

# Farmer sown and harvested replicated fertiliser trials

■ By Harm van Rees (Cropfacts), Cameron Taylor (farmer Wimmera, Victoria), Sean Mason (Agronomy Solutions)

## AT A GLANCE...

- Technology is now available to enable farmers to sow/harvest/analyse replicated large-scale trials with their own machinery.
- In this study, undertaken in the southern Wimmera of Victoria, the soil P status based on Colwell P, DGT P and the PBI (Phosphorus Buffer Index) indicated that the soil should be responsive to higher rates of P fertiliser than normally sown by local farmers.
- Four rates of P fertiliser (ranging from 0 to 35 kg P) were sown with wheat in a fully randomised pattern. The zero P, 8.8 P, 17.5 P and 35 kg P treatments yielded 5.4, 5.7, 5.8 and 6.1 tonnes per hectare 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 also financial returns.



Southern Wimmera farmer Cameron Taylor was a key co-operator in these trials.

**S**MALL scale replicated trials are the backbone of scientific based evidence in agricultural research. They have greatly improved our understanding of agronomic factors such as how crops grow, which cultivars perform the best in different environments, what nutrients are required to optimise production, 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'.

The small-scale replicated trials and farmer sown test strips have their advantages and disadvantages. A significant disadvantage of 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](http://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 article we outline the findings of a large scale replicated P nutrition trial, sown and harvested using farm machinery.

**TABLE 1: Five-year paddock rotation, yield, fertiliser P applied, P removed in the crop per hectare 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
				<b>83.1</b>	<b>79.5</b>	<b>3.6</b>

## How we did the trial

### 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 per hectare.

### Sowing

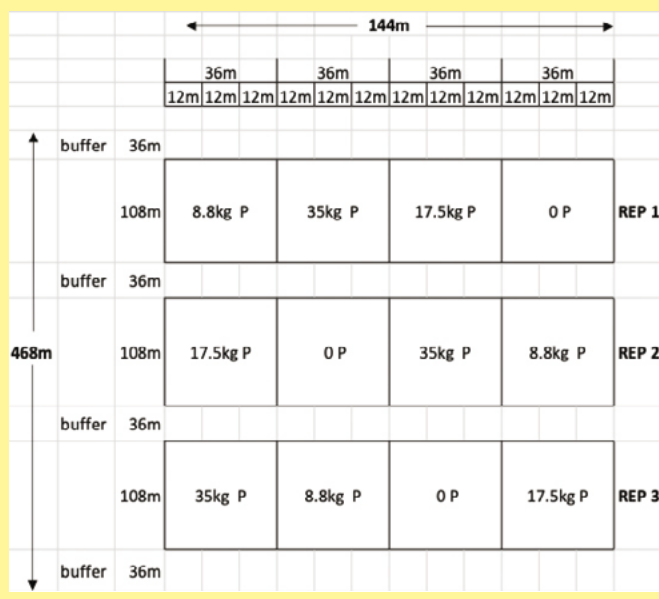
The on-farm trial was sown with a Boss single shoot tyne seeder (12 m wide) at a speed of 9 km per hour. The tynes had a row spacing of 30 cm, seed and fertiliser are delivered together. The lay-out of the trial is shown in Figure 1. Wheat was sown in between the rows of the previous crop.

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



Large scale modern farm machinery has enabled farmers to do their own on-farm replicated trials.

**FIGURE 1: P trial layout sown May 12, 2020**



**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	0.0	92
Half farm rate	8.7	96
Double farm rate	35.0	110

**TABLE 3: Soil test results**

	Texture (profile)	pH water (topsoil)	Org C% (topsoil)	Colwell P mg/kg (topsoil)	DGT P ug/L (topsoil)	PBI (topsoil)	Total N kg/ha profile	EC (70–100 cm)
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
<b>Average</b>	<b>Clay</b>	<b>7.5</b>	<b>1.5</b>	<b>25</b>	<b>31</b>	<b>102</b>	<b>62</b>	<b>0.7</b>

widths (for a total of 36 m per treatment), the length of each plot was 108 m and buffer strips of 36 m 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 84 kg per hectare on 12/5/2020 into a standing canola stubble. Urea was applied on July 1 and August 16, at 46 kg N per hectare each time (total 92 kg N/ha plus what was applied at seeding with Granulock Z) (Table 2).

## Results and interpretation

### 2020 seasonal condition

Growing Season Rainfall, April to October, was average (297 mm). 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 and 70–100 cm). 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 Apsol (746) was used to calculate total available soil N (in kg per hectare) 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).

### 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.

## Yield response to increased rates of P fertiliser

Treatment yields were determined from yield map data for each of the 108 m 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 that there was a small impact of sowing N in the yield increase. But, it is highly unlikely that the additional 16 kg N in the highest P rate treatment could have been responsible for a 0.7 tonne per hectare increase in grain yield (compared with the OP, ON control treatment).

**TABLE 4: Yield response to increasing rates of Granulock Z**

	OP, ON	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

Note: 92 kg N was applied in-crop to all treatments.

## 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**

	OP, ON	8.7P, 4N	17.4P, 8N	35P, 16N
Cost of fertiliser*	\$108	\$136	\$164	\$220
Return of wheat#	\$1400	\$1482	\$1508	\$1586
<b>Partial gross margin</b>	<b>\$1292</b>	<b>\$1346</b>	<b>\$1344</b>	<b>\$1366</b>

\* Cost of fertiliser on-farm GranulockZ \$700/t, Urea \$540/t

# Price of wheat on-farm \$260/t

Note 92 kg N, at \$108/ha) was applied as urea in-crop to all treatments.

## 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. 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.

## Commercial practice and profitability

### Potential yield

Gravimetric soil water to 100 cm 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 32 mm 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

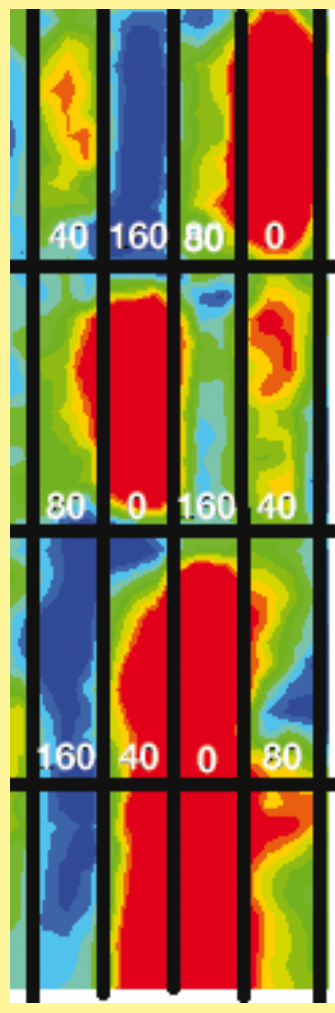
$$PY = 22 * ((\text{pre sowing PAW} + \text{May to Oct rainfall}) - 60)$$

$$PY = 22 * ((32 + 262) - 60) = 5.1 \text{ tonnes per hectare}$$

(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 5.7 tonnes per hectare.

**FIGURE 2: Normalised Difference Vegetation Index (NDVI) imagery of the trial area also helped to identify variability across the plots with different fertiliser rates**



The average paddock yield was 5.5 tonnes per hectare and the highest yielding P treatment had an average yield of 6.1 tonnes per hectare. It is an exceptional outcome to achieve a paddock yield higher than the potential yield as calculated by WUE and as 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 OP, ON (5.4 t/ha) to 8.8P, 4N (5.7 t/ha) to 17.5P, 8N (5.8 t/ha) to 35P, 16N (6.1 t/ha). All treatments had 92 kg 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 5.5 tonnes per hectare wheat crop on just below average growing season rainfall, especially considering the season prior was a 3.5 tonnes per hectare canola crop and the summer period (2019–20) had below average rainfall. Soil moisture prior to sowing in 2020 was low (PAW was 32 mm).

If higher than long term average yield is the new 'norm', then increased P rates, and possibly N inputs, should be investigated.

**This research was funded by the GRDC. Project: 'Using soil and plant testing to better inform nutrient management and optimise fertiliser investments for grain growers in the Southern region. (Project number: 9176604)**

This article was also published in the *BCG Research Manual 2020*.