Ley legumes increase soil nitrogen

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The soils of Central Queensland are relatively new (in terms of age of cultivation) and fertile; in the early years of crop production, nitrogen supply did not usually limit production. But with continuous cropping the inevitable decline in nitrogen fertility has occurred and an economic response to nitrogen fertiliser is frequently observed, particularly on open downs soils (shallow black vertosols).

Supplementary nitrogen is primarily being applied as nitrogen fertiliser with a limited amount coming from pulse crops or ley legumes.

Incorporation of legumes, as pulse crops or ley pastures, as a way to reduce fertiliser input is a good option in CQ. High rainfall variability (which makes prediction of optimal nitrogen fertiliser rates difficult), the relatively high cost of nitrogen fertiliser, and the fact that the majority of CQ grain farms also include a beef cattle enterprise, adds to the attractiveness of legumes.

While ley pastures incorporating legumes have been a major component of farming systems in other parts of Australia, their use in cropping systems in CQ has been limited. Reasons for this have included the lack of suitable pasture/fodder legume varieties for the variable climate of the region, lack of agronomic information regarding establishment and removal of legumes, and the poorly defined 'value' of ley pastures to farmers.

Butterfly pea (*Clitoria ternatea* cv. Milgarra) and lablab (*Lablab purpureus*) have shown potential as ley pasture species to improve the nitrogen and organic carbon content of cropping soils. They are sum-

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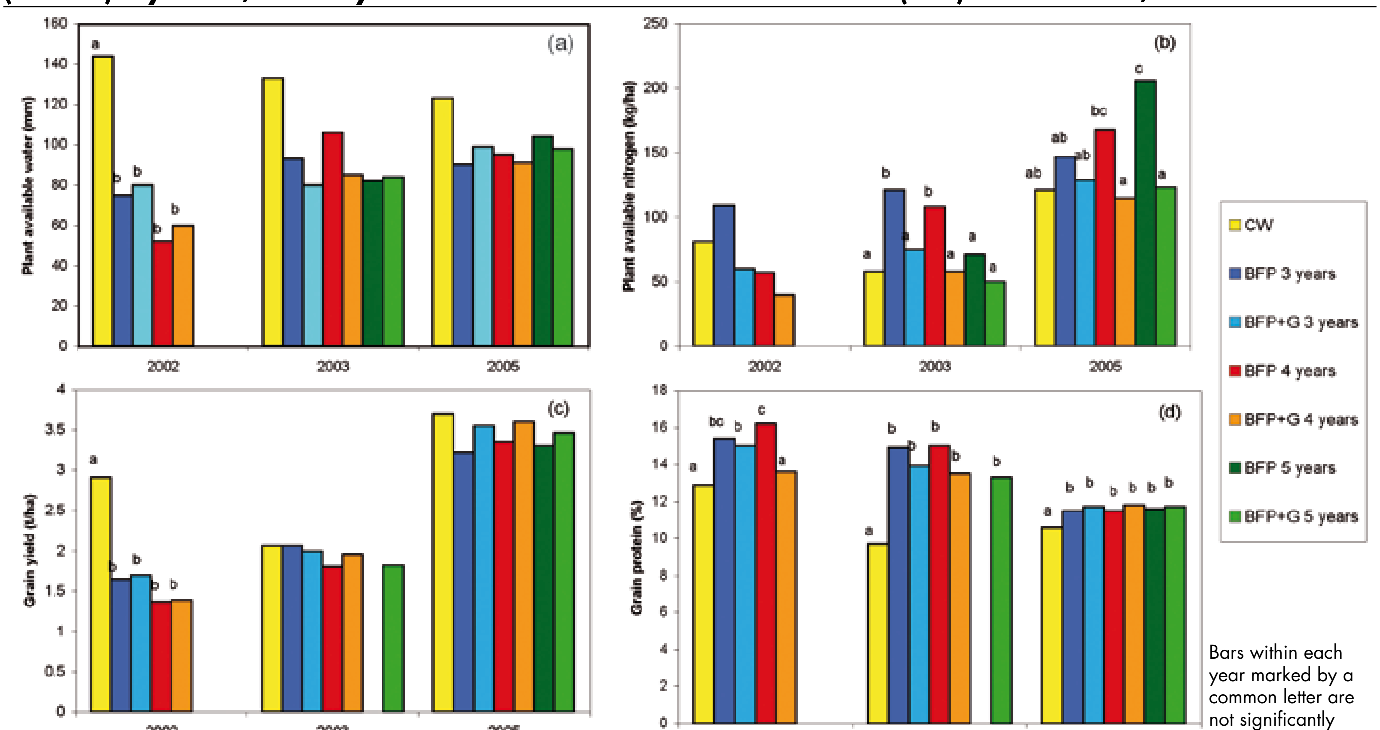
AT A GLANCE...

- Both butterfly pea and lablab ley pastures can reduce the nitrogen fertiliser requirement for subsequent crops and provide short to medium term reliable pasture for stock. Lablab is a very productive short term (one to two year) forage legume with nitrogen benefits for following crops lasting about two years. Butterfly pea is not as productive as lablab but as a medium term (three to five year) pasture ley can provide nitrogen benefits to subsequent crops for at least three years.
- Increased plant available nitrogen following ley pastures may not always result in higher yields of subsequent cereals if soil water limits yield. Timing of pasture removal needs to allow adequate duration of fallow to recharge soil water. But higher cereal proteins could increase returns where premium payments are on offer.
- Although difficult to quantify, post-legume benefits for lablab and butterfly pea seem to equate to the rates of fertiliser nitrogen (25–35 kg N per hectare) commonly applied to cereals in CQ.

FIGURE 1a: Plant available water (mm); and,
FIGURE 1b: Plant available nitrogen (kg/ha) at wheat planting
FIGURE 1c: Grain yield (t/ha); and,
FIGURE 1d: Grain protein (%) at harvest following butterfly pea (BFP) or butterfly pea and grass (BFP+G) leys of 3, 4 or 5 years' duration and continuous wheat (CW) at Baralaba, CQ



Bars within each year marked by a common letter are not significantly different at P=0.05.

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mer growing legumes suited to the climate and clay soils of the region.

While there is now more information on the agronomy of ley pasture legumes in cropping systems, there has been less knowledge of the extent and longevity of their nitrogen contribution for subsequent grain crops.

Three trials run by the GRDC-funded CQ Sustainable Farming Systems project looking at the inclusion of butterfly pea or lablab in cropping rotations – has studied their contribution to soil nitrogen for following cereal crops.

TRIAL 1

Trial 1 was established on a black vertosol soil that had been cropped (mainly wheat and sorghum) since the 1950s near Baralaba. There were three treatments:

- A continuously wheat-cropped area;
- An area sown to a ley pasture of pure butterfly pea; and,
- A ley pasture mix of butterfly pea and grass.

Butterfly pea cv. Milgarra was planted on February 10, 1998 at seven kg per hectare. The butterfly pea and grass mixture included finecut Rhodes grass (*Chloris gayana*) at 1.25 kg per hectare, Queensland bluegrass (*Dichanthium sericeum*) at 0.68 kg and Bisset bluegrass (*Bothriochloa insculpta*) at 0.1 kg.

Pasture strips were removed on January 18, 2001, February 11, 2002 and March 3, 2003 to create three periods of pasture (3, 4 and 5 years).

Pure lablab ley pasture about six weeks after planting.

Wheat was sown on July 2, 2002, May 6, 2003 and May 30, 2005 (no crop in 2001 or 2004 due to drought).

The results

The crops following the BFP only pasture treatment had more plant available nitrogen than the crops following the BFP + grass treatments (Figure 1b). This increased nitrogen availability did not increase grain yields but did produce higher grain proteins (one to five per cent higher) (Figure 1b & d).

Crop yields in the first year after spraying out the ley phase (2002) were lower than continuous wheat due to the much lower plant available water after the pasture (Figure 1a & c). In 2005, when water was not limiting, grain yields were not significantly different between the treatments but all prior pasture treatments still had significantly higher grain protein levels than continuous wheat treatments (Figure 1c & d).

The greatest contribution of the ley pasture to plant available nitrogen occurred two or three years after the removal of the pasture and this was also seen in another trial (see Trial 2) where cereals were planted after two years of butterfly pea or lablab.

TRIAL 2

Trial 2 was established in 2000 near Baralaba on a self-mulching, black vertosol. Lablab cv. Endurance and butterfly pea cv. Milgarra were sown on January 15, 2000.

The soil water at planting was sufficient for a satisfactory pasture establishment; plant population (November 2000) was 2.9 plants/m^2 for Endurance lablab and was 8.0 plants/m^2 for butterfly pea.

Twelve months later, the lablab population had declined (0.8 plants/m^2) but the population of butterfly pea had almost doubled (15.8 plants/m^2).

Hence, by February 2002, when all strips were sprayed out to enable cereal planting, the lablab strips were effectively a bare fallow. Crops planted after the legume treatments were wheat in 2002 and 2003 and sorghum in 2004.

The results

Over the pasture phase (January 2000 to February 2002) lablab produced more dry matter than butterfly pea, particularly during the first 18 months. But the lablab had almost totally died out by the end of the two years while butterfly pea was still actively growing.

Plant available nitrogen increased for two years following lablab then decreased. After butterfly pea it increased in the second and third years and not the first year (Figure 2). This is probably due to timing of decomposition of the residues.

During the fallow prior to planting wheat in 2002 lablab residues appeared

TABLE 1: Grain yields (t/ha) and grain protein contents (%) of wheat (2002, 2003) and sorghum (2004) following two years of butterfly pea or lablab (Trial 2)

Prior pasture/crop	Wheat 2002	Wheat 2003	Sorghum 2004	Wheat 2002	Wheat 2003	Sorghum 2004
	Yield (t/ha)			Protein (%)		
Butterfly pea 2 years	1.22	1.42	3.80	14.3	13.1a	NA
Lablab 2 years	1.64	1.98	3.70	14.7	12.7b	NA
Significance	ns	ns	ns	ns	P<0.05	NA

Levels of significance between prior pasture crops are indicated.
NA = not available; ns = not significant (P>0.10)

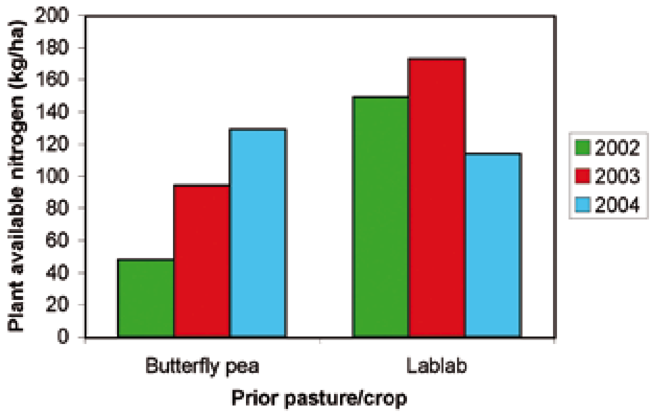
TABLE 2: Effect of lablab or cereal (wheat) on the following sorghum grain yield in 1999–2000 season at Fernlees (Trial 3)

Nitrogen rate applied to sorghum (kg/ha)	Grain sorghum yield (t/ha)	
	following wheat#	following lablab#
0	1.9	2.2a
35	2.3	2.9b
70	2.8	3.3b
Significance	ns	P=0.07

Levels of significance among nitrogen rates within prior crops are indicated.
Means within prior crops followed by the same letter are not significantly different at P=0.10.
In both sorghum crops following wheat or lablab, lodging increased with the increased nitrogen rate; up to 36 per cent in the cereal area and 59 per cent in the legume area with 70 kg N/ha. Yields are adjusted for lodging. ns = P>0.10.

Cattle grazing a four month old butterfly pea pasture at Gordon Downs, Capella. Establishing butterfly pea first and then the grass ensures a grass/legume mix – the most productive and stable pasture.

FIGURE 2: Plant available nitrogen (kg per hectare) at time of planting of wheat (2002 & 2003) and sorghum (2004) crops following two years (2000–02) of butterfly pea or lablab pasture (Trial 2)



to have completely decomposed while woody residues were still evident after the butterfly pea.

Similar cereal yields, (wheat in 2002 and 2003 and sorghum in 2004), were obtained after butterfly pea or lablab. Grain protein levels were also similar (more than 12.7 per cent) for the wheat crops and indicated no nitrogen limitation on yield (Table 1).

These trials indicate lablab to be a very productive short term forage legume, with temporary nitrogen benefits lasting for about two years. Butterfly pea's forage production is not as high over the short term, but its greater longevity could provide longer lasting nitrogen supply for subsequent cereal crops.

TRIAL 3

Trial 3 was planted on a shallow black vertosol soil at Fernlees (near Emerald). The experiment incorporated two adjacent areas of the same age of cultivation and recent cropping histories. A lablab–cereal rotation was maintained on the smaller area (32 hectares) while the larger area (122 hectares) was continuously cropped.

Both areas grew wheat in 1997. Lablab (cv Highworth) was planted on December 27, 1997 in the lablab-cereal rotation area, which was grazed by cattle from June 14, 1998 until August 17, 1998. The lablab was removed prior to planting sorghum on January 1, 1999.

Sorghum was also planted in the continuous cropping area on the same day.

Within each area, two replicates of three levels of nitrogen fertiliser (0, 35 and 70 kg N per hectare) were applied.

The results

The prior lablab crop appeared to increase the sorghum yield compared to the continuous cereal by 0.5 tonnes per hectare, averaged across all treatments (Table 2).

Unfertilised grain yield after lablab was similar to continuous cereal fertilised with 35 kg N per hectare, while post-lablab sorghum fertilised with 35 kg N per hectare was similar to that for continuous cereal fertilised with 70 kg N (Table 2).

From this single season bio-assay, lablab appears to contribute 35 kg per hectare of plant available nitrogen. There was no yield loss after lablab in this trial as opposed to what was experienced post-butterfly pea in Trial 1.

A similar trial was planted in 1998 on a black vertosol soil near Theodore with one section planted as continuous cereal (sorghum) and another section as a lablab-sorghum rotation. The sorghum component of the rotation was planted in 1999 and 2001.

The continuous cereal section had two replications of four rates of nitrogen fertiliser applied (0, 30, 45 and 60 kg N per hectare).

Soil nitrate and grain yield and protein measurements showed that lablab contributed up to 60 kg N per hectare to the following sorghum crop. In the sorghum crop harvested in 1999 there was no difference in yield between sorghum planted after lablab (4.26 tonnes per hectare) or any fertiliser rates applied (average 4.25 tonnes) but protein was higher in sorghum after lablab. In that year sorghum yielded 3.76 tonnes per hectare without fertiliser.

Sorghum harvested in 2001 had a higher yield (4.32 tonnes per hectare) following the second lablab crop (2000) than any of the fertiliser treatments (2.76 tonnes per hectare in 0 N treatment, 3.9 tonnes in fertilised N treatments) but lower grain protein (8.6 per cent) than 45 and 60 kg N per hectare (9.5 per cent).

These trials show that in most years lablab can contribute sufficient nitrogen to grow the succeeding crop of sorghum without additional N fertiliser applied and no yield penalty.

BUTTERFLY PEA AND SOIL ORGANIC CARBON

Preliminary trials show that butterfly pea can have a substantial impact on soil organic carbon.

Measurements of soil organic carbon were taken on a vertosol at Gindie (near Emerald) in 2008. The samples were taken from paddocks with similar cropping histories until one was planted to butterfly pea in 2001, another section was planted to butterfly pea in 2005 and the remainder continued to be cropped.

Organic carbon levels at these sites were 0.85 per cent (continuous cropping), 1.11 per cent (three year butterfly pea) and 1.73 per cent (seven year butterfly pea).

This trend is consistent with other work showing that butterfly pea has the potential to considerably increase soil organic carbon.

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