# FARMER SOWN AND HARVESTED REPLICATED FERTILISER TRIALS

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## TAKE HOME MESSAGES

- Technology is now available to enable farmers to sow/harvest/analyse replicated large-scale trials with their own machinery.
- Undertaken in the southern Wimmera, this study investigated soil P (phosphorus) status based on Colwell P, DGT P and the PBI (Phosphorus Buffer Index). It indicated that the soil should be responsive to higher rates of P fertiliser than normally sown by the landowner.
- Four rates of P fertiliser (ranging from 0 to 35kg P) were sown with wheat in a fully randomised pattern. The 0P, 8.8P, 17.5P and 35kg P treatments yielded 5.4, 5.7, 5.8 and 6.1 t/ha respectively.
- This trial demonstrates the power of on-farm statistically valid experimentation managed with farm equipment. The technology will enable farmers to test and verify different inputs to not only optimise production but financial returns as well.

## BACKGROUND

Small scale replicated trials are the backbone of scientific based evidence in agricultural research and have greatly improved our understanding of how crops grow, which cultivars perform the best in different environments, what nutrients are required to optimise production and how tolerant crops are to different herbicides. In addition, practices such as various row spacing, fertiliser rates and placement, sowing depth etc can be compared and tested. Importantly, the results of these small scale replicated trials leads to an understanding of the internal processes of how a crop grows and yields.

Farmers can test the findings of small scale replicated trials using their machinery by sowing test-strips. These test strips are generally not replicated, they have fewer methods of evaluation and therefore have fewer controls and are often called 'on-farm demonstrations'.

Small-scale replicated trials and farmer sown test strips have their advantages and disadvantages (Hansson 2019). A significant disadvantage when applying the results of nutrition focused small-scale replicated plot trials to farm scale conditions are differences in soil type and nutrient status of the soil at the trial site compared with farmer paddocks – it is likely these will not be the same resulting in different responses.

Farm machinery has undergone massive changes in technology over the last decade with guidance (GPS), variable rate sowing (fertiliser and seed), yield and protein mapping and more. This adds great value to making 'in-paddock' decisions to suit local conditions. It has also enabled farmers to more easily undertake their own replicated field trials to test new practices and link the findings from small scale trial plots to large scale on-farm experimentation. This has the benefit of increasing confidence in on-farm trials and understanding of optimal fertiliser programs. Software is now available to automate the sowing and analysis of replicated farm-based trials with products such as SMS Agleader <www.agleader.com/farm-management/sms-software>. To get the most out of an on-farm replicated large-scale trial, soil testing must be undertaken on the allocated replicate areas to be able to correlate yield responses to soil P status. In this paper we outline the findings of a large scale replicated P nutrition trial, sown and harvested using farm machinery.

# METHOD

*Paddock history and long-term P balance*

The trial paddock was located in the southern Wimmera, Victoria. The paddock five-year history, average crop yield, P applied as fertiliser and exported in the grain or hay and the annual P budget (P applied minus P exported) are outlined in Table 1. Over the five-year rotation there was a small positive P balance of 3.6 kg/P.

**Table 1. Five-year paddock rotation, yield, fertiliser P applied, P removed in the crop/ha and the annual P balance.**

| Year | Crop | End use | Yield (t/ha) | Fertiliser | Grain or hay | |
|---|---|---|---|---|---|---|
| | | | | P applied (kg/ha) | P removed (kg/ha) | P balance (kg/ha) |
| 2016 | Wheat | Grain | 6.4 | 13.1 | 19.2 | -6.1 |
| 2017 | Barley | Grain | 5.3 | 17.5 | 14.3 | 3.2 |
| 2018 | Wheat | Hay | 2.5 | 17.5 | 5.0 | 12.5 |
| 2019 | Canola | Canola | 3.5 | 17.5 | 24.5 | -7.0 |
| 2020 | Wheat | Grain | 5.5 | 17.5 | 16.5 | 1.0 |
| **Total** | | | | **83.1** | **79.5** | **3.6** |

*Sowing*

The on-farm trial was sown with a Boss single shoot tyne seeder (12m wide) at a speed of 9km/hr. The tynes had a row spacing of 30cm, seed and fertiliser are delivered together. The lay-out of the trial is shown in Figure 1. Wheat was sown in between the rows of the previous crop.

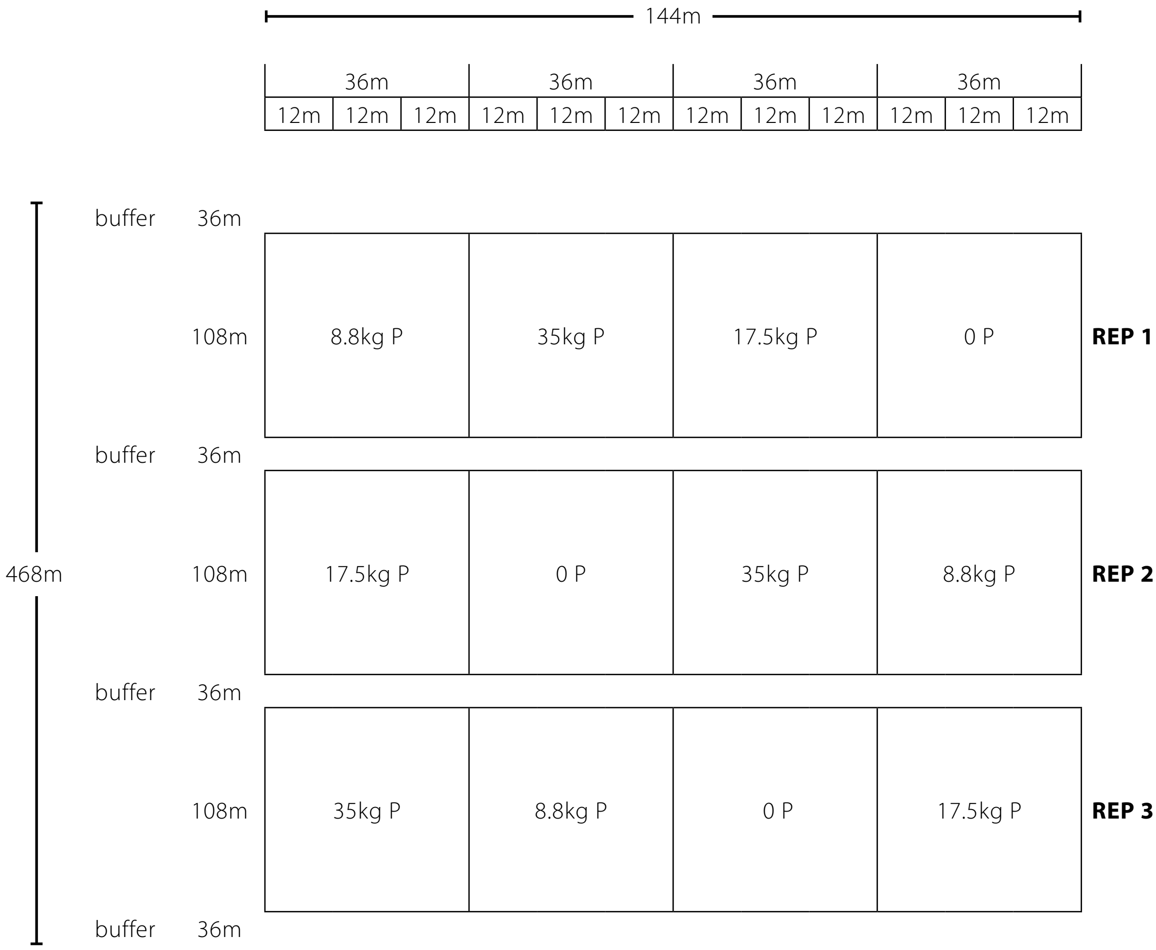



**Figure 1. P trial layout sown May 12, 2020.**

There were four P rate treatments (0, 8.8, 17.5 and 35 kg P applied with Granulock® Z) and three replicates. In each replicate the four individual P treatments were applied with three seeder widths (for a total of 36m per treatment), the length of each plot was 108m and buffer strips of 36m separated each replicate (Figure 1). The buffer strips were long enough to ensure the treatment areas received the right amount of fertiliser.

Scepter wheat was sown at 84kg/ha on 12 May 2020 into a standing canola stubble. Urea was applied on July 1 and August 16, at 46 kg N/ha each time (total 92kg N/ha plus what was applied at seeding with Granulock® Z) (Table 2).

**Table 2. P rate treatments and N applied per treatment (fertiliser applied as Granulock® Z and Urea).**

| P treatment | P rate (kg P/ha) | N rate (kg N/ha) (applied at sowing plus top-dressed) |
|---|---|---|
| Farm rate | 17.4 | 101 |
| Zero rate | 0 | 92 |
| Half farm rate | 8.7 | 96 |
| Double farm rate | 35 | 110 |

# RESULTS AND INTERPRETATION

**2020 seasonal condition**

Growing Season Rainfall, April to October, was average (297mm). There were no significant frosts or heat shock days during flowering and early grain filling of the crop.

**Soil test results and interpretation**

Each replicate was soil sampled separately prior to sowing. In each replicate six deep available N cores were taken in four depth increments (0-10, 10-40, 40-70, 70-100cm). The soil collected for each depth layer in each replicate was thoroughly mixed and analysed for available N (nitrate and ammonium) and for moisture content (gravimetric soil water). Bulk density based on a measured local Apsoil (746) was used to calculate total available soil N (in kg/ha) and total volumetric soil water (mm). Around each deep N core, six additional topsoil samples were taken for soil P analysis (for a total of 36 topsoil samplings per replicate) (Table 3).

**Table 3. Soil test results.**

| | Texture (profile) | pH water (topsoil) | Org C% (topsoil) | Colwell P mg/kg (topsoil) | DGT P µg/L (topsoil) | PBI (topsoil) | Total N kg/ha profile | EC (70-100cm) |
|---|---|---|---|---|---|---|---|---|
| Rep 1 | Clay | 7.3 | 1.4 | 31 | 33 | 105 | 58 | 0.7 |
| Rep 2 | Clay | 7.7 | 1.7 | 23 | 28 | 103 | 68 | 0.9 |
| Rep 3 | Clay | 7.4 | 1.5 | 22 | 31 | 97 | 59 | 0.6 |
| **Average** | **Clay** | **7.5** | **1.5** | **25** | **31** | **102** | **62** | **0.7** |

**Soil P status interpretation**

Based on the Colwell P and DGT P status in combination with the soil PBI (Phosphorus Buffer Index) the three trial replicates are regarded as responsive to fertiliser P, with replicates 2 and 3 being highly responsive.

### Tissue test response to increased rates of P fertiliser

Tissue tests and dry matter cuts were taken at GS37 (flag leaf). Increasing rates of fertiliser P resulted in increased dry matter production as well as a significant increase in tissue P (Figure 2).

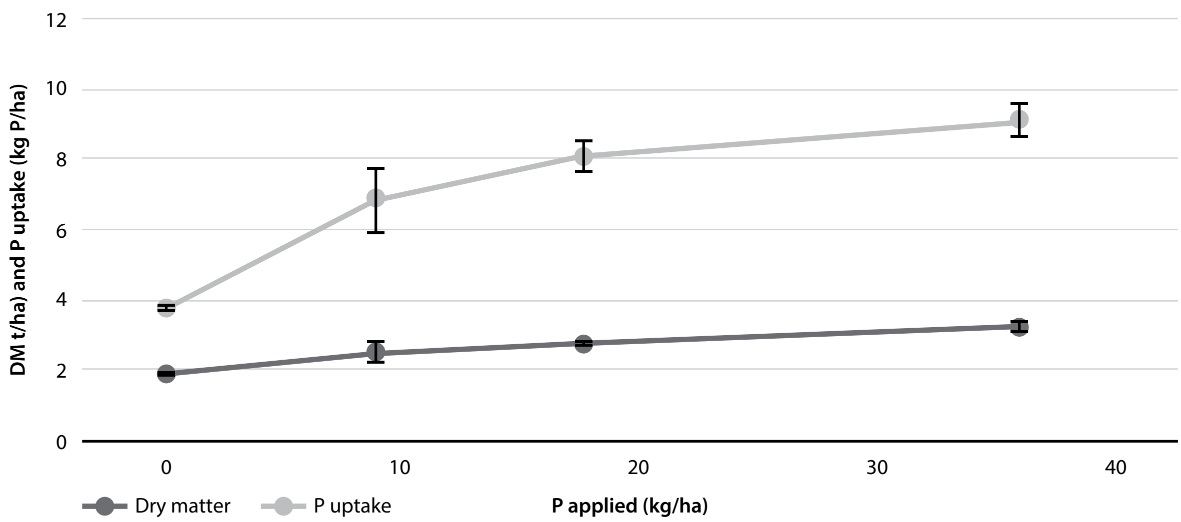



**Figure 2. Tissue dry matter and P uptake at GS37 (flag leaf).**

### Yield response to increased rates of P fertiliser

Treatment yields were determined from yield map data for each of the 108m strips with different P treatments.

There was a significant yield response (P<0.001, LSD = 0.2) to increased rates of P fertiliser (Table 4). It is possible there was a small impact of sowing N in the yield increase. It is highly unlikely however that the additional 16kg N in the highest P rate treatment could have been responsible for a 0.7t/ha increase in grain yield (compared with the control treatment).

**Table 4. Yield response to increasing rates of Granulock® Z (note 92kg N was applied in-crop to all treatments).**

| | 0P, 0N | 8.7P, 4N | 17.4P, 8N | 35P, 16N |
|---|---|---|---|---|
| Rep 1 | 5.1 | 5.7 | 5.7 | 6.1 |
| Rep 2 | 5.5 | 5.7 | 5.9 | 6.1 |
| Rep 3 | 5.4 | 5.8 | 5.9 | 6.2 |
| **Average t/ha** | **5.4** | **5.7** | **5.8** | **6.1** |

### Partial gross margin

At indicative current prices for wheat, Granulock® Z and Urea the partial gross margins for the four treatments are listed in Table 5.

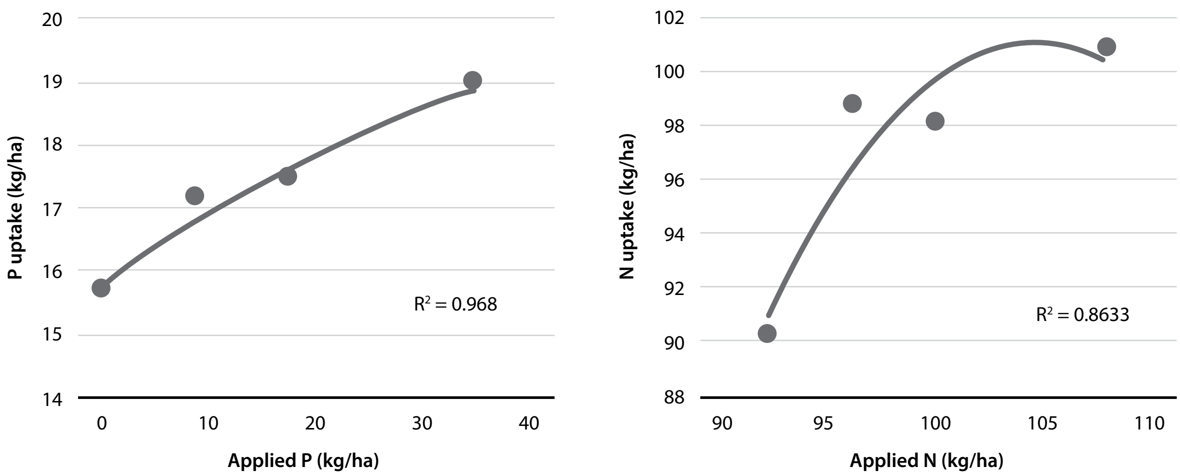
**Table 5. Partial gross margin (note 92kg N, at $108/ha) was applied as urea in-crop to all treatments).**

| | 0P, 0N | 8.7P, 4N | 17.4P, 8N | 35P, 16N |
|---|---|---|---|---|
| Cost of fertiliser* | $108 | $136 | $164 | $220 |
| Return on wheat# | $1400 | $1482 | $1508 | $1586 |
| **Partial gross margin** | **$1292** | **$1346** | **$1344** | **$1366** |

*Cost of fertiliser on-farm GranulockZ $700/t, Urea $540/t
# Price of wheat on-farm $260/t

### Grain test response to increased rates of P and N fertiliser

Grain samples were analysed for P and N content and P and N uptake from the four rates of fertiliser applied was calculated (Figures 3 and 4). A linear relationship was achieved for P uptake by P applied, whereas for N the optimum rate for grain N content, or grain protein, was between 100 and 105 kg N/ha.




**Figures 3 and 4. Grain P and N uptake for the four rates of P and N applied.**

## COMMERCIAL PRACTICE AND ON-FARM PROFITABILITY

### Potential yield

Gravimetric soil water to 100cm soil depth was determined prior to sowing and using the local Apsoil Crop Lower Limit (wilting point of the soil) and soil bulk density it was calculated there was 32mm of plant available water (PAW) at sowing.

Two methods for calculating potential yield were used: (i) WUE (water use efficiency) using the method described by Sadras and Angus (2006) and (ii) Yield Prophet.

(i) Potential yield (PY) based on WUE
PY = 22 * ((pre sowing PAW + May to Oct rainfall) – 60)
PY = 22 * ((32 + 262) – 60) = **5.1 t/ha**

(ii) Yield Prophet
Yield Prophet (using APSIM, Hochman et al. 2009) using local conditions simulated a Yw (water limited and nitrogen unlimited yield) for the paddock rate of N inputs of **4.8t/ha**.

The average paddock yield was 5.5t/ha and the highest yielding P treatment had an average yield of 6.1t/ha. It is an exceptional outcome to achieve a paddock yield higher than the potential yield as calculated by WUE and simulated by Yield Prophet.

**Response to fertiliser**

The soil test results indicated the soil was responsive to fertiliser P. A clear step-wise increase in yield was found from sowing 0P,0N (5.4t/ha) to 8.8P,4N (5.7t/ha) to 17.5P, 8N (5.8t/ha) to 35P, 16N (6.1t/ha). All treatments had 92kg of N applied over two in-crop applications of urea and Yield Prophet simulated the highest yielding treatment (35P, 16N) to have achieved above Yw (water limited yield).

Soil test results indicated the soil is responsive to fertiliser P (based on the Colwell soil P test results with PBI interpretation).

The five-year P balance (P applied minus P exported in the grain) showed the balance between P applied and P exported is being maintained yet an increase in grain yield was obtained with higher P rates in 2020, highlighting the importance of soil P monitoring. Replacement P strategies do not factor in variance of soil properties across the paddock that drive P reactions of applied P. PBI is a useful guide to highlight potential P complexation/fixation with this paddock having a moderate to high PBI.

In 2020, higher rates of P resulted in increased dry matter production and P uptake. This was further reflected in increased yield with increased rates of P fertiliser. On this farm, four out of the last five years have had above long-term average yield. In 2020 it was exceptional to grow a 5.5t/ha wheat crop on just below average growing season rainfall, especially considering the season prior was a 3.5t/ha canola crop and the summer period (2019-20) had below average rainfall. Soil moisture prior to sowing in 2020 was low (PAW was 32mm). If higher than long-term average yield is the new 'norm' then increased P rates, and possibly N inputs, should be investigated.

## REFERENCES

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## ACKNOWLEDGEMENTS

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