# Effects from long-term application of nitrogen and phosphorus fertilisers



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Incitec Pivot has been running a long-term fertiliser trial located at Dahlen in the Wimmera since 1996.

In this trial, there has been a positive response to phosphorus fertiliser applied at 9kg/ha at sowing and a positive response to nitrogen fertiliser applied at 20kg/ha.

There has been a negative response to applied nitrogen both at sowing and top-dressing at higher than 20kg N/ha rates, which can be attributed to low growing season rainfall (GSR), which has occurred through prolonged periods over the course of the trial.

High grain protein results have confirmed a post-anthesis moisture stress, with the average grain protein for the entire experiment being 12.3 percent, which is well above the district average of 10-11 percent.

After 13 years of cropping, treatments receiving 9kg/ha of phosphorus have slightly increased soil phosphorus test levels (sustainable), whereas treatments receiving no phosphorus fertiliser have significantly less soil phosphorus (unsustainable) and the 18 and 36kg/ha phosphorus treatments now have accumulated relatively very high levels (uneconomic).

Measurements of soil organic carbon have not detected any changes in levels, although this trial site has now been no-till for 13 years.

Treatments returning the most dollars per dollar spent on nutrients have been 9kg P/ha applied at sowing and 20kg N/ha applied at either sowing or top-dressed.

## Dahlen trial site history

The trial site is under continuous cropping and the soil and crop rotation are typical of those in the area. Since its establishment, the following crops have been grown: barley (1996, 2000, 2004, 2008), chickpeas (1997), canola (1998, 2002, 2006), wheat (1999, 2003, 2007) and lentils (2001, 2005). Phosphorus levels at the start of the trial in 1996 were approximately 9mg/kg (Olsen).

The trial looks at the combination of four phosphorus rates (zero, nine, 18 and 36kg P/ha applied via triple superphosphate) and five nitrogen rates (zero, 20, 40, 80 and 160kg N/ha applied via urea) as well as two nitrogen timings, at sowing and top-dressed.

The entire site had a basal application of 30kg/ha sulfur, 2kg/ha zinc and 75kg/ha potassium and 5kg/ha magnesium prior to sowing canola in 1998. Zinc as liquid zinc sulfate has been banded at each sowing since 2005.

## 2008 results

At sowing there was a significant response to phosphorus fertiliser at the 9kg/ha rate and with both nitrogen fertiliser rates of zero and 20kg/ha. There was a non-significant trend of the higher the nitrogen rate, the lower the yield. This indicates that a certain amount of yield may have been lost to 'haying-off', as the GSR was only 183mm and a late post-anthesis moisture stress occurred.

**Table 1.** Grain yield (Source: Incitec Pivot, 2009).

| | | Nitrogen rate kg/ha | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **20** | **40** | **80** | **160** |
| **Phosphorus rate kg/ha** | **0** | 0.93 | 1.02 | 1.10 | 0.92 | 0.93 |
| | **9** | 1.46 | 1.63 | 1.14 | 0.77 | 0.48 |
| | **18** | 1.56 | 1.69 | 1.35 | 0.88 | 0.55 |
| | **36** | 1.63 | 1.52 | 1.39 | 0.68 | 0.36 |

The late anthesis moisture stress was clearly evident in grain protein responses at the nitrogen rates of 40, 80 and 160kg/ha, for both sowing and top-dress treatments at Zadoks 30 (Tables 2 and 3).

**Table 2.** Grain protein percentage for nitrogen at sowing (Source: Incitec Pivot, 2009).

| | | Nitrogen rate at sowing kg/ha | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **20** | **40** | **80** | **160** |
| **Phosphorus rate kg/ha** | **0** | 10.1 | 13 | 13 | 13.7 | 13.7 |
| | **9** | 8.57 | 10.8 | 12.9 | 14.1 | 14.7 |
| | **18** | 9.17 | 10.3 | 12.3 | 13.8 | 14.9 |
| | **36** | 8.83 | 11.1 | 11.9 | 14.7 | 13.3 |

**Table 3.** Grain protein percentage for top-dressed nitrogen (Source: Incitec Pivot, 2009).

| | | Nitrogen rate top-dressed kg/ha (at Zadocks 30) | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **20** | **40** | **80** | **160** |
| **Phosphorus rate kg/ha** | **0** | 11.1 | 12.4 | 13.3 | 13.8 | 14.2 |
| | **9** | 8.67 | 10.3 | 12.7 | 13.7 | 14.8 |
| | **18** | 8.43 | 10.8 | 13 | 13.9 | 15.2 |
| | **36** | 8.47 | 10.3 | 12.4 | 14.2 | 15.7 |

## Discussion

The data collected from the site over the past 13 years (1996-2008) has been analysed with the specific focus on economics and nutrient budgets.

There were considerable differences between gross margins (GM) across different treatments and across years.

Assuming individual yield results from each year are affected only by the fertiliser applied in that year, it was found that if the top returning treatment was achieved each year, across all 13 years, the average GM across that period would be $524/ha/year.

This represents what would have been possible with perfect knowledge and good management. However, it is recognised that perfect knowledge is not achievable, and the yield result of an individual year is generally not independent of the years prior.

**Table 4.** Highest gross margin (GM) and treatment for each year (Source: Incitec Pivot, 2009).

| Year | Crop | GM $/ha | P kg/ha | N kg/ha | N timing | N applied |
|---|---|---|---|---|---|---|
| 1996 | Barley | $1615 | 36 | 160 | Sowing | Yes |
| 1997 | Chickpeas | $907 | 18 | 20 | Sowing | No |
| 1998 | Canola | $667 | 0 | 80 | Sowing | Yes |
| 1999 | Wheat | $347 | 9 | 20 | Top-dressed | Yes |
| 2000 | Barley | $983 | 18 | 80 | Sowing | Yes |
| 2001 | Lentils | $538 | 9 | 20 | Top-dressed | No |
| 2002 | Canola | -$222 | 0 | 0 | Sowing | Yes |
| 2003 | Wheat | $912 | 18 | 20 | Top-dressed | Yes |
| 2004 | Barley | $226 | 18 | 20 | Top-dressed | Yes |
| 2005 | Lentils | $493 | 9 | 160 | Top-dressed | No |
| 2006 | Canola | -$222 | 0 | 0 | Sowing | Yes |
| 2007 | Wheat | $468 | 9 | 20 | Top-dressed | Yes |
| 2008 | Barley | $306 | 9 | 20 | Sowing | Yes |
| Average for 13 years | | $524 | | | | |

In the current environment of uncertainty, a set fertiliser strategy may be a beneficial risk management option as opposed to altering fertiliser rates in response to seasonal outlook.

The top returning strategy across 13 years was 9kg P/ha and 20kg N/ha applied as a top-dressing treatment.

The results achieved in 2008 support results from 2007 (Table 5). In a similar dry season to 2008, wheat yields were only significantly different at 9kg P/ha and in combination with 20kg N/ha. These responses were also reflected in grain protein responses (Table 6).

**Table 5.** 2007 Derrimut wheat grain yield t/ha (Source: Incitec Pivot, 2009).

| | | Nitrogen rate kg/ha | | | | |
|---|---|---|---|---|---|---|
| | **0** | **20** | **40** | **80** | **160** | |
| **Phosphorus rate kg/ha** | **0** | 1.997 | 2.106 | 2.031 | 2.01 | 2.221 |
| | **9** | 2.21 | 2.506 | 2.316 | 2.17 | 2.187 |
| | **18** | 2.406 | 2.501 | 2.34 | 2.31 | 2.003 |
| | **36** | 2.601 | 2.508 | 2.372 | 2.08 | 2.188 |

**Table 6.** 2007 Derrimut wheat grain protein percentage (Source: Incitec Pivot, 2009).

| | | Nitrogen rate kg/ha | | | | |
|---|---|---|---|---|---|---|
| | **0** | **20** | **40** | **80** | **160** | |
| **Phosphorus rate kg/ha** | **0** | 12.32 | 13.12 | 13.53 | 13.7 | 13.78 |
| | **9** | 10.57 | 12.9 | 14.78 | 15.4 | 15.58 |
| | **18** | 10.8 | 12.97 | 14.2 | 15.3 | 15.22 |
| | **36** | 11.6 | 13.47 | 14.37 | 15.4 | 16.07 |

## Soil phosphorus levels

Colwell P levels for the 9kg/ha rate indicate that soil reserves of phosphorus are not being mined. Compare this to the two higher rates of 18 and 36kg P/ha, where soil phosphorus levels are rapidly increasing. This could be viewed as unnecessary and uneconomical.

**Table 8.** Impact on soil phosphorus from fertiliser applications (Source: Incitec Pivot, 2009).

| Year | Average Colwell P mg/kg | | | |
|---|---|---|---|---|
| | 0P | 9P | 18P | 36P |
| 2007 | 14 | 33 | 50 | 109 |

## Soil carbon

Soil carbon levels are often used as a guide to soil health. As this trial site has been continuously cropped using a no-till cropping system since 1996, any changes in soil carbon levels should indicate the sustainability of the cropping system.

After 13 years there has been no apparent change in organic carbon levels (Table 9) as measured by laboratory analysis.

Comparing the trial site levels with an uncropped and undisturbed area, there are large differences in soil carbon levels, but there is little difference compared with neighbouring conventionally tilled paddocks.

**Table 9.** Soil organic carbon percentage (Source: Incitec Pivot, 2009).

| Treatment/site | Average organic carbon % |
|---|---|
| Pre-experimental (1996) | 1.10 |
| Trial site average (2008) | 1.12 |
| Neighbouring non-cropped fence line (2008) | 0.72 |

## Conclusion

In the current situation of uncertainty, with year to year variability in cropping seasons, this trial and analysis of the data obtained suggests a 'best bet' approach of applying a set fertiliser strategy, such as 9 kg P/ha at sowing and 20 kg N/ha at sowing or topdress in the Wimmera.

This can achieve good returns over the long term and minimise some of the risks involved in trying to guess the likely seasonal outcome and adapting fertiliser rates to suit.

## Refererences

**Dalal, R.C. et al (1995).** Sustaining productivity of a Vertisol at Warra, Queensland, with fertilizers, no-tillage or legumes 1. Organic matter status Australian Journal of Experimental Agriculture Vol 35, pp 903-913.

**Dalal, R.C. et al (1997).** Sustaining productivity of a Vertisol at Warra, Queensland, with fertilizers, no-tillage or legumes 4. Nitrogen fixation, water use and yield of chickpea.Australian Journal of Experimental Agriculture. Vol 37, pp 667-676.

**Foley, B.J. (1997).** Wheat yield, protein and apparent nitrogen use efficiencies of the Victorian Wimmera and Mallee. Proceedings of the Third Annual Cropping Zone Conference, Horsham, Victoria. pp 2-4.

**Foley, B.J. and Norton R. (1998).** N and P fertilizers and hostile sub soils. Australian Grain. Vol 8, No. 3 (Southern Focus) pp 6-7.

**Nelson, T. Norton R (2007)** Longterm Phosphorus by Nitrogen Trial at Dahlen Executive Summary University of Melbourne.

**Russel, J.S. (1980).** Nitrogen in dryland agriculture. International Congress on Dryland Farming Proceedings, Adelaide 1980, pp. 202-207. (South Australian Department of Agriculture: Adelaide).