average) from 9 January to 6 February 2001(28 days). Weight gains were highest on butterfly pea only, intermediate on butterfly pea and grass and lowest on grass only (Table 8).

Because heat wave conditions caused extensive defoliation of butterfly pea plants, all steers were removed to a common buffel grass paddock to allow the pasture to recover and ensure the steers did not lose condition. During this period, very low weight gains were achieved, although there was some compensatory weight gain in individual steers that recorded low weight gains in the previous period. Steers were weighed and returned to their original paddocks on 21 March.

The total weight gain of steers grazing the legume pastures for both periods (total of 50 days) was high and similar for butterfly pea only and butterfly pea and grass. Steers gained significantly less on grass only.

Table 8. *Average daily gain (kg/head/day) of steers grazing pastures at* Bindaree *2000 and 2001*

	2000				2001			
	trial paddocks summer	common grass	total summer period	trial paddocks autumn	trial paddocks	common grass	trial paddocks	total - trial paddocks
Date in	08/12/99	17/2/00	08/12/99	06/3/00	9/01/01	6/02/01	21/03/01	9/01/01
Date out	17/ 2/00	06/03/00	06/3/00	22/5/00	6/02/01	21/03/01	11/04/01	11/04/01
Butterfly pea	1.020 a	0.556 c	0.926 a	0.706 ab	0.905 a	0.163 bc	1.293 a	1.076 a
Butterfly pea & grass	0.904 b	0.544 c	0.831 1	0.639 bc	0.676 b	0.283 a	1.471 a	1.026 a
Grass only	0.549 c	0.522 c	0.544 c	0.486 c	0.508 c	0.233 ab	1.000 b	0.724 b

numbers followed by the same letter are not statistically different

Liveweight gain in 2002

Paddocks were stocked at 2.75 steers/ha (average liveweight 345 kg) for 33 days (30 January to 4 March). Steers grazing butterfly pea and grass recorded similar weight gains to steers on butterfly pea only (0.63 and 0.54 kg/hd/day, respectively) but both gained appreciably more than steers grazing grass only (0.22 kg/hd/day).

Liveweight gain in 2003

Paddocks were stocked at 2.2 heifers/ha (average liveweight 310 kg) for 73 days (10 March to 22 May). Heifers grazing butterfly pea only recorded greater weight gains (0.92 kg/hd/day) than those on butterfly pea and grass (0.58 kg/hd/day) and grass only (0.45 kg/hd/day).

Liveweight gains from December 1999 to May 2003

The average weight gain of four drafts of cattle (total 43 steers and 10 heifers/paddock) grazing the pasture for a total of 294 days was higher for butterfly pea. In this trial there was little difference in the average daily weight gain between animals grazing butterfly pea (0.87 kg/hd/day; range 0.54-1.29) and those grazing butterfly pea and grass (0.75 kg/hd/day; range 0.58-1.47) but less weight gain from animals grazing buffel grass (0.50 kg/ha/day; range 0.22-1.00). For pastures of similar age and quality when grazed at the same stocking rate it would be expected that butterfly pea only pastures would produce higher average daily gains but fewer days grazing than butterfly pea and grass pastures.

Conclusions from *Bindaree* site

During early season grazing, steers are able to maximise average weight gains by eating a greater amount of high quality pasture. Later in the season pasture intake returns to normal levels and lower daily weight gains are achieved.

Stuart Coaker, *Lindley Downs*, Springsure

A 45 ha paddock of butterfly pea was planted at *Lindley Downs* on a self mulching black cracking clay downs soil in mid January 1999. The soil profile was full prior to planting and above average rainfall was recorded during the period post planting — pre grazing.

Grazing commenced on 25 March 1999, nine and a half weeks after planting. The paddock was stocked at 0.8 steers/ha (average liveweight 386 kg). When weighed 53 days later (17 May 99) excellent daily weight gain of 1.45 kg/head/day was recorded.

Following a period of low rainfall and cooler temperatures which resulted in little pasture growth, 60 days later (16 July 99), steers gained only 0.3 kg/head/day. The pasture was grazed for a further 45 days (until 30 August 1999) but animals barely maintained their weight (0.06 kg/head/day gain).

Barry Kucks, *Sunshine Plains*, Theodore

A butterfly pea & grass pasture was planted at *Sunshine Plains* in February 1998. Steers gained on average 1.31 kg/head/day at a stocking rate of 1 steer/ha for 24 days (14 July to 7 August 1998). The steers then grazed sorghum stubble at 0.8 steers/ha for 82 days (7 August to 10 September 1998), recording an average daily gain of 0.75 kg/head/day. The steers returned to graze the butterfly pea & grass pasture for 91 days (29 October 1998 to 28 January 1999) to average 0.84 kg/head/day.

Comparative liveweight gains from lablab and butterfly pea

Lablab, a productive tropical forage legume, can be grown as an alternative to butterfly pea in central Queensland. As an annual, lablab will generally need to be replanted each summer, but with management can be productive for 18-24 months. Steer liveweight gains from grazing lablab were recorded at *Juanita*, *Fernlees* and *Silverton*, Theodore during the summer of 1997/8, when below average rainfall fell.

Table 9. *Animal performance on lablab in trials conducted during 1997-98*

	Juanita 32 ha lablab, 89 head	Silverton 81 ha lablab + 80 ha grass, 205 head
Stocking rate (head/ha)	2.74	2.53
Time in paddock (days)	64	61
Average weight gain (kg)	44.3	40.5
Gain per beast (kg/head/day)	**0.69**	**0.66**
Daily weight gain/ha (kg/day)	1.89	1.67

These data show that under low rainfall conditions, lablab produced similar liveweight gain to that expected from butterfly pea in the same season. In higher rainfall situations, lablab should produce higher forage yields and therefore higher liveweight gains than butterfly pea grazed at the same stocking rate. However, lablab will only produce these results over one to two seasons whereas butterfly pea should be productive over a longer period of time.

Steers grazing butterfly pea

7 Hay production

Maurie Conway and Rod Collins

Butterfly pea makes high quality hay if cut when actively growing before pods form. At this stage the growing tips have a crude protein content of between 20-25% and a digestibility of 70%. Good quality hay will contain 12-15% protein. At equivalent plant populations, butterfly pea often has finer stems and thicker leaves than lablab, allowing butterfly pea to be baled quicker after cutting. The leaves generally stay attached to the braches, minimising leaf loss when raking or baling.

Lucerne is the premium and preferred hay for many end users. It is familiar to livestock owners, who recognise its quality and limitations. It is not easy to consistently grow good quality lucerne in north Queensland or the northern parts of central Queensland. Butterfly pea can produce good quality hay in these areas.

Feeding butterfly pea hay

Industry acceptance of butterfly pea hay is increasing as availability and grower experience increases. The hay does not contain any compounds likely to cause toxicity or palatability problems. Cattle readily eat butterfly pea hay, although feeding high quality pure butterfly pea to weaners may cause scouring, so butterfly pea/grass hay is more suitable in these situations. Butterfly pea/grass hay will be more readily eaten by some cattle than pure butterfly pea.

Horses can vary in their acceptance of butterfly pea hay. This difference is likely to be due to a number of factors, including:

- the quantity and quality of the horse's diet
- whether the horse had been fed butterfly pea hay previously
- whether the horse had grazed butterfly pea in the paddock.

Recent experience suggests that horses who have not previously been fed butterfly pea hay should have it gradually included in the diet. Suddenly changing the diet (particularly when hay is a significant component of intake) may result in refusal unless there is little alternative feed available. Pouring a small amount of water over the hay is reported to improve palatability, although this should only be done where the horses are likely to consume all of the hay within a day.

Establishing a dedicated hay production stand

Successful butterfly pea hay crops can be grown in dryland situations on medium to high fertility soils with sufficient rainfall. To establish a dedicated hay stand, ensure good weed control prior to planting and during establishment (see Chapter 5). Plant on narrow rows (20-30 cm) to maximise competition with weeds and dry matter production. Aim to establish a minimum of 6-10 plants/m^2 but 10-15 plants/m^2 is ideal (see Chapter 4). High plant populations ensure fine stems and higher quality hay. Higher rainfall locations or access to irrigation will maximise hay yields.

When to cut

When to cut for hay is a compromise between quantity and quality. By delaying cutting, the quantity (hay yield) increases but quality (hay protein) declines as stems thicken, lower leaves die and fall and some of the nutrients are transferred from the leaves to maturing pods.

Butterfly pea is best cut when the leaves and branches are still soft and succulent. A few flowers present does not cause problems, however it is preferable to cut the crop before seed pods form. If cutting is delayed, cutting when seed pods are half formed is acceptable

David Sasse

Butterfly pea hay

although hay quality drops quickly as seed pods thicken because mature pods are slower to dry than other plant parts.

Cutting height should not be lower than 7–10 cm as butterfly pea re-shoots mostly from existing stems rather than the crown. Cutting too low can reduce the plant population, particularly if plants encounter severe moisture stress shortly after cutting. Aim to cut when there is at least 5 days of fine weather expected. Cut in the morning after dew has evaporated to allow maximum hours of sun and drying time. In very hot dry weather, it may be necessary to cut in the cool of the evening or night to help retain more leaf. Preferably use a mower conditioner, or condition in a separate operation immediately after cutting. Conditioning speeds up drying by splitting and cracking thicker plant parts such as stems and green pods, ensuring the hay dries out evenly.

Yields vary depending on plant population, soil fertility, growing conditions and the populations of companion grass or weeds. Indicative yields under various conditions are shown below in Table 10, however yields greater than these are achievable in a very good season.

Table 10. *A guide to dry matter production for butterfly pea only pastures*

	Estimated dry matter production (kg/ha)		
Year	low rainfall and/or shallow soils	medium rainfall and moderate–good soils	high rainfall and deep fertile soils
1	100 - 500	1000 - 2500	3000 - 4000
2	500 - 1500	1500 - 3000	4000 - 6000
3	500 - 1500	1500 - 3000	4000 - 6000
Average	**350 - 1200**	**1300 - 2800**	**3500 - 5000**

During summer with good growing conditions, dryland pastures may be cut at 10-12 week intervals and irrigated pastures at 8-10 week intervals. Well-managed pastures can be cut more frequently when soil water (from rainfall or irrigation), soil fertility and temperatures are high. When plant population, soil water, soil fertility or temperatures are low, these cutting intervals will be extended.

Curing

Curing aims to dry the material as quickly as possible to minimise nutrient losses from weathering and microbial degradation. In hot dry conditions, hay will bleach when it is nearly dry, reducing the quality of the hay. Rain prolongs drying time and leaches out soluble nutrients. Rain will do less damage to recently cut pasture than to cured hay.

Air temperature, humidity, wind, soil moisture, and density and thickness of the swath all affect the rate of drying. In warm weather, rake the swath into a windrow the day after cutting (during the night or early morning) and then every 1-3 days to ensure even drying throughout the windrow. Rake when it is cooler and the leaf is wilted but still soft and pliable (40-50% moisture) to minimise leaf loss. In the middle of the day the leaf is brittle and shatters easily.

Baling

Moisture content can vary considerably so it is important to inspect numerous sites throughout the paddock and collect samples from the centre of the windrow before deciding to bale. Aim to bale when the moisture content is about 20–23%. Generally small

David Sasse

Loading butterfly pea hay

rectangular bales will store at slightly higher moisture content than large square or round bales, for which ideal moisture content may be closer to 18–20%. Baling when the moisture content is a lot lower than 20% will cause high leaf loss as leaves are very brittle when dry. These losses can be reduced by baling at night or early morning after the dew has remoistened the leaf. Baling at greater than 25% moisture causes reduced hay quality due to spoilage from mould, and in extreme cases combustion may occur. In warm weather baling can commence in 2–4 days but in cooler periods 1–2 weeks of drying may be necessary.

As a rough guide, the pasture can be baled when the skin of the stem peels back to reveal fairly dry pith inside the stem. Grower experience suggests that tests used by lucerne growers also apply to butterfly pea. Take a bunch of 8-10 stems from the centre of the windrow and crank them using both hands. If the stems break cleanly and easily, without any free moisture in the area that was cranked, then the crop is ready to bale.

The more accurate method is to take a random sample from the centre of the windrow and cut it into small pieces. Weigh out 100g and dry in a microwave oven (slowly on the lowest setting) before reweighing the sample. The difference between the before and after drying weights is the moisture content. For example, if the sample is 100 g before drying and 80 g after, then difference is 20 g, making the sample 20% moisture. A number of samples should be tested from throughout the paddock to get an idea of variations across the paddock.

Hay quality

Hay quality depends primarily on the quality of the pasture when cut. Quality can be retained or lowered by cutting, drying and baling practices but never raised. Hay quality varies enormously and is dependent on many factors including:

- the fertility of the soil in which it is grown
- maturity of the pasture at the time of cutting
- timeliness of cutting, baling and drying operations
- hay storage conditions.

Pen feeding trials conducted with beef cattle by CSIRO in Townsville compared the quality of hay made from a number of pasture species, including butterfly pea. The hay quality and intake data from this trial are presented in Table 11.

Table 11. *Hay quality and intake data of pen feeding trials (Source: D. Coates, Pers. Comm.)*

	Crude protein (%)	Dry matter digestibility (%)	Intake (g/kgLW)	DDMI* (g/kgLW)
butterfly pea	12.5	53.4	20.3	10.8
lucerne	17.5	60.7	21.9	13.3
Verana stylo	-	56.5	21.1	11.9
Cavalcade centro	-	57.7	17.3	10.0
peanut hay + fine cut rhodes grass	8.4	54.4	17.8	9.7
purple pigeon grass	6.5	56.5	18.4	10.4
fine cut rhodes grass	9.4	57.2	18.5	10.6
buffel grass (sample 1)	8.3	53.4	19.4	10.4
buffel grass (sample 2)	5.3	54.0	15.3	8.3
Urochloa (Sabi grass)	4.8	54.7	17.8	9.7
ryegrass	-	63.3	18.8	11.9

*DDMI is digestible dry matter intake (intake x digestibility). DDMI is a measure of the energy intake of the cattle and will be closely correlated with liveweight gain.

Table 11 shows that butterfly pea hay can contain protein levels similar to that of other pasture legumes and that hay made from pasture legumes often contains more protein and is more digestible than grasses. Butterfly pea hay can be of high quality if cut at the correct growth stage, however harsh growing conditions produce poorer quality hay.

Experience suggests that butterfly pea can produce hay with similar protein to lablab but with lower yields. However, a butterfly pea stand will continue to produce hay over a number of seasons whereas lablab will not.

David Sasse

Stored butterfly pea hay

CQ Sustainable Farming Systems Project trial results:

Hay yields from butterfly pea and lablab

What was done?

Endurance® lablab and butterfly pea were planted at *Belvedere*, Baralaba on 15 January 2000. Both legumes were cut with a mower / conditioner and raked into windrows. Once dried, material was baled into round bales. Each bale was weighed to obtain paddock yields (kg/ha). Hay quality samples (total N% and protein%) were taken prior to baling.

What happened?

The established plant population was low for Endurance® lablab and moderate for butterfly pea. Twelve months later the population for lablab had declined but almost doubled for butterfly pea.

Both legumes were cut for hay immediately after a frost in late May 2000. Before mowing, hand cuts were taken to assess biomass and protein. At the time of mowing, lablab and butterfly pea were flowering, and had formed green pods (butterfly pea also had mature pods). There was considerable leaf loss during raking. Lablab was significantly greater yielding than butterfly pea when hand cuts were taken, but butterfly pea had higher protein then lablab. Higher proteins in the hand cut versus baled samples reflected the loss of quality that occurred with leaf fall at baling.

Table 12. *Results from hand cuts and baled hay samples of lablab and butterfly pea*

Treatment	Legume	Yield - paddock dried (kg/ha)	Yield - oven dried (kg/ha)	Total N (%)	Protein (%)
Hand cuts 23/05/00	Endurance® lablab		3844	2.0	12.3
	Milgarra butterfly pea		1741	2.6	16.5
Baled for hay 8/06/00	Endurance® lablab	2506	2258	1.2	7.4
	Milgarra butterfly pea	1925	1822	1.9	12.2

When next cut for hay (13 Jan 2001), the lablab significantly out-yielded the butterfly pea and was also higher in protein. At the time of cutting, the butterfly pea had flowered and was filling pods (reducing quality and protein levels) whereas the lablab was still producing high quality vegetative material.

Table 13. *Endurance® lablab and Milgarra butterfly pea cut for hay (13 Jan 2001) and baled (18 Jan 2001)*

Treatment	Yield - paddock dried (kg/ha)		Yield - oven dried (kg/ha)	Total N (%)	Protein (%)
Endurance® lablab	2900	a	2613	2.4	15.3
Milgarra butterfly pea	1800	b	1704	2.3	14.5

Numbers followed by the same letter are not statistically different

Lack of rain meant very little biomass was produced during autumn 2001. The population of lablab declined to such low numbers that hay production in these strips was not possible. The butterfly pea strips were cut for hay in January 2002 but rain between cutting and baling spoilt the cut material. The protein of the butterfly pea hay was low (9.5%) reflecting the low leaf and high stem ratio in the hay produced during the dry spell. The windrows were subsequently burnt.

What did we learn?

Low legume production and therefore hay yields measured at this site were not unexpected during a period of low rainfall especially on a soil with levels of subsoil salinity and sodicity which can limit rooting depth and plant available water capacity. Lablab was more productive over two seasons than butterfly pea but by then most lablab plants had died. When cut at the appropriate time for haymaking, lablab had greater biomass but lower protein than butterfly pea.

The plant population of butterfly pea increased under a haymaking system, although hay yield and quality was lower than lablab. To avoid reduced hay quality, lablab and butterfly pea should be cut for hay before pods develop as they dry more slowly than leaves and stems. Hay quality is significantly reduced when a lot of leaf has been lost before baling.

Acknowledgements

Results from this trial have been compiled by Maurie Conway (DPI&F Emerald) and Stuart Buck (DPI&F Biloela). The project is grateful for the co-operation and assistance of the Webb family of *Belvedere*.

David Sasse

Baling butterfly pea hay

David Sasse

Grading butterfly pea seed

8 Seed production

Maurie Conway, Rod Collins and John Hopkinson

Highest seed yields will be achieved in butterfly pea pastures that have a high (6-20 plants/m^2) population of well grown plants and are managed to eliminate grass and weed competition. A herbicide such as Spinnaker® at planting is often required to reduce competition from grass and weeds.

High yielding seed crops of butterfly pea have produced more than 900 kg/ha of seed but 200–500 kg/ha is a realistic target. Opportunity crops that have some grass or weeds present and lower plant numbers are likely to yield 50-200 kg/ha. As a very rough guide, 30-40 pods/m^2 will yield about 100 kg/ha.

Harvest timing

Butterfly pea is unaffected by day length and can flower within as little as six weeks of sowing. Its growth habit is indeterminate – it will continue to grow, flower and set seed as long as soil moisture and air temperature are adequate. It is common to have mature seed, green pods and flowers on the plant at the same time. The most mature pods will be the lowest pods on the plant but mature pods will remain intact on the plant for a number of weeks. Aim to harvest when 90% of seed is hard and black and the remaining 10% is firm (can be marked with your fingernail).

Rainfall will dictate when a seed crop commences and timing of harvest under dryland conditions. A paddock can be locked up anytime from October onwards. Most often, paddocks are locked up after rain in January to February and harvested from May to July. Only one seed crop per summer season is possible regardless of when the first rain falls and the seed crop starts. The chance of frost and its timing need to be considered when locating seed production paddocks as frost will kill flowers and prevent green seed from maturing.

Harvest timing should aim to minimise losses from shattering and weather damage and maximise yield from maturing pods. During very hot weather it is possible that more seed will be shattering than is ripening. In these situations harvesting should commence as soon as possible. Losses from shattering during normal summer temperatures are usually around 10%, but high losses (60%) have occurred during prolonged very hot weather. Some weather damage of seed will occur during prolonged wet weather, reducing its germination rate.

Desiccation methods

Seed crops that have been desiccated (have lost all green leaf) are easier to harvest and often produce high yields. Desiccation can be achieved either by natural drying in a dry finish to the season, severe frosting, or by application of a herbicide. Another option is to cut the crop green using a swather and then harvest the windrows.

Desiccation using a herbicide

Reglone® (200 g/L diquat) is registered for pre-harvest desiccation in perennial legume seed crops in Queensland at 1.5–3 L/ha. As Reglone® is a contact herbicide, it will only kill the plant tissue it contacts, rather than being translocated throughout the plant. This means that high water volumes (80–100 L/ha) are necessary to ensure a good result. The lower rate will be sufficient in lower-yielding crops or where the crop has started to dry down naturally. However, in very leafy crops the higher rate will produce better results. Generally harvesting can begin 3-4 days after spraying, although it can be sooner in hot, dry weather and in crops with a small amounts of green leaf.

At approximately $21/L, desiccation using Reglone® will cost between $32 and $64/ha. Commercial spray contractors cost about $6-8/ha per application, with a typical farm boom spray costing $2-4/ha. Allow for up to 5% loss in seed yield from the wheel tracks of the ground sprayer when desiccating.

On-farm research and development work in central Queensland has shown excellent results by desiccating with Spray.Seed® (135 g/L paraquat + 115 g/L diquat) but this is not a registered use at the time of printing.

Advantages of desiccation

Chas Burrell, a harvesting contractor from Emerald, Queensland, (Case IHC 2388 axial flow) has considerable experience in harvesting butterfly pea. He considers the axial flow does a better job on legume crops than conventional harvesters as they are less likely to damage the seed.

His harvester has a bat reel and a draper front, which he says "*does a good job but a pick-up reel may be better." Chas also says "Harvesting a desiccated crop is much easier – 10 times easier – to harvest than direct heading a green crop. It threshes and cleans better. A crop that has not been desiccated is very slow to harvest. It's hard on the machine. The plant is green and ropey and the header becomes very tight. The cost of desiccation is more than recovered in the extra seed gained and improved harvest efficiency."*

"Crops allowed to dry down naturally experience much greater pod shattering at the knife, while there is much less seed lost at the knife from a desiccated crop. Minimal seed losses will occur in desiccated crops (similar to sprayed-out mungbean crops) when the header and operator are up to speed".

Swathing and windrowing

Some of the first butterfly pea seed crops grown in central Queensland were harvested using swathing and windrowing. The crop is cut 10–15 cm off the ground using swathing equipment, which places the cut material in windrows. These windrows need to be turned to dry evenly. The rate of drying is dependent on temperature and humidity as well as how often the windrows are turned. Harvest may be possible in 3-5 days in hot, dry weather but can be greater than 14 days in cool, showery weather. Once the windrows have dried sufficiently, a pick-up front is used to harvest the crop. With a pick-up front, windrows are quicker to harvest than direct heading.

The main problems with windrows include:

- large windrows fail to dry quickly, can form a dense mat and become mouldy
- if wet by rainfall, they can become an entangled mass and go mouldy resulting in seed loss and quality reduction
- seed shattering will occur if windrows are turned.

This technique is quite reliable if the harvest is done during dry winter conditions, but if rain falls on the windrowed crop it can cause partial or total loss.

Harvesting

For a desiccated crop of butterfly pea, header settings should be similar to those used for grain sorghum. Experience suggests that rotor speed should be reasonably slow (400–600 rpm) and the concave clearance (distance between rasp bar and concave) set at medium. Sieve settings should be similar to those for sorghum with air flow set at 800–900 rpm. However, header speeds should be reduced to 7–8 kph (similar to mungbeans, or about half that for sorghum). Butterfly pea augers as well as wheat and better than mungbeans.

Even in a desiccated crop, some green material will travel through with the seed. Grade out this green material as quickly as possible as it will increase the moisture content of the seed and cause individual seeds to go mouldy. Grading can be done on-farm using commercial grading equipment or by feeding the grain back through the header. If newly harvested seed is greater than 12% moisture it should be dried as soon as possible to prevent overheating and spoilage.

Desiccated butterfly pea can be very dusty and may pose a low fire risk during harvest. This risk is not as high as chickpea. Take similar precautions as you would when harvesting a wheat crop.

Harvesting seed in north Queensland (NQ)

Neither desiccation nor windrowing are favoured before seed harvesting on the Atherton Tableland. This is partly because the necessary dry weather following either is less certain than in central Queensland and also partly because headers are already fitted with narrow (4-6 m) open fronts for other seed crops and handle heavy, tangled, green crop more easily. Seed should be routinely dried to 10% moisture content immediately after harvest with forced draught and heated air.

Grazing after a seed crop

Some grazing is possible after harvest. Given that harvest will normally take place in early to mid winter, whatever grazing is possible is likely to be highly regarded. In well grown crops that produce high seed yields, there will be more grazing potential than a low yielding crop. When a desiccant is used there is little leaf material available to graze after harvest, however remaining stems are readily eaten by stock and often are of sufficient quality to provide animal maintenance or small weight gains. If there is sufficient soil moisture and warm temperatures, regrowth can be expected soon after desiccation and harvest which can also provide some grazing potential.

Harvest costs

Harvest cost will include the cost of desiccation ($40-70/ha), heading cost ($50-62/ha) and on-farm cleaning and aeration ($15/tonne).

Producing a commercial grade product will incur added cost. Further grading using gravity tables will frequently be necessary ($60/t) – expect 8-10% grade-out during this process. Freight (to and from the grading plant) will vary with location. Bagging ($20/t) and storage of the cleaned product will add to the final cost. At least one germination test ($35), purity test ($35), or a combined purity and germination test ($61) should be considered.

Do I buy commercial seed or harvest my own?

Deciding whether to buy seed or lock up a paddock to harvest seed will depend on the following:

Butterfly pea seed

- value of forage foregone (grazing from 4-7 months growing period)
- yield of seed
- cost of commercial seed
- harvest and seed cleaning costs.

An estimate of the costs associated with producing butterfly pea seed are shown in Tables 14 and 15. Note that establishment costs are not included and some costs such as the value of grazing foregone can vary significantly between enterprises.

Table 15 shows that low yielding crops are relatively less profitable than high yielding crops. This is often because the extra costs associated with desiccation and contract harvesting are outweighed by the seed yield harvested. Higher yielding crops are also more likely to produce high quality seed.

__Table 14.__ Butterfly pea seed production costs

	Low yield crop	Medium yield crop	Heavy yield crop
Grazing foregone ($/ha)	$150	$250	$350
Desiccation ($/ha)	$38	$64	$70
Harvest costs ($/ha)	$50	$55	$60
On-farm aeration and cleaning	$15/t		
Seed grading	$60/t		
Seed bagging cost	$20/t (based on 40 bags/t)		
Freight to seed cleaning firm	$15/t		
Freight from seed cleaning firm	$10/t		
Seed grade-out	10% of harvested yield		

__Table 15.__ Estimated cost per kg for cleaned, graded and bagged butterfly pea seed

Paddock yield(kg/ha)	Seed cost ($/kg)		
	Low yield crop	Medium yield crop	Heavy yield crop
50	$5.37		
100	$2.75	$4.19	
200	$1.44	$2.16	
300	$1.00	$1.48	
400		$1.15	$1.45
500		$0.94	$1.19
600		$0.81	$1.01
700			$0.89
800			$0.79
900			$0.72

Seed drying and storage

Seed will maintain a high germination, viability and vigour only if air temperature, relative humidity and grain moisture are low. Seed stored in a shipping container must be aerated to maintain quality. Attention to storage hygiene is necessary to prevent seed damage. When planning for control of rodents (rats and mice) and insects (weevils, moths and cockroaches), consider physical, biological and chemical measures. The polypropylene bags commonly used to store butterfly pea seed degrade when stored in sunlight, so store the bags out of the sun.

Stored butterfly pea seed will tolerate temperatures of up to 50°C for short periods but this temperature can be exceeded in high moisture bulk seed within three hours and reduce seed quality. Freshly harvested seed with high moisture (greater than 12% in central Queensland) will heat if left in bulk. A good rule of thumb is that storage life is halved for every 1% increase in moisture content or 5°C increase in temperature. Generally:

- seed at 10% moisture will store safely
- seed at 10–12% moisture needs to be aerated to store
- seed at greater than 12% moisture needs drying. Dry using low temperatures so that germination is not reduced.

Adding storage temperature (°C) to relative humidity (%RH), provides a rough guide to storage life.

- short-term (up to 6 months) must not exceed 80 e.g. 30°C/50%RH or 20°C/60%RH
- intermediate (6–18 months) must not exceed 70 e.g. 30°C/40%RH or 20°C/50%RH
- long-term (18 months–5 years) must not exceed 55 e.g. 30°C/25%RH or 20°C/35%RH

9 Impact of butterfly pea on whole farm economics in central Queensland

Fred Chudleigh, Howard Cox and Veronica Chapman

Background

Butterfly pea was initially incorporated into central Queensland farming systems to restore soil fertility during a 3-5 year ley phase with an expectation that savings in nitrogen (N) fertiliser could be made during a following 3-5 year cropping phase. The reduced income from the ley system was to be offset by reduced costs of N fertiliser, with overall profitability remaining largely unaffected.

Butterfly pea has now been planted in situations where the ley may be extended for 5-10 years or until the relationship between cattle prices and crop returns changes. It has also been planted as a component of a permanent improved pasture. This adds further dimensions to the economics of butterfly pea and require each role to be assessed separately.

As part of the Central Queensland Sustainable Farming Systems project (CQSFSP), the economics of butterfly pea were analysed as a component of two farming systems:

- a grazing system where the choice is between a long term grass pasture or a long term grass pasture supplemented with butterfly pea
- a cropping system where the choice is between continuous cropping or a butterfly pea ley cropping system.

Analyses make use of real data obtained by CQSFSP grazing trials. This data is enhanced by use of computer models in some instances to gain further information and insights, especially over the longer term.

Butterfly pea as a component of a grazing system

Butterfly pea can be an attractive investment when used to improve the performance of a grazing system on high clay content soils in central Queensland. This increase in profitability is evident over a range of cattle prices, weight gains and climatic scenarios, with highest returns available on a rising cattle market.

For a pasture improvement that has an expected life of ten years, returns to extra capital invested can be up to 30% after tax. However, the returns depend very much on successful establishment of the pasture and then using the pasture strategically to add weight to high value livestock such as sale steers. Poor establishment and/or high capital costs incurred in making the investment severely reduce returns.

Assessing potential investment in a butterfly pea pasture

When considering an investment in butterfly pea the existing system (and its costs and returns) needs to be compared to those of the proposed system. An economic analysis should be performed for the entire life of the proposed investment (e.g. 5-10 years).

There may be some conversion costs associated with including butterfly pea in a farming system. These should be recorded in the first year the proposed new system is implemented.

Example: Butterfly pea as a component of a grazing system

The existing situation is a 200 ha fully-developed grass paddock used to finish steers. The proposal is to develop 14 ha of the 200 ha paddock to butterfly pea. Establishment costs of the development (land preparation, planting, fencing and water supply) are included in Year 1 of the development. In this example the purchase price and selling price (in c/kg) of the steers is the same.

Table 16. Expected annual cash flows for the ***current*** *use of the 200 ha paddock*

	Each year	Components
Cattle sales	$49,019	50 head x 632.5 kg/head x $1.55 /kg live
Cattle purchases	$34,875	50 head x 450 kg/head x $1.55 /kg live
Cattle selling costs	$1,250	50 head x $25 /head
Cattle variable costs	$300	50 head x $6 /head
Cash flow without change	$12,594	

As this is a comparison of two grazing activities, increasing or decreasing livestock prices will change the *absolute* benefit of the change to the farm business but will have little effect on the *relative* profitability of the change to the proposed system.

Table 17. Expected annual cash flows for the ***proposed*** *use of the 200 ha paddock (14 ha butterfly pea development)*

	Year 1	Years 2-4	Years 5-10	Components
Cattle sales	$50,956	$50,956	$50,956	50 head x 657.5 kg/head x $1.55 /kg live
Land preparation, planting	$1,834			
Fencing	$1,000			
Water	$1,000			
Cattle purchases	$34,875	$34,875	$34,875	50 head x 450 kg/head x $1.55 /kg live
Cattle selling costs	$1,250	$1,250	$1,250	50 head x $25 /head
Cattle variable costs	$300	$300	$300	50 head x $6 /head
Extra tax payable	**$526**	**$412**	**$511**	
Cash flow after tax with change	$10,171	$14,119	$14,020	

Note that there is an adjustment for the possible net effect on taxable income as a result of the investment. The marginal tax rate applied was 30%. It is assumed that the life of the investment is ten years. Therefore, at the end of this period the paddock produces no weight advantage and could be replanted or used for some other purpose. It is also assumed that the planting of the butterfly pea pasture does not change the value of the paddock at the end of the investment period.

The sensitivity of the predicted outcome to changes in the assumptions made in the above example can be determined by recalculating the expected benefit from planting butterfly pea for:

- a range of carrying capacities and weight gains for the paddock prior to the development
- a range of buying and selling prices for steers
- a range of starting weights for steers
- a range of weight gains for both the grass pasture and the butterfly pea pasture after the development
- an increase or decrease in the number of steers purchased and sold.

Analyses simulating these changes showed that the *relative* profitability of the 14 ha development depended on a number of factors:

- the successful establishment of the pasture in the first year
- the turnoff of steers from the improved paddock being equal to or greater than the number of steers turned off prior to undertaking the pasture improvement
- the weight gain of steers on the legume being consistently better than that possible on the pre-existing grass pasture
- the pasture maintaining these benefits for at least six years out of the ten-year investment period after establishment.

If these factors could be maintained, the return on the funds invested in the pasture would exceed 20% after an allowance for tax.

Butterfly pea as a component of a ley system

Central Queensland Sustainable Farming System project (CQSFSP) trials at three sites showed butterfly pea maintained returns per hectare similar to cropping returns achieved in the alternate cereal cropping treatments. Over the longer term, ley farming systems that include butterfly pea will only be more profitable than continuous farming systems when all of the following combine:

- soil N fertility has declined to a low level
- livestock returns are rising
- crop prices are low
- suitable livestock management skills are available to the farm business.

Ley farming systems that include butterfly pea can potentially be made more profitable if the ley pasture is removed in autumn and is immediately followed by a zero tilled winter cereal crop. This would allow maximum benefit from pasture over summer followed by a winter crop. However, removing butterfly pea in early autumn after it has been grazed over summer would frequently leave a dry soil profile that has been severely compacted by the grazing activity. Successful winter cropping activities would only be expected in less than 20% of years under this scenario in central Queensland. A more reliable method of growing a profitable winter crop after a butterfly pea pasture is to grow the butterfly pea in spring - early summer so that all plants are actively growing. Graze the pasture so that young fresh leaves are present when you remove the pasture by spraying or ploughing early in the summer season with the paddock fallowed through to late autumn.

Depending where the paddock is located in central Queensland, there is also a 15-30% chance that no suitable planting rains will be received for wheat, even if the profile has been mostly filled over the summer. If the ley pasture is removed and a dry summer follows, the soil profile will not be recharged and the profitability of a winter crop will be reduced even if soil nitrate levels are high. The profitability of the ley farming system is reduced if a summer cereal follows the summer ley compared to a winter cereal immediately following a summer ley.

Example: Butterfly pea as a component of a ley system

Butterfly pea gross margins are expected to be slightly more reliable than wheat gross margins in about 20% of years at Biloela and 40-50% of years at Capella (Figure 2). In this

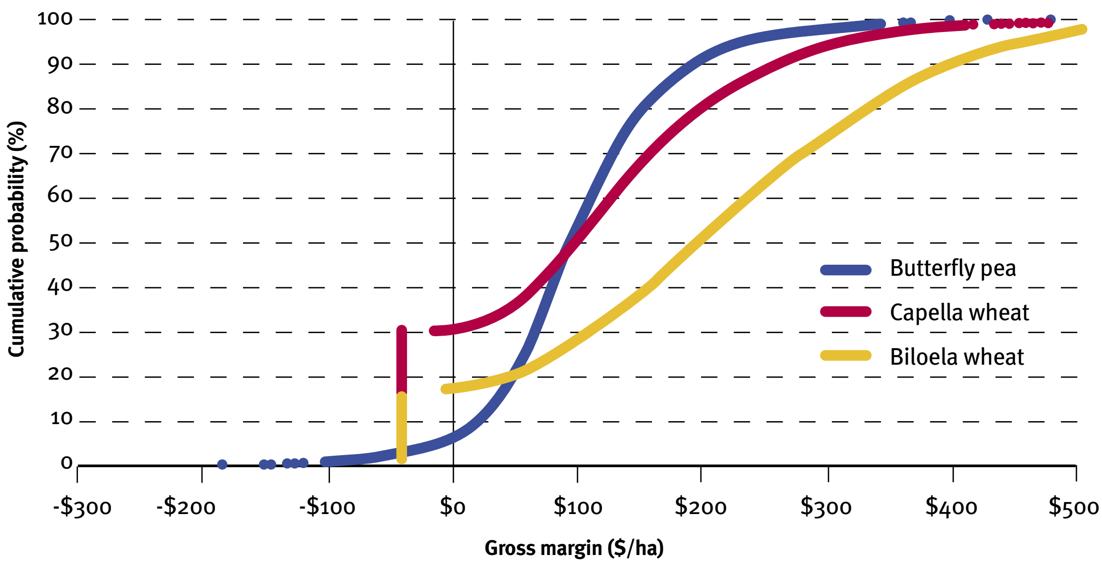


Figure 2. *Potential gross margin distributions for wheat at Biloela on a 158 mm PAWC, high nitrate soil, wheat at Capella on a 120 mm PAWC, high nitrate soil and butterfly pea.*

example, nitrogen fertiliser was not required at either Biloela or Capella to grow wheat. Conversely, wheat at Biloela will outperform butterfly pea in about 80% of years while at Capella wheat will outperform butterfly pea in about 50% of years.

The Biloela wheat data indicates that a decision to grow wheat is likely to be more profitable than retaining a butterfly pea pasture in about 75-80% of years on the deeper soil at this location. Soils of higher water holding capacity than those used in this example (e.g. >150 mm) at Capella also show an increased advantage for the wheat scenario over retaining the butterfly pea pasture.

Wheat at Biloela only shows an advantage over butterfly pea in 50% of years once fertiliser is needed. Most probably the cropping phase would continue at Biloela due to the risk and expense involved in establishing a ley pasture.

The choice of continuing the cropping phase with fertiliser or returning to the ley phase is not so clear at Capella on shallower soils. At the range of prices and yields chosen there would be little difference in the ley system and the wheat cropping system with fertiliser.

The decision to long fallow into wheat after a butterfly pea pasture could be very profitable if:

- livestock prices are expected to fall
- wheat prices were expected to be relatively high over the planning period with reasonable bonuses for high protein
- the soil has a high soil water storage capacity
- the paddock is in the southern end of the central Queensland cropping region.

The decision to retain the pasture and not long fallow into wheat is more likely made when:

- livestock prices are high or likely to rise
- wheat prices were relatively low with little bonus for high protein wheat
- the soil is relatively shallow or varied across the paddock
- the paddock is in the northern end of the central Queensland cropping region
- the butterfly pea pasture is still vigorous.

Shallower soils that store less soil water would be expected to show less advantage for long fallow wheat when compared to retaining the butterfly pea pasture.

Figure 3 shows the gross margin trends for sorghum at Biloela and Capella, and butterfly pea across central Queensland. Yield potential and cropping reliability are slightly better

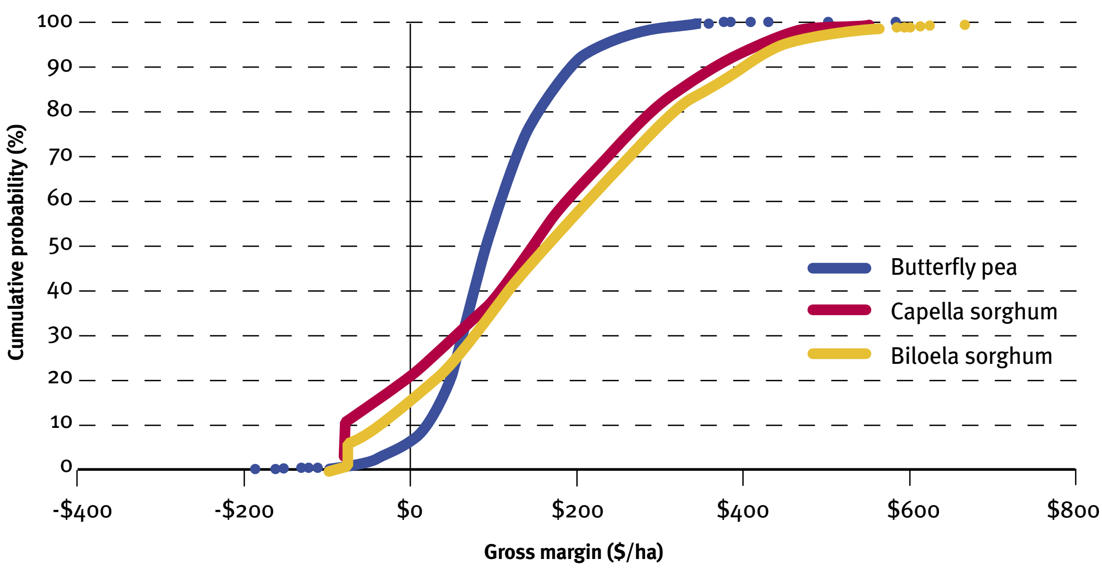


Figure 3. *Potential gross margins for monoculture sorghum on an average PAWC, high nitrate soil at Capella, a high PAWC, high nitrate soil at Biloela and butterfly pea.*

for sorghum at Biloela than at Capella. Much of this advantage is due to the greater storage capacity of the soil modelled at Biloela together with a more reliable pattern of rainfall received over the 100 years of climate data modelled.

There would seem to be few sound economic reasons for substituting butterfly pea for fertilised cereal cropping on soils with a reasonable PAWC at Biloela unless the right price signals are received.

The calculations associated with comparing the existing cropping system with moving to a ley farming system should be subjected to sensitivity analyses. Factors to consider include :

- grain prices
- cropping sequences (these will be strongly influenced by climatic sequence encountered during the life of the proposed investment)
- input costs (e.g. fertiliser and herbicide).

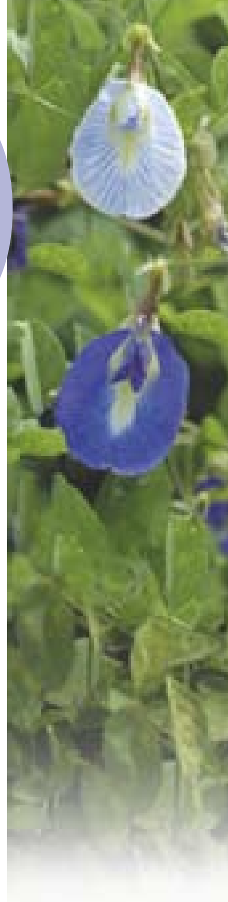
Riskiness of butterfly pea in a ley system

A central Queensland farm business that includes a significant area of ley farming is likely to have less variable farm returns over time than a continuous cultivation farming system that relies on inputs of nitrogen fertiliser to grow cereal crops. It may therefore be considered to be less risky than farming systems that rely on nitrogen fertiliser.

Conversely, converting a continuous cultivation business to a ley farming business will involve a considerable amount of extra capital, especially if livestock prices are high. This may increase business risk in the short term.

David Sasse

Butterfly pea and grass pasture



10 Best management practices

Rod Collins and Maurie Conway

Butterfly pea is a tropical, summer-growing legume that will be most productive on fertile soils with high plant available water capacity (PAWC) and when temperatures are warm. To maximise production from butterfly pea, there are a number of best management practices to consider.

Climate

Butterfly pea is productive in areas with an average annual rainfall of 650-1250 mm (26-50 inches). Given sufficient rainfall, the warmer the climate, the greater the production from butterfly pea.

Seedlings are susceptible to frost, however mature plants with woody stems will survive a moderate frost. If planting in a frost prone area, plant at least 10 weeks before the first frost to allow development of woody stems. This will enable the plants to re-shoot following the frost period.

Soils

Butterfly pea is persistent and productive on a wide range of soil types. It performs best on deep, fertile soils, preferably with high water holding capacity. In central Queensland, these are often self-mulching, medium to heavy cracking clay soils such as brigalow clays and open downs soils, red basaltic soils and fertile alluvial soils.

Butterfly pea will not persist on soils that are infertile, have poor waterholding capacity or have severe limitations to rooting depth.

Field observation suggests that buttefly pea is productive and persistent on soils with levels of subsoil salinity and/or sodicity that are considered acceptable for cropping. The production and persistance on these soils is goverened by the severity of these limitations and the depth at which they occur.

With appropriate management, butterfly pea will persist:

- indefinitely on fertile soils with high water holding capacity
- three to five years on soils with minor limitations
- three to five years where grazing management causes continuous pressure on butterfly pea plants
- one to three years on soils that have major limitations such as low plant available water, sodic or saline layers in the upper subsoil and/or have low fertility levels.

Avoid soils that are frequently flooded as most butterfly pea plants will die if submerged for greater than 12-36 hours. Some plants will persist when standing in shallow water for 2-6 weeks on soils that drain slowly.

Planting

Planting butterfly pea-only pastures into fallowed or zero tilled paddocks is the easiest and safest method of establishing a strong pasture. Butterfly pea and grass can be planted at the same time, however the success of butterfly pea establishment will be affected by:

- seed quality (normal and hard seed percentage, seed viability)
- planting conditions (soil moisture, soil tilth, soil/seed contact)
- weed/grass competition (less competition ensures better establishment).

Butterfly pea planted into wheat stubble

Planting into cultivation

Ensure good subsoil moisture and plant as soon as practical after planting rain, selecting seed with a low hard seed content. Plant at 2.5 to 5 cm deep into moisture using crop planting machinery with presswheels or a roller. Narrow rows are preferred. Ideally, plant on 20-30 cm row spacings, but preferably less than 50 cm.

Plant at 7-10 kg/ha and apply Spinnaker® according to label directions to ensure weed control during establishment.

Planting at a higher rate (10-15 kg/ha) can increase plant population but should not be considered as an alternative to applying Spinnaker® when weed populations are moderate to high. Spinnaker® should not be applied when grass seed is planted at the same time as the butterfly pea. Spinnaker® may not be necessary when soil moisture and temperatures are high and weed seed population is very low.

Control weeds prior to planting to conserve soil moisture and ensure minimal grass/weed competition at planting time to maximise establishment. Use zero till methods in the fallow to ensure weed control and maximise soil moisture storage.

Planting into existing pasture

There are several methods used for planting butterfly pea into established grass pastures, however establishment is often lower than planting into cultivation.

Spray and broadcast

Butterfly pea can be established by herbicide treating strips in native or improved pasture and broadcasting seed into the strips using a fertiliser spreader. A good season is needed to ensure successful establishment.

Planting with a crocodile planter

Sowing with a crocodile planter into native pastures can be successful but only when grass competition is low. Success is dependent on follow up rain and low grass/weed competition during establishment. Reducing competition before planting by using a selective grass herbicide will improve seedling survival.

David Sasse

Butterfly pea and grass pasture

Planting using a roller drum during blade ploughing

Some seed may be buried too deep so planting rates may need to be adjusted to achieve the desired plant population. Select seed with a high hard seed content. Success of butterfly pea establishment varies enormously and is dependent on factors including amount of follow up rain, the proportion of grass killed or that re-establishes, the rate of subsequent grass growth, and early grazing management.

Butterfly pea seed is spread via dung

Cattle will successfully spread butterfly pea seed in established stands in a wet summer. Nil or lenient grazing, good soil moisture, and low grass and weed competition are required to ensure establishment. This is not a recommended method of introducing butterfly pea into a paddock.

Planting grass with butterfly pea

While butterfly pea-only pastures usually result in best establishment, the most productive and stable pastures are a legume/grass mix. For best results when planting grass into an established butterfly pea pasture:

- plant when the chance of good soil moisture and follow up rainfall is most likely (December – March for most of Queensland)
- plant adapted grass species
- plant shallow (1 cm) or on the surface into a firm seedbed with a roller or presswheels following. Some soil coverage is an advantage but planting too deep will result in nil or low emergence of most grass seeds.

Weed management

In trials, the cost-effective planting rate for butterfly pea was 7 kg/ha sown on narrow rows (26 cm) with weed free conditions. Spinnaker® applied no closer than 2 weeks prior to planting will provide the desired weed-free conditions. Narrow rows and/or high planting rates improve the competitiveness of butterfly pea with weeds. Butterfly pea may become a summer germinating perennial weed within the farming system. It is only likely to be a problem in winter crops if mature plants are permitted to survive over the autumn, or if the winter season is very mild. Use appropriate herbicides in subsequent crops and fallow periods to control butterfly pea.

Seed treatment

When to scarify seed?

If seed is being planted into a rough seedbed or broadcast into existing pasture and a staggered germination is sought (so that germination will occur over time following rainfall events), use seed with a high hard seed count (greater than 40% hard seed). However, if planting into cultivation where a quick and even establishment is required, plant seed that has a high normal seed count (greater than 40%) or mechanically scarify seed to achieve a high normal seed count (preferably greater than 90%).

Inoculation

Inoculation is required for effective nodulation of the roots by *Rhizobium* bacteria, which produce nitrogen for plant use. Use Tropical group M inoculant, which needs to be kept cool to ensure it is effective. Inoculate the seed as close as possible to planting time and only inoculate enough seed to plant within 12 hours.

Grazing management

In the first season, delay grazing until plants have set seed. This will provide seed for future regeneration and also enable the plant to develop a woody frame that is more tolerant of grazing. Under ideal growing conditions, butterfly pea can be grazed within 12 weeks of planting although in most cases 14–20 weeks is needed, depending on rainfall and temperature. If the plants are moisture stressed from drought or competition, grazing should be delayed as long as possible. Young butterfly pea subjected to high grazing pressure under these conditions will not persist.

Steers in mature butterfly pea pasture

Butterfly pea seedlings are selectively grazed and will die if grazed early. Seedlings will only establish amongst mature plants after good rain, when there is lenient grazing pressure and low weed / grass competition.

Butterfly pea will coexist with aggressive grasses such as buffel grass with good management. Mature plants are tolerant of periodic heavy grazing but prolonged periods of continuous heavy grazing may reduce plant numbers. Grazing using a rotational system is more likely to maintain a higher plant population and maximise dry matter production.

Hay production

Haymaking aims to dry the material down to 20-23% moisture as quickly as possible to minimise nutrient losses from weathering and microbial degradation.

When to cut?

Butterfly pea is best cut at about knee height when the leaves and branches are soft and succulent. Flower will be present, but cut before seedpods form. Cutting when seed pods are half formed makes acceptable hay, but hay quality drops quickly after this stage. Cut before seed pods start to thicken, as mature pods are slower to dry than other plant parts. Do not cut lower than 7-10 cm as butterfly pea reshoots mostly from existing stems rather than the crown.

Preferably use a mower conditioner, or condition in a separate operation immediately after cutting. Where possible cut when there is at least five days of fine weather expected. Cut in the morning after dew has evaporated to allow maximum hours of sun and drying time. In very hot, dry weather, it may be necessary to cut in the cooler evening or night to retain more leaf.

When to rake and bale?

In good haymaking weather, rake the swath into a windrow the day after cutting (during the night or early morning) and then every day to ensure even drying throughout the windrow. Rake in the cooler part of the day when the leaf is wilted but still soft and pliable (40-50% moisture) to minimise leaf loss.

As a rough guide, the pasture can be baled when the skin of the stem peels back to reveal fairly dry pith inside the stem. Grower experience suggests that tests used by lucerne growers also apply to butterfly pea. Take a bunch of 8-10 stems from the centre of the windrow and crank them using both hands. If the stems break cleanly and easily, without any free moisture in the area that was cranked, the crop is ready to bale. Below 20%, the leaf is very brittle and will shatter when handled. Aim to bale when moisture content is 20-23%. Baling at greater than 25% moisture causes reduced hay quality due to spoilage from mould, and in extreme cases combustion may occur. In warm weather, baling can commence in 2–4 days but in cooler periods, 1-2 weeks drying may be necessary.

Harvesting and storing butterfly pea seed

Butterfly pea seed crops have yielded over 900 kg/ha but 200–500 kg/ha is a realistic target in well-managed crops. Opportunity crops that have some grass or weeds present and/or lower plant populations are likely to yield 50-200 kg/ha. As a very rough guide, 30-40 pods/m^2 will yield about 100 kg/ha.

To achieve high seed yields from butterfly pea:

- eliminate weed and grass competition in the crop (Spinnaker® at planting)
- aim for high populations of well-grown plants, (6-20 plants/m^2).

It is common to have mature seed, green pods and flowers on the plant at the same time. When soil moisture is good and air temperature high the plant will continue to grow and flower. The ripest pods will be the lowest pods on the plant but mature pods will hang on

for a number of weeks before they open and shatter. Aim to harvest when 90% of seed is hard and black and the remaining 10% of the seed is firm (can be marked with your fingernail). Only one seed crop per summer season is possible regardless of when pods begin to form. The chance of frost and its timing need to be considered when choosing seed production paddocks. Frost will kill flowers and prevent green seed from maturing.

Naturally dried crops can be successfully harvested when there is a very dry finish to the season or when severe frosting causes most leaf to fall. Harvest desiccated crops of butterfly pea using the same header settings as for grain sorghum, but reduce header speeds to 7–8 kph, (similar to mungbeans, or about half that for sorghum). Even in a desiccated crop, considerable green material will travel through with the seed. Grade out green material as quickly as possible as moisture content will increase and cause mouldy seed. Dry high moisture seed immediately to around 12% to prevent overheating and spoilage.

Stored seed will only maintain a high germination, viability and vigour if air temperature, relative humidity and grain moisture are low. Seed that is stored in a shipping container must be aerated to maintain quality.

David Sasse

Spraying out butterfly pea

Further reading

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Since its release in the early 1990's, Milgarra butterfly pea has proven itself as a productive and persistent legume adapted to a range of soils and climates in central and northern Queensland. It has been successfully incorporated into ley and permanent pastures in these areas where it provides high quality forage and improved liveweight gains in cattle. At the same time, it has shown the potential to improve soil fertility in cropping soils which helps improve the sustainability of grain production in central Queensland.

The Butterfly Pea Book : a guide to establishing and managing butterfly pea pastures in central Queensland contains the accumulated knowledge and the practical experience of growing and managing butterfly pea pastures as well as results from a number of research trials. This publication will allow farmers and graziers to determine whether butterfly pea is suited to their enterprise and to use best practice to establish a productive and persistent butterfly pea pasture. Topics covered also include the role of butterfly pea as a ley pasture, hay production, weed management, seed production and the impact of butterfly pea on whole-farm economics.

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