Precision Agriculture AUSTRALIA

Precision Ag Trials

Phosphorous rate trial

Kybunga, SA

Although PA tools have been available to Australian grain growers for many years, and the benefits have been well documented, it is estimated that less than 1-% of grain growers utilise PA 'beyond guidance' in any form.

The objective of this GRDC / SPAA funded project is to increase the level of adoption of PA 'beyond guidance' by broadacre farmers. The project specifically aims to increase the level of adoption of variable rate (VR) by growers in the project to 30% by 2013. This goal will be achieved by demonstrating how to use PA tools to growers at a regional level and by increasing the skills of growers and industry in PA to a level where they can then use PA tools in their farming systems to achieve economic, environmental and social benefits.

Trials and demonstrations are conducted on growers' properties and are visited throughout the season using farm walks and workshops to discuss the advantages and disadvantages of PA techniques with the involvement of other regional growers.

This information sheet presents the outcomes of the SPAA trial **on phosphorous (P) rates across zones in a paddock at Kybunga** from season 2010.

Aims:

- To compare the effects of P rates on barley yields across production zones.
- To assess the effects of P rates on plant and grain P concentrations.

Background:

Phosphorus (P) fertiliser is a significant cost in the annual farm budget. Therefore it is important that P fertiliser is used efficiently and not wasted. This area in the Mid North has a long history of cropping and with it a long history of fertiliser application. Up until recently the fertiliser has been applied uniformly, regardless of variability in soil type and yield potential of different paddock zones. This often results in variable levels of soil available P as variable crop yields mean that the removal of P from the paddock is also variable. So, areas of consistently lower yields tend to build up P as less is removed and areas of higher yields tend to have lower P levels as more is removed. Variable rate applications of fertiliser provide an opportunity to match the fertiliser input to crop requirement in each part of the paddock. This trial aimed to establish what the variability in soil P is across the trial paddock and investigate what impact that has on the responsiveness of the crop to P fertiliser.

About the trial:

The trial paddock is 200ha and is located approximately 3km west of Kybunga, in the Mid North of SA, where it receives an average annual rainfall of 400mm. The soils in the paddock range from sandy dunes to heavier loamy swales, with some areas of shallow rock with grey calcareous soils. The Google Earth image shows that in the past the sand hills have been farmed separately in some years with a different crop (Figure 1a & b), this being a simple form of site specific management.

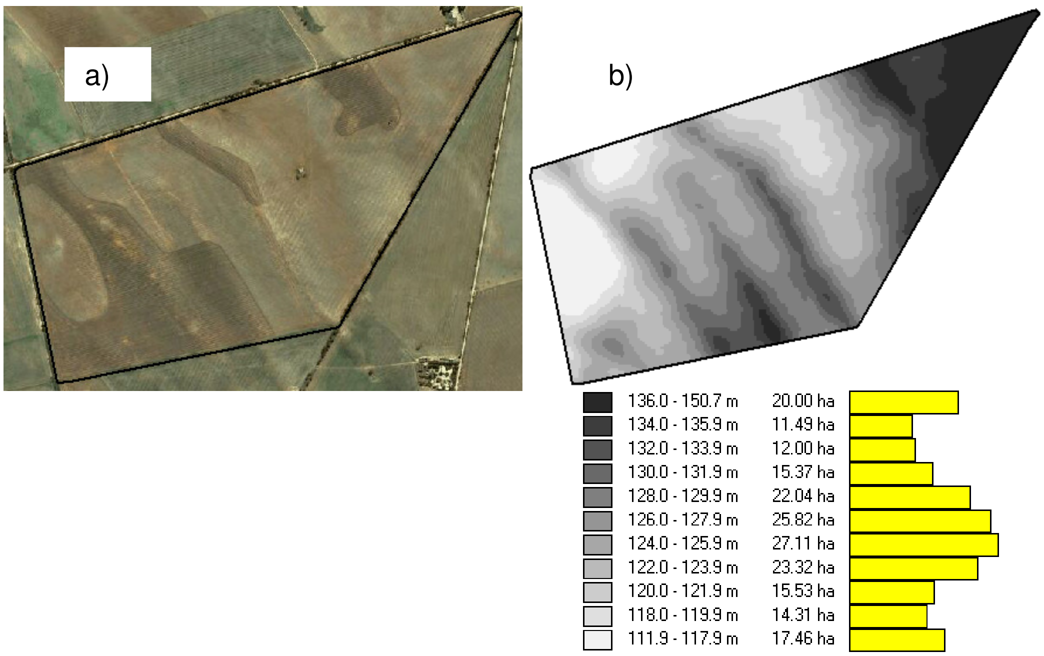

Figure 1 a) Google Earth image of the paddock, different crop types have been grown on the flats and sand hills the year this image was collected, b) elevation.

The paddock was zoned into three zones using K-means clustering of three historical yield maps from 2006 (wheat, Figure 2a), 2007 (barley, Figure 2b) and 2008 (canola, Figure 2c). These three seasons were dryer years and the resultant zone map depicts the soil types quite well according to the growers' knowledge. The paddock was soil tested with samples targeted within each zone (Figure 2e). Historical Landsat imagery was also compiled from images captured in the growing seasons of 2004, 2005, 2006, 2007 and 2009 (Figure 2f). The 2009 wheat yield map shows opposite trends to those from the earlier years, with higher yields on some of the heavier loam soil types (Figure 2d), this can be related to the wetter growing conditions experienced in 2009. The 2009 yield map has the best correlation with the Landsat compilation. It is expected that the higher growth areas depicted in the Landsat image (Figure 2f) have yielded more in 2009 as they had the moisture resources to convert growth into grain in that season. However, in the dryer seasons the areas of greater growth are more likely to have run out of moisture and subsequently yielded less in a dry year.

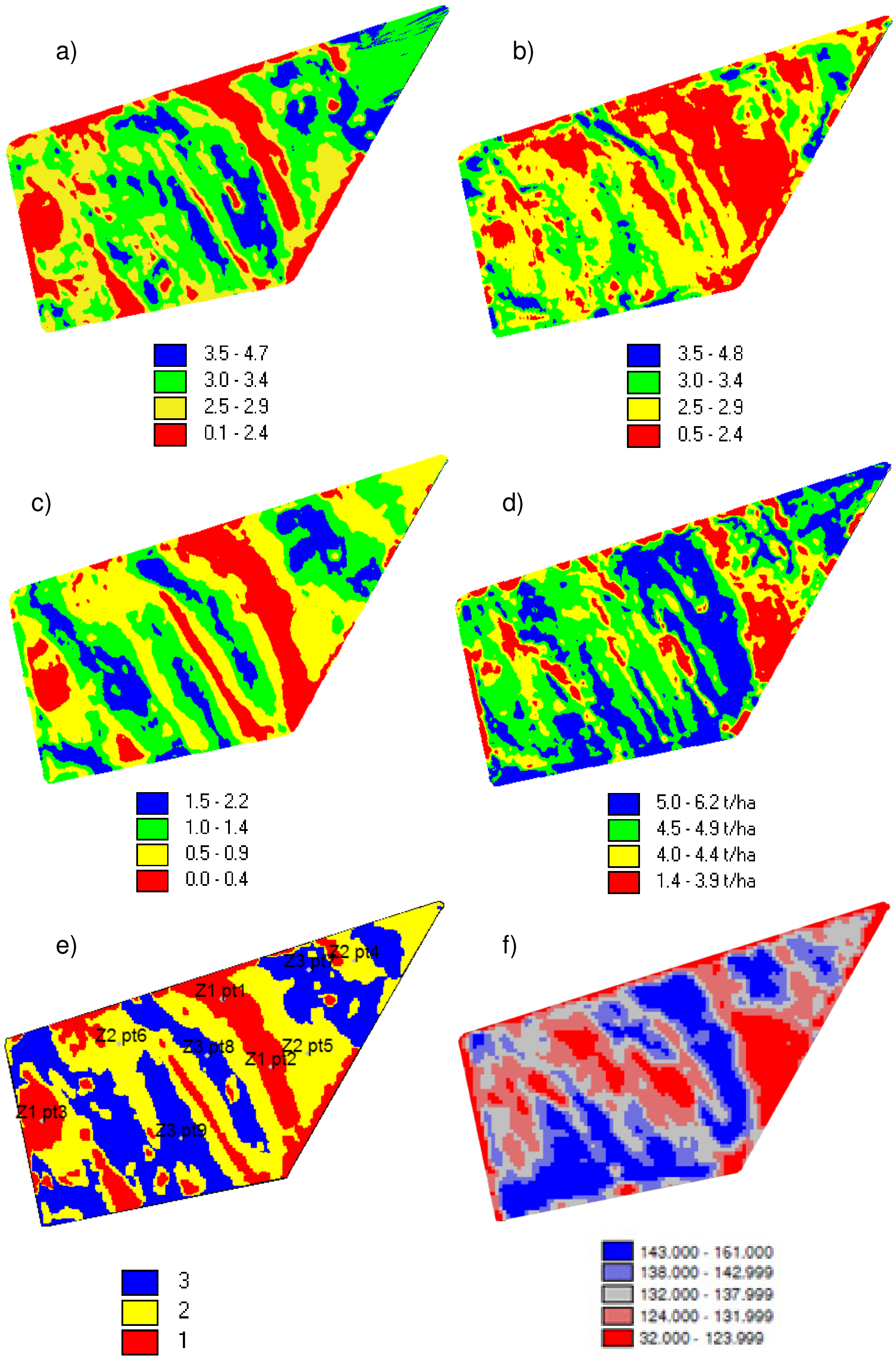

Figure 2 a) wheat yield map 2006, b) barley yield map 2007, c) canola yield map 2008, d) wheat yield map 2009, e) zone map generated from yield maps from 2006, 2007 and 2008 showing soil test locations, f) Landsat imagery compilation from seasons 2004, 2005, 2006, 2007 and 2009. Higher values indicate greater crop growth.

The paddock was sown with Fleet barley on June 10th 2010. The seeding equipment consists of a triple bin 3450 Flexicoil box, an 18m Flexicoil ST820 bar and a John Deere 9400 tractor in front. The bar is fitted with 16mm Agmaster knife points on 225mm spacing with Agmaster spring boots and sharman press wheels. Variable rate applications are controlled with a Topcon X20, plugged into the Flexicoil controller via its diagnostics plug. GPS input is supplied to the X20 from the autosteer system. This was originally a BeeLine system, but has since been replaced with a John Deere Greenstar system.

The three bin seeder was setup with seed, MAP and urea. Seed and urea were varied according to zone (Table 1).

Table 1: Seed and urea rates applied in each paddock zone.

Zone	Seed Rate (kg/ha)	Urea Rate (kg/ha)
Zone 1 - Loam	60	30
Zone 2 - Mid	70	50
Zone 3 - Sand	75	65

The MAP fertiliser that had been budgeted for the paddock was redistributed according to the previous year's yield in 2009 with rates ranging from 40 to 70 kg MAP/ha (Figure 3). However, five adjacent constant rate strips were applied across the zones with rates of 0, 30 and 60 kg MAP/ha for the trial.

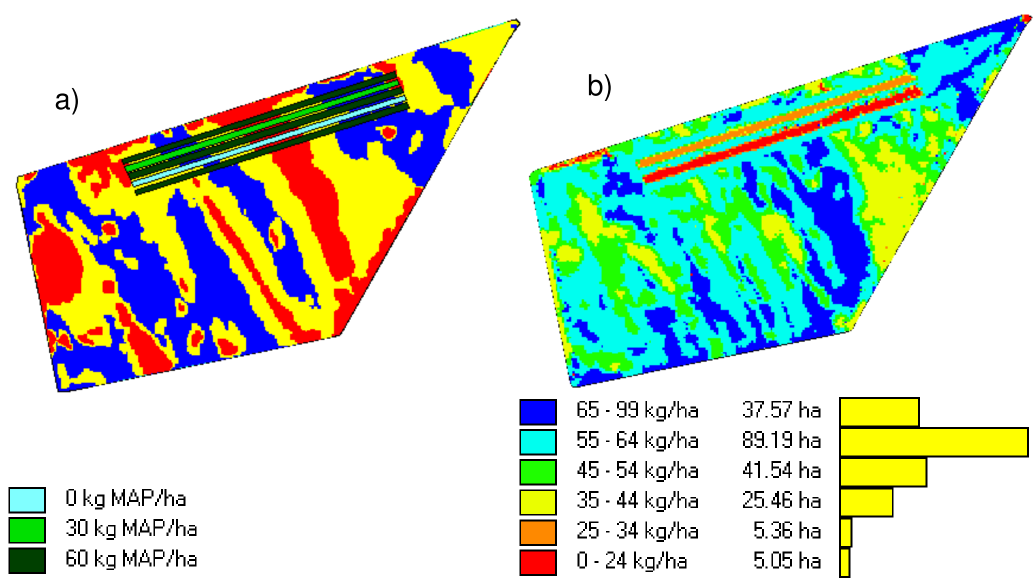

Figure 3 a) trial strip location with respect to zones, b) as applied map recorded on the Topcon X20 of the rates of MAP that were applied according to trial design and previous years yield.

Assessments:

Soil tests
Leaf nutrient analysis
Grain nutrient analysis
Grain yield

Results:

Two different methods of P test were used on the soil samples. One was the Colwell method and the other diffuse gradients in thin films (DGT), a new method developed at the University of Adelaide. The DGT method is able to better simulate what P the plant roots have access to. The results (Table 2) indicate that zone 2 has less available P. Despite zone 2 having the highest Colwell P value, it also has the highest phosphorous buffering index (PBI) indicating lower availability of that P, and this is reflected with a lower DGT value as well. The critical DGT value to attain 90% of the potential grain yield is 57 micro g/L, values below this indicate that a significant grain yield response is predicted. With a DGT value of 47 micro g/L in zone 2 it was predicted that this zone would only reach 82% of the potential yield if no additional fertiliser was applied. Zone 1 and 3 both had sufficient soil P according to the DGT, while the Colwell P and PBI method is not predicting a yield response in any zone.

Table 2: soil P test results from zones and predicted grain yield response. The critical DGT value to attain 90% yield potential is 57 micro g/L.

Location	Colwell P (mg/kg)	PBI	Critical Colwell P	DGT (micro g/L)	DGT Grain yield predictio	Response prediction	
						Colwell P with PBI	DGT
Zone 1 - Flat	41	51	21	126	99	No	No
Zone 2 - Mid	42	98	28	47	82	No	Yes
Zone 3 - Sand Hill	34	19	14	178	100	No	No

Leaf nutrient analysis of P didn't show any clear response to increasing P rates within each zone (Table 3). However, they did show significant differences between zones that follow the same trend as the DGT soil tests, where zone 2 has the lowest concentration of P in the plant and zone 3 (sand hill) has the highest. For the majority of the other nutrients including Iron (Fe), Manganese (Mn), Boron (B), Copper (Cu) and Sulphur (S) the leaf nutrient analysis shows that nutrient concentration grades from highest on the flat and lowest on the sand hill. This is expected given the lower clay and organic matter content of the sand and its poorer ability to store nutrients. Despite this, none of the other nutrients were below the critical level for deficiency.

Table 3: leaf nutrient analysis results from treatment strips within zones collected at the 5-6 leaf stage (Zadoks 15-16, 22-24). Elements tested are Iron (Fe), Manganese (Mn), Boron (B), Copper (Cu), Zinc (Zn), Calcium (Ca), Magnesium (Mg), Potassium (K), Phosphorous (P) and Sulphur (S).

Leaf Nutrient Analysis												
Location	MAP (kg/ha)	Growth Stage	Fe mg/kg	Mn mg/kg	B mg/kg	Cu mg/kg	Zn mg/kg	Ca mg/kg	Mg mg/kg	K mg/kg	P mg/kg	S mg/kg
Zone 1 - Flat	0	6 leaf	134	47	6.2	14	30	5500	1660	30000	3400	4900
Zone 1 - Flat	30		122	39	9.9	14	23	4600	1880	31000	4000	4600
Zone 1 - Flat	60		106	46	7.7	14	25	5200	1740	29000	3600	4700
Zone 2 - Mid	0	6 leaf	90	32	5.9	12	27	5100	2100	27000	2900	4100
Zone 2 - Mid	30		87	32	5.8	12	30	5500	2000	24000	2600	3900
Zone 2 - Mid	60		87	34	7.0	11	26	5600	1890	27000	3100	4100
Zone 3 - Sand Hill	0	5 leaf	74	31	4.4	7.4	24	6700	1650	39000	3700	3100
Zone 3 - Sand Hill	30		81	39	4.3	7.6	26	7300	1570	42000	3900	2900
Zone 3 - Sand Hill	60		74	32	4.2	7.6	23	6400	1570	39000	3900	3200
Zone 1 - Flat	Average of zone		121	44	8	14	26	5100	1760	30000	3667	4733
Zone 2 - Mid			88	33	6	12	28	5400	1997	26000	2867	4033
Zone 3 - Sand Hill			76	34	4	8	24	6800	1597	40000	3833	3067
Critical nutrient levels at 5 leaf stage												
Deficiency			25	20		3.0	20	2000	1200	25000	3700*	3000
Toxicity					40.0							

* Critical P concentration 3000 mg/kg at 6 leaf stage

Grain nutrient analysis showed a similar trend to the leaf nutrients and soil tests, with zone 2 having the lowest grain P levels, while zone 1 (flat) had the highest (Table 4). The rate response within zones is not strong, although in each zone the treatment of 0 MAP has the lowest grain P levels. The concentration of other nutrients does not follow the same trends as leaf nutrient with respect to zones, with Manganese (Mn) showing the strongest trend with higher concentrations in the sample from zone 1 (flat) and lowest from zone 3 (sand hill).

Table 4: grain nutrient analysis results from treatment strips within zones collected at maturity. Elements tested are Iron (Fe), Manganese (Mn), Boron (B), Copper (Cu), Zinc (Zn), Calcium (Ca), Magnesium (Mg), Potassium (K), Phosphorous (P) and Sulphur (S).

Grain Nutrient Analysis											
Location	MAP (kg/ha)	Fe mg/kg	Mn mg/kg	B mg/kg	Cu mg/kg	Zn mg/kg	Ca mg/kg	Mg mg/kg	K mg/kg	P mg/kg	S mg/kg
Zone 1 - Flat	0	24	17	1.6	4.1	15	470	1110	4400	3000	1030
Zone 1 - Flat	30	23	15	1.5	3.5	12	440	1130	4800	3300	1000
Zone 1 - Flat	60	24	17	1.6	3.7	13	460	1120	4700	3300	1020
Zone 2 - Mid	0	19	14	1.7	3.9	16	380	1080	4200	2300	1040
Zone 2 - Mid	30	21	13	1.5	3.4	14	420	1100	4200	2700	1040
Zone 2 - Mid	60	21	14	1.7	4.1	16	390	1110	4300	2400	1060
Zone 3 - Sand Hill	0	21	10	1.7	3.1	12	460	1140	4500	2500	960
Zone 3 - Sand Hill	30	24	13	1.6	3.7	11	440	1120	4300	2500	1030
Zone 3 - Sand Hill	60	23	12	1.3	3.0	11	460	1120	4500	2700	970
Zone 1 - Flat	Average of zone	24	16	1.6	3.7	13	457	1120	4633	3200	1017
Zone 2 - Mid		20	14	1.6	3.8	15	397	1097	4233	2467	1047
Zone 3 - Sand Hill		23	12	1.5	3.3	11	453	1127	4433	2567	987

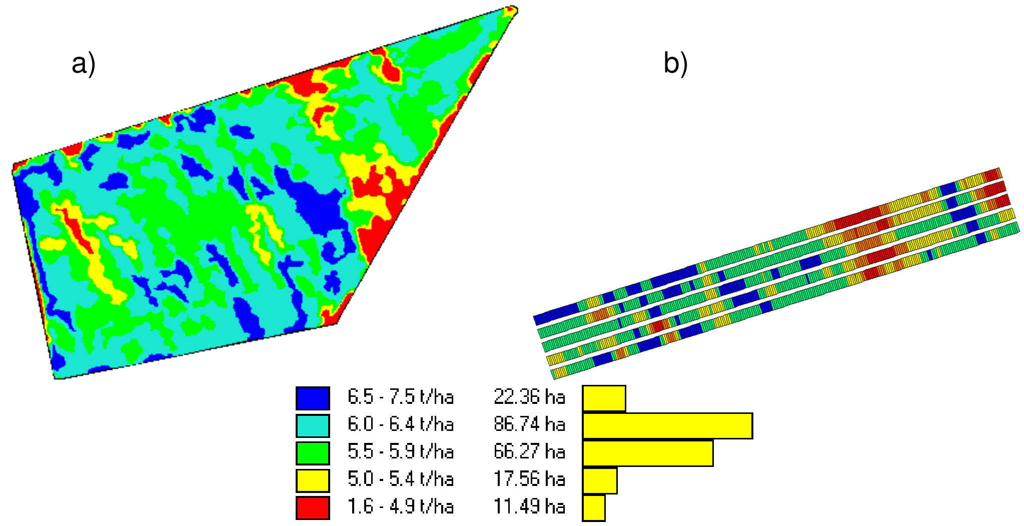

Figure 4 a) barley yield map for 2010, b) yield data for trial strips in 5m segments.

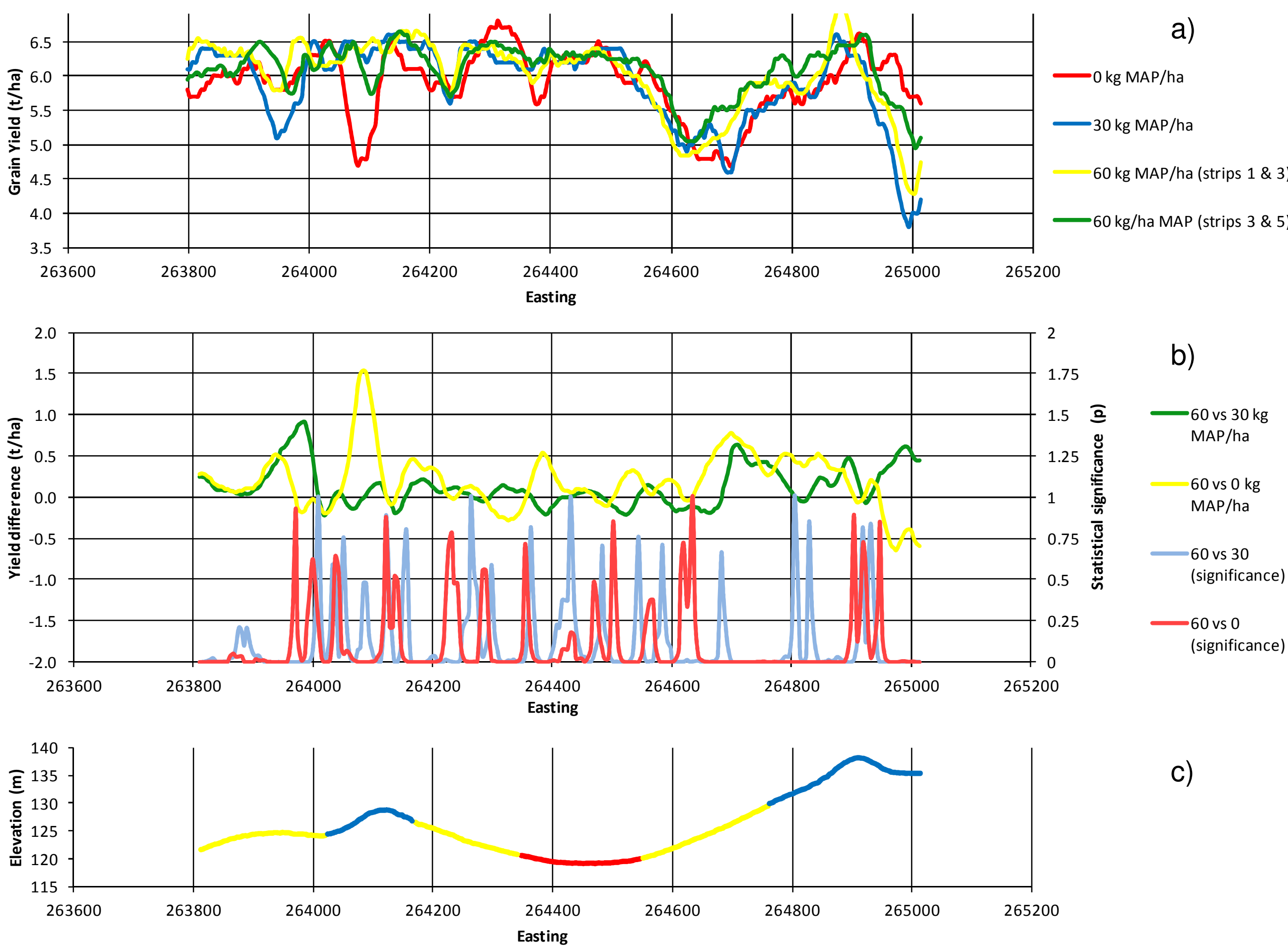

Figure 5 a) grain yield recorded from individual treatment strips, b) the difference in grain yield between 60 kg MAP/ha and the adjacent treatment of 30 and 0 kg MAP/ha and the statistical significance of those differences. *P* < 0.05 indicates a statistically significant yield difference, c) the elevation along the trial strips and associated zone.

Yield differences between the trial strips are not significant except for 250 metres between easting 264650 and 264900 (Figure 4 & 5). In this region the treatment of 60 kg MAP/ha yields 0.5 t/ha more than the 30 and 0 kg MAP/ha treatments. This region is part of zone 2 and also zone 3. Zone 2 also had low DGT soil test values and low leaf and grain nutrient levels, so the results are consistent. However in zone 3 a yield response was not expected based on the other soil and plant measurements. However, the same yield response is not observed along the treatment strips in zone 2 or 3. There is an additional soil type that is not represented in the zone map. It is a grey calcareous soil type (Figure 6), and pockets of this soil type have influenced the soil and leaf nutrient tests, particularly in zone 2, and are responsible for this yield response. This soil type should be split to create a fourth zone, as it is more responsive to phosphorous. This explains the different P response along the treatment strips. The fourth zone that contains the grey calcareous soil type is also obvious in the Landsat compilation (Figure 2f), where the lower growth may be a result of the lower P status and also in the yield maps from 2009 (Figure 2d) and 2010 (Figure 4a). It may be more obvious in those wetter seasons with higher yield potential as crop nutrition, rather than soil moisture is the yield limiting factor.

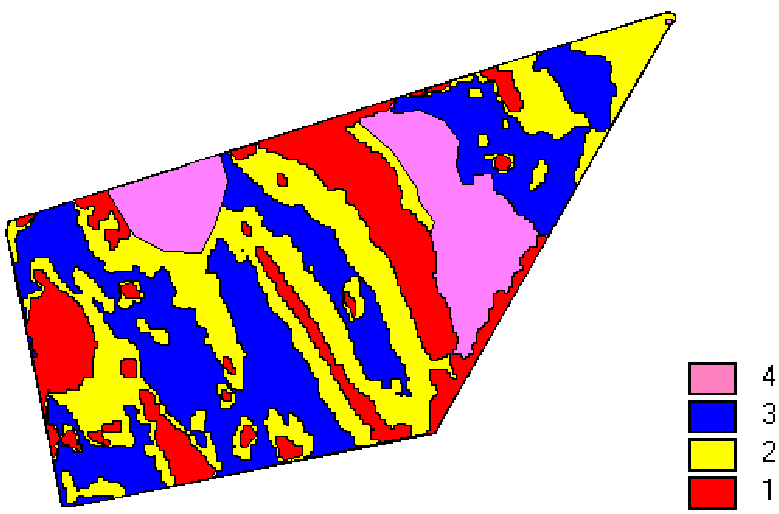

Figure 6: Redrawn zone map depicting the location of the grey calcareous soil type relative to the other zones.

This trial shows that there are P responsive soils in this paddock, where P rates should not be cut too severely. However, the trial also indicates that on large areas (85%) of the paddock P rates could be cut significantly with no loss of yield in the short term. However, this will lead to a decline in P reserves and yield losses would be expected in future years, how many years this would take is not clear. Soil test and leaf nutrient tests were useful in predicting the yield response and will be useful in future monitoring of zones. In this paddock, cutting rates from 60 kg MAP/ha to zero on the 170 ha that are not responsive would equate to a saving of $7,140 in 1 year with MAP at $700/t, while maintaining adequate fertiliser rates on the responsive soils. Rather than cutting rates too severely, the grower will use a maintenance program to keep P levels adequate, but target more P at the responsive areas to build them up. This scenario is relevant for the western half of the property.

Who was involved?

Kenton and Tracey Angel hosted the trial.
Leighton Wilksch (Landmark) supplied compiled historical LandSAT data.
Sean Mason (University of Adelaide) tested soils for P availability.
Sam Trengove (Trengove Consulting) coordinated the trial and completed the trial analysis.

Grower/Regional feedback:

The grower found the process of applying the trial quite simple, with the trial strips already programmed into the application map the variable rate controller ensured the strips were put in the right spot without any input required from the driver.

In future the grower will pay more attention to the small pockets of calcareous soils on the western half of the property and ensure that rates are not cut below 50-60 kg MAP/ha in those zones. However, the trial reinforced that for the majority of soil types P levels are sufficient such that P rates can be cut with no yield penalty in the short term.

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For more information

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