Establishment Phosphorus Compounds and Nutrient Supply for Wheat Crop Production – Large Plot Trial, Yornaning

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AIM

Numerous compound fertiliser products can supply phosphorus (P) to crops, each with a unique P content and bulk density meaning differences in rate and granule distribution to supply the same P. Product choice has cost and logistical implications. We investigate the agronomic response of Magenta wheat to various rates and compounds of P fertilisers in a scaled-up plot trial. This trial also aims to assess the effectiveness of trial methodology of sowing a cereal crop through placed strips of P compounds, as well as comparing remote and on-ground biomass measurements for in-paddock variability in growth and yield.

KEY MESSAGES

- Yornaning experienced a decile 2 growing season rainfall in 2020.
- In-season biomass readings done both by hand using a handheld Greenseeker® and through high-resolution satellite imagery indicated that biomass was not significantly affected by increasing P rates but was primarily influenced by variations in soil type across the trial.
- Increasing P rates resulted in significant increases in yield, with a mean yield of 2.91t/ha.
- The most profitable treatment under 2020 conditions was when 12kg P/ha was applied as MAPSZC, with an indicative return of $805/ha.
- The higher-analysis products MAPSZC and Vigour had higher yields and higher gross margins than the low analysis product AllRich, however differences between products was not significant.

TRIAL DETAILS

Property:	**Scott Young, Yornaning**	
Plot size & replication:	4.5 x 100 metres, 10 treatments 3 x replicates = 30 plots	
Soil type:	Loamy sand	
Crop:	Magenta wheat, sown 24/05/2020 at 65 kg/ha	
Weed/Fungal/Insect Control:	Pre-Emergent:	Paraquat 1.5L/ha, Avadex 2L/ha, Trifluralin 2L/ha, Diuron 0.3L/ha
	Post-Emergent:	Arcade 2.5L/ha, Flight 0.6L/ha

BACKGROUND

Many soils in Western Australia are P deficient in their natural state, so correct application of P has been shown to improve the yield and grain quality of wheat in Western Australia. Phosphorus is essential for plant production, particularly in early crop development. It plays a key role in energy transfer during photosynthesis, respiration, and cell division at growing points. Cereal crops that do not have access to adequate amounts of P often show reduced vigour and growth. Soil characteristics including extractable P, clay content, phosphorus buffering index (PBI) and soil pH all influence P availability.

Phosphorus has a low soil mobility, meaning the most effective applications are banded just below the seed drill row where it will be intercepted by roots. Pre-drilling establishment fertilizer means it is not being placed immediately beneath the seed. Fortunately, it appeared there was not a lot of lateral movement of fertilizer during seeding of this trial, meaning plant roots still were able to locate the fertilizer.

Different phosphorous based fertilizer products need to be applied to crops at different rates to achieve the same desired target output. As a result, granule output from seeding machinery will differ and granule distribution will also vary with product. This trial incorporated MAPSZC, Vigour and AllRich fertilizers at 6, 12 and 18kg P/ha. AllRich is a low analysis phosphorus product at only 8.7% P, compared to Vigour at 12% P and MAPSZC at 19.8% P. In order the achieve the same nutritional output, AllRich needs to be applied at a higher rate than other products, resulting in more granules per unit area. For example, to achieve an output of 12kg P/ha, 60kg/ha MAPSZC, 100kg/ha Vigour or 140kg/ha AllRich is required. As greater quantities of a low-analysis product are required, there are more logistical requirements and a greater storage demand.

This trial was designed in conjunction with the Facey Group with the aim of assessing crop differences at a scale larger than small plot trials. Pre-drilling establishment P fertilizers allowed Summit to establish a larger scale trial while having minimal interference with the farmers paddock management and a hands-off approach through the restricted Covid-19 pandemic response period of 2020. This also allowed the seeding to be consistent with the rest of the paddock, all weeds, pests and diseases and in-season fertilizer applications to be controlled as per paddock practice while still allowing for monitoring by remote sensing. Through DataFarming, NDVI values were able to be collected through high-resolution satellite imagery, which were then able to be compared with ground measurements recorded with a handheld Greenseeker®.

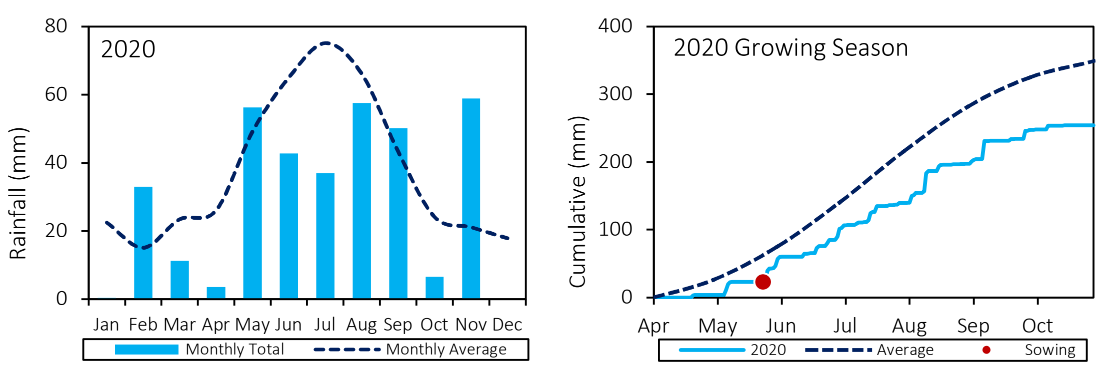


Figure 1. *2020 monthly rainfall from Popanyinning DPIRD Station (15km NW). 30-year average rainfall data from Narrogin BOM Station (22km S). Growing season rainfall fell 95mm below the long-term average.*

Table 1. *Soil nutrient analysis, average taken over four sites*

Depth	pH_{Ca}	EC	PBI	$P_{[Col]}$	$P_{[DGT]}$	$K_{[Col]}$	S	OC	NO_{3^-}	NH_4^+	Cu	Zn	Mn
0-10	5.35	0.13	64	29	28	145	16	1.8	20	4	0.48	0.48	7.1
10-20	5.23	0.03	64	8	8	93	5	0.5	3	1	0.27	0.12	1.7
20-30	5.85	0.02	78	5	5	78	6	0.3	2	2	0.27	0.11	0.6

Table 2. *Fertilizer applications and treatments. In-season nitrogen applications applied firstly as urea at the 3-4 leaf stage and secondly as UAN at the 5-6 leaf stage.*

No	Treatment	Establishment Fertiliser Banded	In-Season N		Total applied (kg/ha)		
		(kg product / ha)	(kg/ha)	(L/ha)	N	P	K
1	P6 MAPSZC	30 MAPSZC, 70 Urea	70 Urea	30 UAN	80	6	0
2	P6 Vigour	50 Vigour, 65 Urea	70 Urea	30 UAN	80	6	6
3	P6 AllRich	70 AllRich, 50 Urea	70 Urea	30 UAN	80	6	0
4	P12 MAPSZC	60 MAPSZC, 60 Urea	70 Urea	30 UAN	80	12	0
5	P12 Vigour	100 Vigour, 55 Urea	70 Urea	30 UAN	80	12	12
6	P12 AllRich	140 AllRich, 25 Urea	70 Urea	30 UAN	80	12	0
7	P18 MAPSZC	90 MAPSZC, 50 Urea	70 Urea	30 UAN	80	18	0
8	P18 Vigour	150 Vigour, 40 Urea	70 Urea	30 UAN	80	18	18
9	P18 AllRich	210 AllRich	70 Urea	30 UAN	80	18	0
10	P11 Paddock	25 MAP, 25 MAP.TE, 25 MOP, 60 Urea	70 Urea	30 UAN	80	11	13

RESULTS

An in-season biomass assessment was conducted on the 14/08/2020 by measuring normalised difference vegetation Index (NDVI) using a handheld Greenseeker®. With these biomass readings a biomass heatmap was created (Figure 2). It is apparent that the eastern end of the trial had more plant growth than the western end, regardless of treatment. This is largely due to variation in the soil type across the trial, which ranges from a recently reefinated gravel area with a brief cropping history at the western end to a sandy loam in the mid-to-eastern area. There are also differences in topography and gravel content across the site, which influences soil depth, hydrology, texture, strength, material, and phosphorus binding.

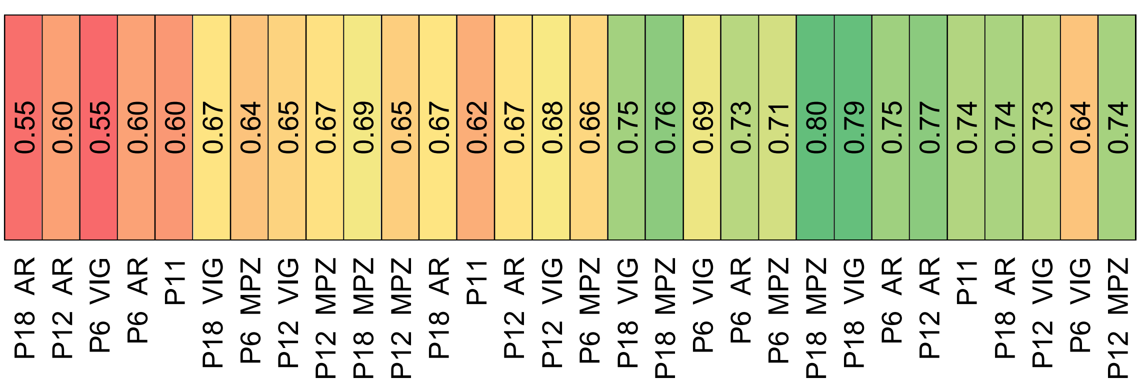


Figure 2. *Trial layout and individual plot biomass recorded by a handheld Greenseeker® on the 14/08/2020. Red to green indicates biomass ranking from low to high. Data is presented as the mean of 12 readings per plot.*

While mean NDVI readings show some increases in biomass with increasing P rates, the differences were not significant (p=0.29) (Figure 3). There were also no significant differences in the biomass between the products (p=0.72). The highest mean plant biomass of 0.75 came from MAPSZC applied at 18kg P/ha, while the lowest reading of 0.63 came from Vigour applied at 6kg P/ha.

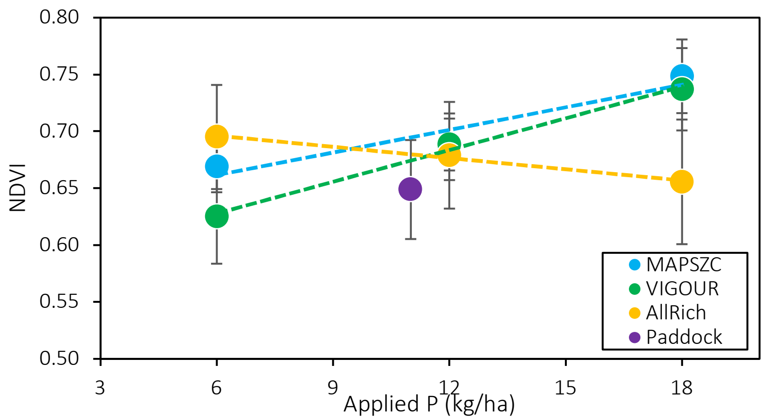


Figure 3. *Whole shoot biomass assessment on the 14/08/2020. A higher NDVI value indicates greater plant density and vigour. Data is presented as the mean of three replicates.*

With 3-metre pixel resolution satellite NDVI sensor data from Data Farming, biomass readings were collated from the 14/08/2020 (Figure 4). Overall, these readings gave higher readings than the ground readings and some subtle differences can be observed, for example there was less variation across the trial. Again, no significant differences between P rates (p=0.81) or products (p=0.64) were observed from this data. However, trends shown from the satellite biomass heatmap resemble the trends observed in the ground readings, with more growth towards the eastern side of the trial.

0.66	0.68	0.68	0.71	0.71	0.74	0.73	0.75	0.75	0.76	0.76	0.76	0.75	0.77	0.78	0.78	0.81	0.81	0.80	0.80	0.80	0.82	0.82	0.81	0.81	0.80	0.80	0.79	0.76	0.76
P18 AR	P12 AR	P6 VIG	P6 AR	P11	P18 VIG	P6 MPZ	P12 VIG	P12 MPZ	P18 MPZ	P12 MPZ	P18 AR	P11	P12 AR	P12 VIG	P6 MPZ	P18 VIG	P18 MPZ	P6 VIG	P6 AR	P6 MPZ	P18 MPZ	P18 VIG	P6 AR	P12 AR	P11	P18 AR	P12 VIG	P6 VIG	P12 MPZ

Figure 4. *High resolution satellite NDVI readings taken on the 14/08/2020 from Data Farming satellite imagery.*

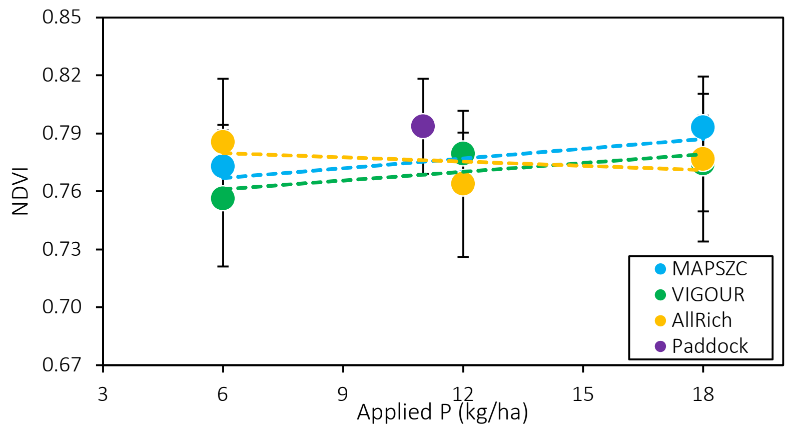


Figure 5. *NDVI readings taken from Data Farming's satellite imagery on the 14/08/2020. No observable trends are shown.*

HARVEST RESULTS

The average yield across the trial was 2.91t/ha (Figure 5). The highest yield was 3.06t/ha when 18kg P/ha was applied as Vigour, and the lowest was 2.73t/ha when 6kg P/ha was applied as AllRich. Yield significantly increased with increasing rates of P ($p<0.01$). When P was applied as MAPSZC and AllRich, yield increased from 6 to 12kg P/ha, and when P was applied as Vigour yield increased from 6 to 18kg P/ha. For each P rate, yields were higher when P was applied as Vigour, followed by MAPSZC then AllRich. However, differences in yields between the products was not significant ($p=0.58$).

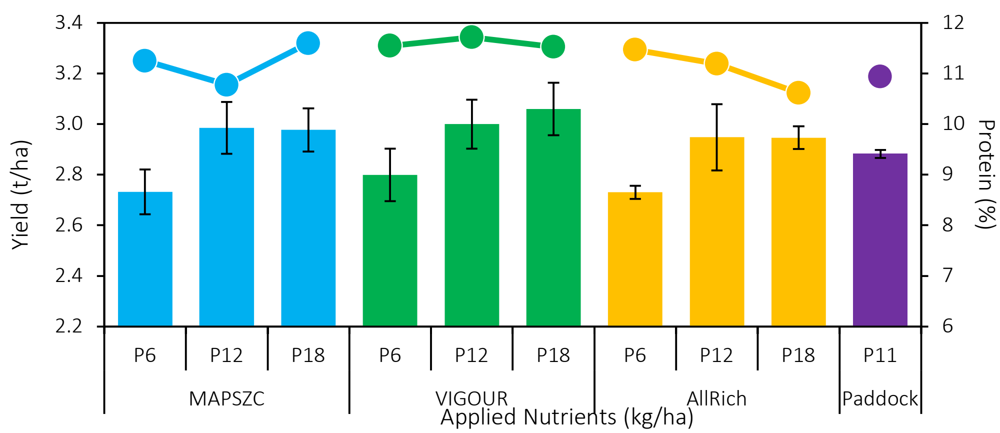


Figure 5. *Harvest yield (bars) and grain protein (lines) presented as the mean across four replicates. Yield increases with applied P in all products.*

There was a moderate correlation between yield and biomass readings taken on the 14/08/2020 with the handheld Greenseeker® (Figure 6). These biomass readings proved to be reasonable predictors of yield, with higher biomass readings generally equating to higher yields, despite not much variation between NDVI values. There was no correlation between yield and biomass readings from Data Farming's satellite imagery from the same day, which is not surprising given the lack of variation between biomass readings from this source.

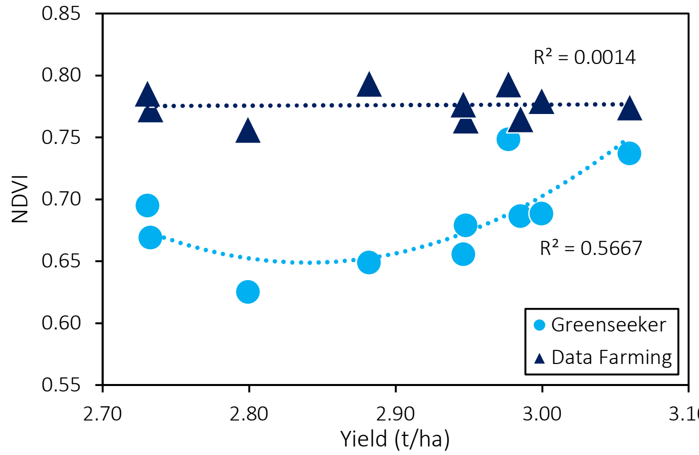


Figure 6. *The relationship between in-season biomass readings and harvest yields. Biomass readings from the handheld Greenseeker® show a moderate correlation with yield, while biomass readings from Data Farming's satellite imagery show no correlation.*

All hectolitre weights were greater than 74kg/hL, and low screenings across the trial meant grain protein determined grading across the trial. All treatments had a protein between 10.6-11.7%. Four treatments, three of which were Vigour treatments, had a protein levels greater than 11.5% and were graded H2 (Figure 6). All other treatments were graded APW1. Applying 12kg P/ha as MAPSZC was the most profitable treatment, returning $805/ha. Across all products returns were maximised at 12kg P/ha, as yields were either greatest at this rate or increases in yield beyond this rate were not large enough to justify extra fertilizer expenses. At 12kg P/ha, MAPSZC had a higher return than Vigour which had a higher return than AllRich. Gross margin data from this trial suggest a high analysis product has the potential for greater returns.

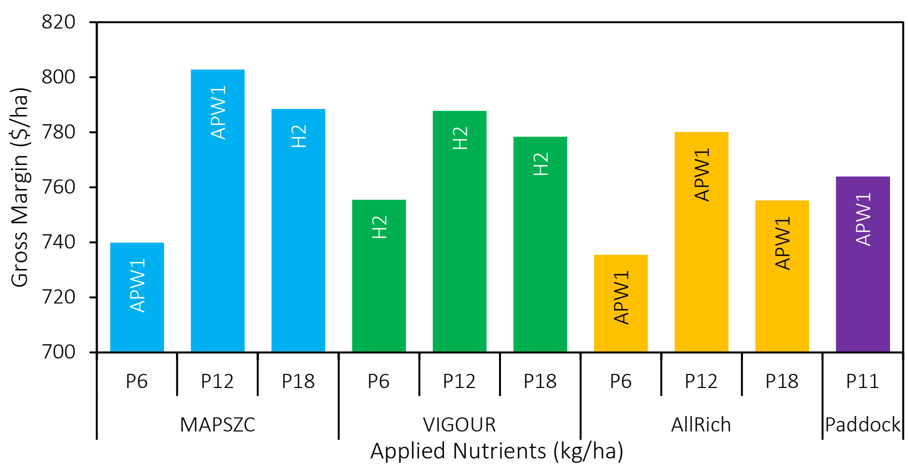


Figure 6. *Individual gross margins across the trial. Returns were greatest when 12kg P/ha was applied for each product.*

Table 3. *Summary table*

Treatment	Fertilizer Cost ($/ha)	Yield (t/ha)	Protein (%)	Hectolitre Weight (kg/hL)	Screenings below 2.5mm (%)	Grade	Grain Value ($/ha)	Gross Margin ($/ha)
P6 MAPSZC	130	2.73	11.3	76.1	2.4	APW1	870	740

P6 Vigour	140	2.80	11.5	74.7	2.7	H2	895	755
P6 AllRich	135	2.73	11.5	76.1	2.7	APW1	870	735
P12 MAPSZC	145	2.99	10.8	76.0	2.6	APW1	950	805
P12 Vigour	170	3.00	11.7	75.1	3.2	H2	960	790
P12 AllRich	155	2.95	11.2	76.4	2.5	APW1	935	780
P18 MAPSZC	165	2.98	11.6	75.8	3.0	H2	955	790
P18 Vigour	200	3.06	11.5	75.7	3.0	H2	980	780
P18 AllRich	180	2.95	10.6	76.4	2.4	APW1	935	755
P11 Paddock	155	2.88	10.9	76.0	2.6	APW1	915	765

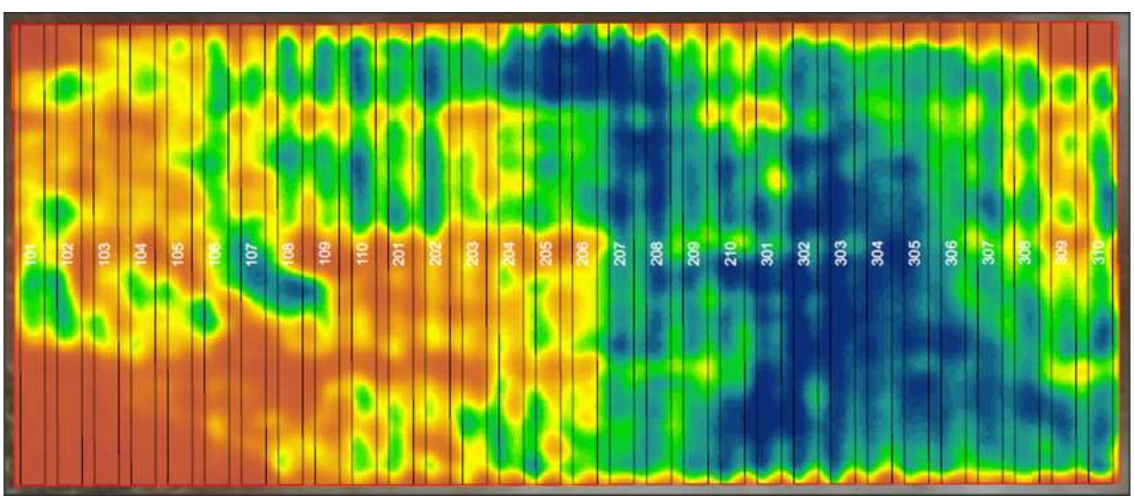
Gross margin is a simple representation of grain value minus cost of fertilizer input. Fertilizer cost based on April 2020 retail list pricing ex Kwinana and grain value based on prices at 26/11/2020

CONCLUSIONS

- Yornaning experienced a decile 2 growing season rainfall in 2020.
- Plant growth was not significantly affected by increasing P rates, but appeared to be primarily influenced by the variation in soil-type across the trial.
- Increasing P rates resulted in significant increases in yield, with yields ranging between 2.73t/ha – 3.06t/ha
- Under 2020 conditions, the most profitable treatment was when 12kg P/ha was applied as MAPSZC, with returns of $805/ha.
- The low-analysis product used in this trial, AllRich, yielded less than the higher analysis products MAPSZC and Vigour and had lower gross margins, however the yield differences between products were not significant.

ACKNOWLEDGMENTS

Thank you to Scott Young for generously hosting the trial site, seeding and ongoing maintenance work. Thank you to Living Farm for harvest and grain quality analysis.



Appendix 1. *Satellite Imagery from Data Farming*