Long term phosphorus (P)

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Take home messages

After eight years of trial work on a Mallee clay loam with subsoil limitations:

- *In only two years (2004 and 2010) did yields increase from applying P fertiliser.*
- *The site has remained responsive at nil and 5P treatments (0 and 5kg P/ha), but maintaining rates greater than 5kg P/ha did not produce any extra yield.*
- *In 2010 there was a 25% increase in wheat yield between nil P and where P had been applied (at rates of 5 kg P/ha or higher).*
- *After eight years, the 5 kg P/ha treatment provided the highest net income.*
- *Soil Colwell P together with the PBI (Phosphorus Buffering Index) accurately estimated the response seen in 2010.*

Background

The long-term phosphorus trial began at the BCG Farming Systems Site on a Mallee clay loam with subsoil limitations in 2003 and focused on the requirements for phosphorus (P) fertiliser to optimise yield and economic returns.

Phosphorus fertiliser is a significant input cost: an accurate determination of the rate is required for maintaining a healthy bottom line.

The Colwell soil P test in combination with the PBI (Phosphorus Buffering Index) provides a more accurate interpretation of likely P fertiliser response compared with the Colwell P test alone.

Aim

To assess the long term impact of a range of P fertiliser rates on crop yield and economic returns.

Method

Six rates of P (0, 5, 10, 15, 20 and 25kg P/ha) were applied annually to the same plots from 2003 – 2010.

Each year, a base rate of mono-ammonium phosphate, MAP (N10:P22:K0:S1), at 23kg/ha (equivalent to the 5kg P/ha rate) was applied to all treatments except the nil P rate. Triple Superphosphate, TSP (N0:P20:K0:S1), was then applied to vary the P rate without adding additional N. Urea was applied at 5kg/ha to the nil P treatment to ensure that the N rate was equivalent in all treatments.

The trial began in 2003 after two years of chemical fallow. A typical Mallee rotation for this soil type was followed throughout the trial (Table 1).

Table 1. Crop rotation and growing season rainfall (GSR) at the Long Term P trial site (note: average GSR for the site is 235mm).

Year	Rotation	GSR (mm)
2003	Yitpi wheat	200
2004	Vic Sloop barley	155
2005	Targa oats (hay)	198
2006	Medic/fallow	103
2007	Yitpi wheat	142
2008	Wyalkatchem wheat	113
2009	Morgan peas (hay)	186
2010	Correll wheat	350

Location: BCG Farming Systems Site, Jil Jil
Replicates: 4
Sowing date: 3 June 2010
Seeding rate: 77kg/ha (140 plants/m^2)
Crop type: Correll wheat
Seeding equipment: no-till, narrow points, press wheels, 30cm row spacing

Soil samples have been taken annually, except in 2004, from each plot for soil Colwell P measurement. Using a 2.5cm diameter topsoil corer, 10 samples were randomly collected within treatments (all replicates).

Based on the annual fertiliser and grain or hay price, the net income after P expenditure and the accumulated income over the period has been calculated.

Results

Soil Colwell P

Increasing rates of P fertiliser raised soil Colwell P levels relative to the 0P and 5P treatments for the duration of the trial to levels higher than 50mg/kg (Table 2). The soil at the site has a PBI (phosphorus buffering index) of 160. Taking into account the PBI, the 0P and 5P treatments with a soil Colwell P of 35mg/kg, should be P fertiliser responsive.

Table 2. Soil Colwell P for the six P rates since 2003.

Fertilizer P (kg/ha)	Soil Colwell P (mg/kg)						
	2003	2005	2006	2007	2008	2009	2010
0	41	18	15	27	33	33	35
5	44	18	21	34	35	35	38
10	49	25	23	29	47	47	63
15	65	30	22	35	49	49	54
20	71	47	44	26	42	42	66
25	68	41	31	29	54	54	66

Crop Yield

From 2003 to 2009 the trial site was either in severe drought (2004, 2006 and 2008) or received below average GSR (refer to Table 1). Crop yields achieved over this period reflect the dry conditions. The 2010 season was a very wet year, with 350mm of GSR at the site (Decile 10).

There was a significant yield increase in wheat with the application of P fertiliser (from 0P to 5P), but no difference in yield with increasing rates of P (Table 3).

Table 3. Crop and hay yield for P fertiliser treatments from 2003 (note: the site was in medic/fallow in 2006).

Fertiliser (kg/ha)	P Crop / hay yield (t/ha)						
	2003 Wheat	2004 Barley	2005 Oats (hay)	2007 Wheat	2008 Wheat	2009 Pea (hay)	2010 Wheat
0	3.0	0.6	1.6	0.7	0.2	2.4	3.2
5	3.3	0.9	1.7	0.7	0.2	2.1	4.0
10	3.2	0.9	1.5	0.6	0.2	2.2	3.9
15	3.3	1.0	1.6	0.6	0.2	2.2	4.1
20	3.5	0.9	1.5	0.5	0.3	2.2	4.1
25	3.4	0.9	1.9	0.6	0.2	2.3	4.2
Sig. diff. LSD (0.05) CV%	**NS**	**P<0.05 0.2 8.8**	**NS**	**NS**	**NS**	**NS**	**P<0.001 0.4 5.2**

In 2010, wheat grain protein was 13.1% and screenings were 2.1%. Neither varied with different rates of P. Test weight was 69kg/hl which unfortunately put it outside the H1 classification (minimum standard is 74kg/hl).

Net income

Net income on a yearly and cumulative basis (2003 – 2010) was calculated, based on the annual price of the grain produced and the price for MAP in that year (Table 4). For 2010 the grain classification was downgraded from H1 to AGP because of low test weight. The price for AGP was $222/t delivered Birchip (23 December) and the price for MAP was $905/t.

Table 4. Annual net income and cumulative net income, 2003–2010.

Fertilizer P (kg/ha)	Net income after P expenditure ($/ha)							
	2003	2004	2005	2007	2008	2009	2010	Cumulative 2003-2010
0	555	69	205	254	64	440	710	2297
5	545	113	195	241	40	419	867	2420
10	535	109	185	228	16	398	824	2295
15	525	105	174	215	-8	377	848	2236
20	515	101	164	143	-32	356	827	2074
25	505	97	156	188	-56	335	828	2053

Interpretation

After seven years of P applications at rates ranging from 0 to 25kg P/ha, the 0 and 5kg P/ha rates had a significantly lower soil Colwell P level compared with the higher rates of P (10 to 25kg P/ha). The Colwell P for both the 0 and 5kg P/ha treatments, at 35mg/kg, is regarded as P responsive when the PBI (Phosphorus Buffering Index) is taken into account, which is exactly what was found in 2010.

Since the inception of the trial in 2003, in only two years, 2004 and 2010, were there significant responses to the input of P fertiliser above the nil control. In both years there was a response only from the nil rate to the 5kg P/ha rate (equivalent to 23kg MAP/ha). The cumulative net income (calculated from the yield obtained, the yearly price for grain and fertiliser) reflects this outcome with the highest return achieved being 5kg P/ha.

It is tempting to apply extra P fertiliser in 2011 after a reasonably high yielding year. However, if financial pressures still exist, it may well be prudent to apply only what the crop needs to achieve a good yield. On the Mallee clay loam soils with subsoil limitations, on which this trial site was located, the evidence after eight years of varied P inputs and crop and hay production is that 5kg P/ha (23kg MAP/ha) is still the most economic. Of course in good years after healthy profits, it is a reasonable to build up soil P reserves which you can then utilise in years after a drought, years with poor grain prices or years when fertiliser prices are very high.

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