Phosphorus rate trial and alternative fertilisers

Key findings

- A response to fertiliser after 5 years of no phosphorus applications.
- Alternative phosphorus sources such as biosolids, chicken litter or biochar, produced significantly lower yields compared to phosphorus fertiliser.
- Biosolids and chicken litter significantly increased leaf and grain zinc concentrations.

Why do the trial?

To investigate the impact of conventional phosphorus fertilisers and alternative sources of phosphorus on the grain yield and quality of wheat.

How was it done?

Plot size	1.4m x 10m	**Fertiliser**	Urea @ 35 kg/ha at sowing Phosphorus applied as per treatment
Seeding date	20th June 2011	**Variety**	Wyalkatchem wheat @ 80 kg/ha

Trial 1. Phosphorus rate: randomised complete block design with 3 replicates and 4 treatments.

Treatments were re-sown over the same treatments from 2007, 2008, 2009 and 2010.

Trial 2. Biosolids and chicken litter: randomised complete block design with 3 replicates and 8 treatments.

A single application of biosolids and chicken litter were broadcast prior to sowing in 2008.

No further fertiliser has been added to these treatments. The biosolids + 65 kg/ha single super, and chicken litter + 65 kg/ha single super treatments had a repeated application of 65 kg/ha single super in 2009, 2010 and 2011. In season foliar phosphorus treatments were added in 2010 and 2011.

Treatments were re-sown over the same treatments areas each year since 2008.

Trial 3. Biochar, phosphorus solubiliser and foliar phosphorus: randomised complete block design with 3 replicates and 12 treatments.

A seed and foliar combination phosphorus treatment plus either 5 or 10 kg of granular phosphorus were added treatments for 2011. All other previously applied treatments of biochar or phosphorus solubiliser were repeated in 2011.
Treatments were sown into standing barley stubble from the 2010 trial.

Single superphosphate was used as the standard phosphorus treatment.
The initial Colwell soil phosphorus (March 2007) was 40 mg/kg (0 – 10 cm).
The phosphorus buffering index (PBI) was 102.

Plots were assessed each year for grain yield, protein, test weight and screenings (2mm screen).

Assessments were also conducted in 2011 for dry matter yield, leaf and grain nutrient concentrations.

Samples of the biosolids and chicken litter used in 2008 were analysed for nutrient concentration (Table 1).

Table 1. Fertiliser nutrient concentrations (kg/t) of biosolids and chicken litter applied in 2008.

Nutrient	Single superphosphate	DAP	Biosolids	Chicken litter
Nitrogen	0	180	15	43
Phosphorus	90	200	10	8
Potassium	0	0	8	2
Sulphur	110	15	8	6
Zinc	0	0	1	1

Results

In the long term phosphorus experiment (Trial 1) the grain yield ranged between 2.5 t/ha (nil phosphorus) to 3.0 t/ha (15 kg P/ha). All applications of phosphorus were higher yielding compared to nil phosphorus. This is statistically significant at the 95% level.

After 5 years of receiving no phosphorus this is the first significant response to the addition of phosphorus, increasing further with fertiliser rate.

Protein levels whilst not significantly different, did decline with increases in grain yield in this treatment.

Table 2. Trial 1.Grain yield (t/ha), protein (%), test weight (kg/hL), retention (%) and screenings (%) at Hart in 2011.

Treatment	Grain yield (t/ha)	Protein (%)	Test weight (kg/hL)	Screenings (%)
Nil	2.5	11.8	76.4	1.1
5kg/ha P	2.7	11.5	78.4	0.8
10kg/ha P	2.9	11.3	78.2	1.1
15kg/ha P	3.0	11.2	78.0	0.8
LSD (0.05)	0.3	ns	ns	ns

In trial 2 the addition of 6 or 10 kg P/ha for the past 4 seasons also significantly increased grain yield compared with no phosphorus. The biosolid or chicken litter treatments alone were lower yielding as were the foliar treatments. There are significant differences between grain protein levels but this would appear to be more as a relationship to yield rather than in response to phosphorus treatments.

There were no significant differences in grain test weight or screenings which are attributable to treatments.

Table 3. Trial 2. Grain yield (t/ha), protein (%), test weight (kg/hL), and screenings (%) at Hart in 2011.

Treatment	Grain yield (t/ha)	Protein (%)	Test weight (kg/hL)	Screenings (%)
Nil	2.2	12.4	80.3	0.4
5t/ha Biosolids	2.5	12.2	79.5	0.6
5t/ha Biosolids + 6kg/ha P	2.7	11.5	79.1	0.8
3t/ha Chicken litter	2.3	12.4	79.3	0.4
3t/ha Chicken litter + 6kg/ha P	2.7	11.9	80.0	0.5
10kg/ha	2.9	11.7	79.7	0.5
Foliar 1	2.5	11.6	79.7	0.5
Foliar 2	2.6	11.7	79.7	0.5
LSD (0.05)	0.2	0.2	ns	0.2

In trial 3 grain yields ranged between 2.0 t/ha and 2.6 t/ha, with no significant difference in grain quality between the treatments. All treatments receiving 5 or 10 kg P/ha for the past 3 seasons were significantly higher yielding (2.4 t/ha) compared to no phosphorus fertiliser (2.1 t/ha). The addition of biochar, phosphorus solubilisers or foliar phosphorus applications did not increase grain yield.

Table 4. Trial 3. Grain yield (t/ha), protein (%), test weight (kg/hL), and screenings (%) at Hart in 2011.

Treatment	Grain yield (t/ha)	Protein (%)	Test weight (kg/hL)	Screenings (%)
Nil	2.0	12.9	77.2	0.7
5kg/ha P	2.4	11.9	78.0	0.8
10kg/ha P	2.5	11.9	77.5	0.7
500kg/ha Biochar	2.0	11.8	78.1	0.8
500kg/ha Biochar + 5kg/ha P	2.3	11.7	78.0	0.6
500kg/ha Biochar + 10kg/ha P	2.5	11.7	78.7	0.7
500kg/ha Biochar + Liquid P	2.4	12.3	78.2	0.6
P solubiliser	2.2	12.0	76.0	1.0
P solubiliser + 5kg/ha P	2.2	12.0	78.1	0.9
P solubiliser + 10kg/ha P	2.5	11.8	77.7	0.8
Seed + foliar + 5 kg P	2.3	12.1	77.7	0.8
Seed + foliar + 10 kg P	2.6	12.0	78.3	0.8
LSD (0.05)	0.2	0.8	ns	ns

Dry matter production (Table 5) was significantly higher in treatments with the highest rates of phosphorus applied over the years of the trial, producing up to 6.24 t/ha (15 kg P/ha).

Phosphorus applications of 10 or 15 kg/ha over the past 4 to 5 years produced significantly higher concentrations of phosphorus, sulphur and potassium in the

youngest leaves, compared to no phosphorus or organic amendments (Table 5). Those treatments also increased the potassium content of the grain.

However, zinc nutrient concentrations in both the leaves and grain were significantly higher for the biosolid and chicken litter treatments in 2011 (Table 6). This can be traced to the zinc concentrations present in the 2008 applications (see Table 1). No zinc supplements have been included in any other treatments in these phosphorus trials.

Table 5. Dry matter (t/ha), and leaf nutrient concentrations (ppm) for long term phosphorus treatments at Hart in 2011.

Treatment		Dry Matter	Leaf nutrient concentration (ppm)			
		t/ha	Zinc	Potassium	Phosphorus	Sulphur
Nil	Trial 1	4.17	21.6	3.11	0.24	0.32
5 kg P		4.89	19.9	3.10	0.25	0.33
10 kg P		6.01	17.8	3.09	0.26	0.36
15 kg P		6.24	17.4	3.16	0.28	0.35
Biosolids 5t/ha	Trial 2	4.91	23.3	3.03	0.24	0.33
Chicken litter 3 t/ha		4.93	21.9	3.00	0.23	0.33
Nil		3.73	20.1	2.99	0.23	0.32
10 kg P		4.99	18.1	3.24	0.25	0.36
Foliar		5.02	19.0	3.12	0.23	0.32
LSD (0.05)		1.2	1.7	0.13	0.02	0.02

Table 6. Grain nutrient concentrations (ppm) at Hart in 2011.

Treatment		Grain nutrient concentration (ppm)			
		Zinc	Potassium	Phosphorus	Sulphur
Nil	Trial 1	22.3	3733	2533	1623
5 kg P		18.7	3767	2600	1610
10 kg P		16.5	3933	2700	1613
15 kg P		14.7	4000	2700	1553
Biosolids 5t/ha	Trial 2	25.3	3667	2500	1630
Chicken litter 3 t/ha		25.2	3700	2533	1670
Nil		21.7	3567	2500	1627
10 kg P		16.6	3733	2433	1597
Foliar		19.5	3533	2433	1620
LSD (0.05)		1.9	182.1	ns	ns

Soil phosphorus measurements in Autumn 2011 showed that 10 kg P/ha applied since 2007 had maintained soil phosphorus levels. Soil phosphorus level has significantly declined with the addition of 0 or 5 kg P/ha/yr, while 15 kg P/ha has increased soil phosphorus levels.

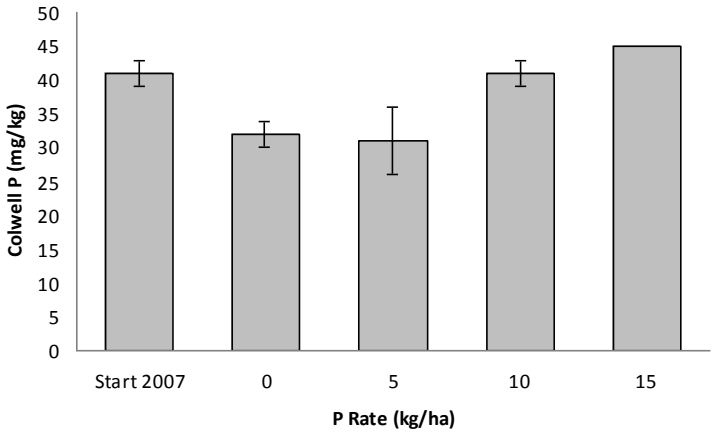

Figure 1. Soil Colwell phosphorus (0-10cm) levels measured in the Autumn of 2007 and then in 2011 for phosphorus rates between 0 and 15 kg/ha/yr at the Hart field site.