Effect of Butterfly pea ley pastures on subsequent wheat crops

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Abstract

Butterfly pea *(Clitoria ternatea)* (BFP) is a perennial, summer growing legume well adapted to the climate and clay soils of the Central Queensland (CQ) grazing and cropping zones. The area of BFP pastures in CQ has increased from less than 500 ha to greater than 200,000 ha since 1996. In addition to its role as a permanent pasture, BFP shows great potential as a ley pasture species to improve the nitrogen (N) and organic carbon fertility of cropping soils in the region.

An experiment was established near Baralaba (S 29' 11", E 149'47") in 1998 to quantify the effect of BFP leys on soil fertility and the performance of subsequent wheat crops. BFP and BFP + grass pastures were established in 1998 and removed after 3, 4 and 5 years of production. Following pasture removal, wheat was sown on all plots. Continuous wheat treatments with a range of nitrogen application rates were included to allow a comparison of the nitrogen contribution of the BFP pasture to applied fertiliser nitrogen.

In 2002, wheat yield in the ex-BFP treatments was lower than in the continuous wheat treatments due to the residual effect of BFP pastures on soil water. In subsequent years, there was no yield difference between ex-BFP and continuous wheat treatments, and grain protein levels indicated that the ex-BFP treatments were supplying nitrogen at a rate equivalent to the 30N and budget N treatments.

Key Words

Nitrogen fertiliser, wheat cropping, Central Queensland

Introduction

The provision of adequate nutrients to optimise crop performance, either by applying fertilisers or by exploiting inherent soil fertility, is a fundamental requirement of any sustainable cropping system. CQ soils are relatively new (in years of arable production) and fertile by national standards and in the early years of crop production, nutrients were not generally a limiting factor. There are two main soil types that are cropped in the region, known locally as 'Open Downs' soils (shallow black vertosols, often overlying decomposing basalt and supporting open bluegrass grasslands in their native state) and 'Brigalow scrub' soils (black, brown and grey vertosols and sodosols, originally supporting Brigalow (*Acacia harpophylla*) dominant woodlands (Spackman and Garside, 1995) . Over time, the inevitable nitrogen (N) fertility decline associated with cultivation and N removal by crops has occurred and an economic response to applied N fertiliser is now observed on some soil types, in some seasons, and more frequently on Open Downs soil types (Spackman and Garside, 1995).

A number of factors combine to make the use of ley legumes attractive as a low cost method of restoring soil N fertility in CQ cropping systems, including: the relatively high cost of N fertiliser, high variability of seasonal rainfall, making prediction of optimal N fertiliser application rates problematic, and the fact that the majority of CQ grain farms also support a beef cattle enterprise. Butterfly pea *(Clitoria ternatea)* (BFP) has shown potential as a ley pasture species to improve the nitrogen (N) and organic carbon content of cropping soils in the region. BFP is a perennial, summer growing legume well adapted to the climate and clay soils of the CQ grazing and cropping zones (Collins and Grundy, 2005).

This paper reports the results of a field experiment established to quantify the effects of BFP ley pastures on following wheat crops and examines the N contribution of BFP pasture in comparison with applied N fertiliser.

Method

In 1998 an experiment was established near Baralaba (S 29' 11", E 149'47") in CQ in a paddock that has been used for grain production (mainly wheat and sorghum) since the 1950's. The experiment used a completely randomised block design with two replicates. There were four continuous wheat (CW) treatments (zero till planted using a modified chisel plough and press wheels) with varying levels of nitrogen fertiliser-Nil (0 N), Low (29 N), Budget (N rate calculated to match pre plant soil nitrate N with yield potential as determined by soil water at planting and seasonal rainfall forecast) and High (60N) and two pasture treatments Butterfly Pea (BFP) and BFP + grass pastures. Butterfly Pea (BFP) cv. Milgarra treatments were planted at 7 kg/ha using a conventional combine planter on 10 February 1998. BFP + grass treatments included a mixture of Finecut Rhodes grass (*Chloris gayana*) at 1.25 kg/ha, Queensland bluegrass (*Dichanthium sericeum*) 0.68 kg/ha, and Bisset bluegrass (*Bothriochloa insculpta*) 0.1 kg/ha, spread on the soil surface in strips. Plot size was 9.4 m wide by 500 m long.

BFP and BFP + grass pastures were removed on 18 Jan 2001, 11 Feb 2002 and 3 Mar 2003 resulting in varying periods of time between pasture removal and subsequent planting of wheat. All treatments were sown to wheat on 2 Jul 2002, 6 May 2003 and 30 May 2005. Wheat crops were not sown in 2001 and 2004 due to drought conditions. Grain yield, grain protein concentration and soil nitrate N and plant available soil water at planting (PAW) were measured for each of these three wheat crops. Data was analysed using standard ANOVA at the 5% level.

Results

2002 Wheat crop

There was no difference in soil nitrate N at planting between any of the treatments at the start of the 2002 wheat crop (Table 1). There was no significant difference in the yield of the continuous wheat N rate treatments; however the continuous wheat treatments all yielded significantly higher than BFP treatments. There was significantly higher PAW in the continuous wheat treatments (average 146mm) compared to the BFP treatments (average 67mm), which has contributed to the greater yields achieved in the continuous wheat treatments. The Nil N treatment was significantly lower in grain protein than the high N treatment, but the protein concentration of 12.9% suggests that yield was not limited by nitrogen stress. Three of the BFP strips had significantly higher protein than the cropped strips, and this is most likely due to the water limited grain yields in these treatments.

Table 1. Yield, Quality, N level at Planting and PAW for the 2002 wheat crop. (Numbers followed by the same letter are not significantly different)

Treatment	Yield (t/ha)	Protein (%)	N at Planting (kg/ha)	PAW at Plant (mm)
CW Nil N	2.91[a]	12.9[d]	81	144[a]
CW Low N	2.78[a]	13.7[cd]	100	149[a]
CW Budget N	2.75[a]	13.5[cd]	138	149[a]

CW High N	2.79[a]	13.9[c]	119	141[a]
BFP 01	1.65[bc]	15.4[b]	109	75[bc]
BFP+grass 01	1.70[b]	15.0[b]	60	80[b]
BFP 02	1.37[c]	16.2[a]	57	52[c]
BFP+grass 02	1.39[c]	13.6[cd]	40	60[bc]
lsd (P<0.05)	0.3	0.8	65	25

2003 Wheat crop

There was no difference in nitrate N at planting or grain yield between any treatments in 2003 (Table 2). Again, PAW at planting was generally lower for the BFP treatments however the higher soil water in the continuous wheat treatments did not result in higher grain yields. The lower PAW in the BFP treatments is likely to be related to a higher summer weed burden observed in these treatments (data not shown). There was evidence of a protein response to N application rate in the CW treatments and the low protein level in the CW nil N treatment indicates that nitrogen supply limited grain yield. Protein levels in all BFP treatments were higher than the CW nil N treatment and in many cases were higher than the Low N and budget N treatments, indicating a nitrogen supply at least equal to that of those treatments.

Table 2. Yield, Quality, N level at Planting and Plant Available Water at Planting (PAW) for the 2003 wheat crop. (Numbers followed by the same letter are not significantly different)

Treatment	Yield (t/ha)	Protein (%)	Nitrate N at Planting (kg/ha)	PAW at Plant (mm)
CW Nil N	2.06	9.7[d]	58	133[ab]
CW Low N	2.19	12.0[bc]	103	134[ab]
CW Budget N	2.18	11.0[cd]	113	126[b]
CW High N	2.33	13.2[ab]	120	146[a]
BFP 01	1.71	14.9[a]	121	93[cd]
BFP+grass 01	2.00	13.9[a]	75	80[d]
BFP 02	1.42	15.0[a]	108	106[c]

BFP+grass 02	1.96	13.5^{ab}	58	85^{d}
BFP 03	Bird damaged	Bird damaged	71	82^{d}
BFP+grass 03	1.82	13.3^{ab}	50	84^{d}
lsd (P<0.05)	0.49	2.2	66	18

2005 wheat crop

The 2005 crop was sown after a long fallow enforced by the lack of a planting opportunity in 2004. There were no significant differences in PAW and grain yield. Grain protein was significantly lower in the CW nil N treatment than all other treatments. Soil nitrate N at planting increased as applied N rates increased in the CW treatments and was generally higher in the more recently removed BFP treatments and higher in the BFP alone than the BFP + grass treatments.

Table 3. Yield, Quality, N level at Planting and PAW for the 2005 wheat crop. (Numbers followed by the same letter are not significantly different)

Treatment	Yield (t/ha)	Protein (%)	N at Planting (kg/ha)	PAW (mm)
CW Nil N	3.70	10.6^{b}	121^{cd}	123
CW Low N	2.95	11.6^{a}	159^{abc}	127
CW Budget N	3.34	11.8^{a}	177^{ab}	114
CW High N	3.18	12.0^{a}	209^{a}	118
BFP 01	3.22	11.5^{a}	147^{bc}	90
BFP+grass 01	3.55	11.7^{a}	129^{bc}	99
BFP 02	3.35	11.5^{a}	168^{abc}	95
BFP+grass 02	3.60	11.8^{a}	115^{d}	91
BFP 03	3.30	11.6^{a}	206^{a}	104
BFP+grass 03	3.46	11.7^{a}	123^{cd}	98
lsd (P<0.05)	0.89	0.5	50	25

Discussion

Realising the nitrogen benefits of the BFP pasture will only occur if Plant available soil water levels at crop planting are high enough to allow high crop yields. Observations of the planting soil water data from the 2005 crop indicate soil water levels were at to similar levels in BFP and CW treatments. Overall, the grain yields produced have not required high amounts of nitrogen so it is difficult to assess the impact of varying nitrogen levels between treatments. Whilst grain protein was high in all treatments in 2002, it was significantly higher in the BFP treatments than the Nil, Low and Budget N treatments. Yield was, however, lower for the BFP treatments. The same trend was seen in 2003, and in both years the Nil N treatment had the lowest grain protein. In the 2003 wheat crop, grain yields in the Nil and budget strips were limited by nitrogen (9.7% and 11%) but water limited grain yield in all other treatments (protein 12–15.5%).Whilst the soil nitrate at planting has been generally lower in the BFP treatments than the cropping N treatments, the grain protein has been higher under the BFP indicating BFP has supplied enough nitrogen to produce high protein grain especially in 2005 where yields were similar between all treatments.

Within the context of the current CQ farming system, the impetus for planting BFP was largely in response to drier seasonal rainfall patterns, changes in commodity prices (lower grain crop prices and higher cattle prices) and the potential to restore soil fertility. BFP provides the basis to integrate livestock and cropping into a farming system to spread the risk of climate variability on economic return. Opportunity cropping has been shown to maximise returns in the CQ region where variable rainfall patterns are more common than not (Carroll et al. 1993). Also the persistence of BFP enables medium term (3 – 5 years) production reliability with the opportunity to re-crop these paddocks without the need for nitrogenous fertilisers in the short term (1 – 3 years).

Conclusions

This experiment demonstrated that butterfly pea ley pastures have the capacity to improve crop N supply for a number of years after the ley pasture is removed and therefore offer an alternative to N fertiliser application for the maintenance of soil N fertility in this environment. In managing BFP ley phases, attention needs to be paid to time of removal to ensure that adequate time is available for soil water levels to replenish prior to planting a following crop.

Ultimately, the role of BFP ley pastures as a soil fertility restoration practice will depend on a range of economic factors relating to the profitability of these pastures when grazed, and the price of nitrogenous fertilisers. It is likely that BFP pastures will have other benefits in terms of improved soil organic carbon status and biological activity.

References

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