Phosphorus rates across zones within a paddock at Kybunga

Funded by the GRDC and conducted by Sam Trengove, SPAA Precision Agriculture Australia, 2010

Key findings

- Results from this trial indicate 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.

Why do the trial?

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.

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.

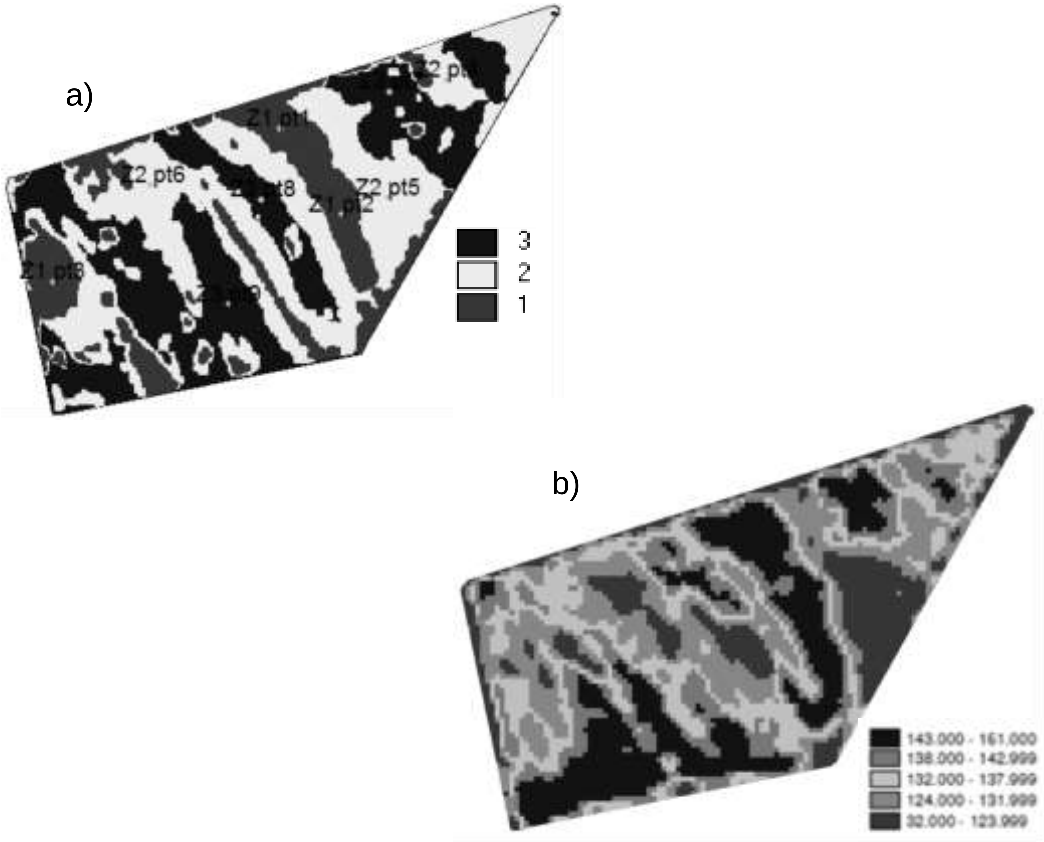
How was it done?

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 paddock was zoned into three zones using K-means clustering of three historical yield maps from 2006 (wheat), 2007 (barley), and 2008 (canola). 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 2a).

Historical Landsat imagery was also compiled from images captured in the growing seasons of 2004, 2005, 2006, 2007 and 2009 (Figure 2b).

a)



b)

Figure 2 a) zone map generated from yield maps from 2006, 2007 and 2008 showing soil test locations, b) 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 was a triple bin 3450 Flexicoil box and 18m Flexicoil ST820 bar. The bar is fitted with 16mm Agmaster knife points on 225mm spacing and with press wheels. Variable rate applications are controlled with a Topcon X20 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.

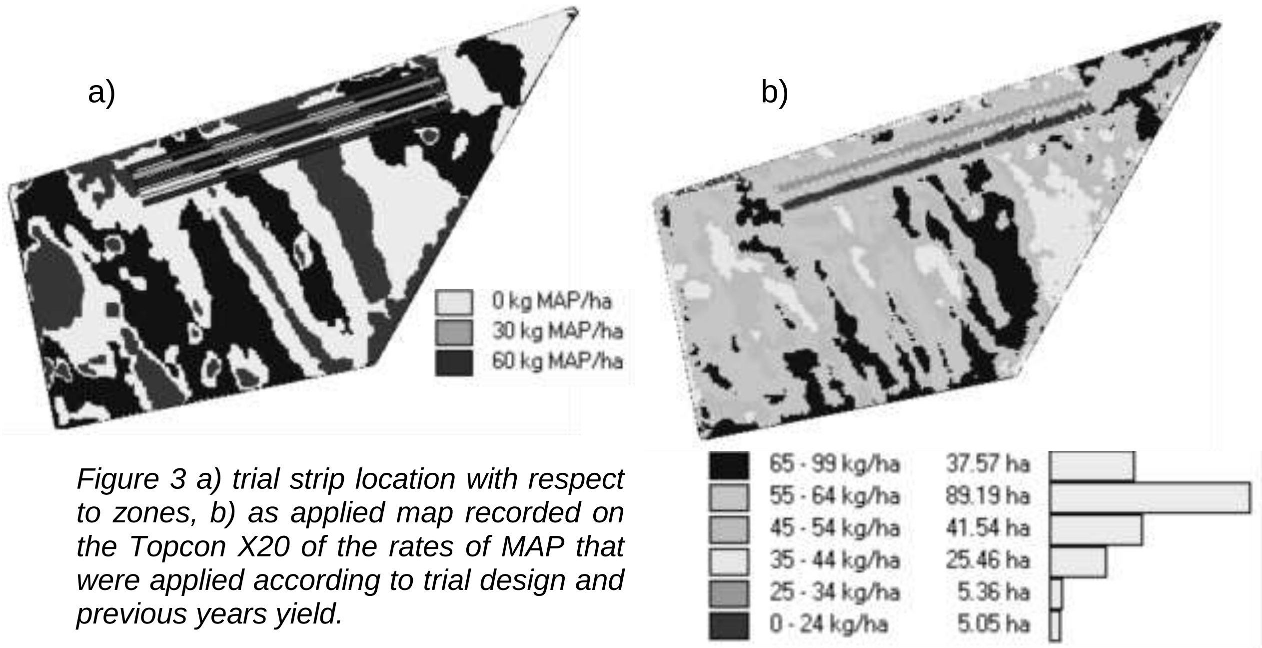


Figure 3 a) trial strip location with respect to zones, b) as applied map recorded on the Topcon X20 of the rates of MAP that were applied according to trial design and previous years yield.

The crop was assessed for leaf and grain nutrients and grain yield.

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 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

Results

The soil test results (Table 2) showed that that zone 2 (mid) had less available phosphorus.

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), phosphorus (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

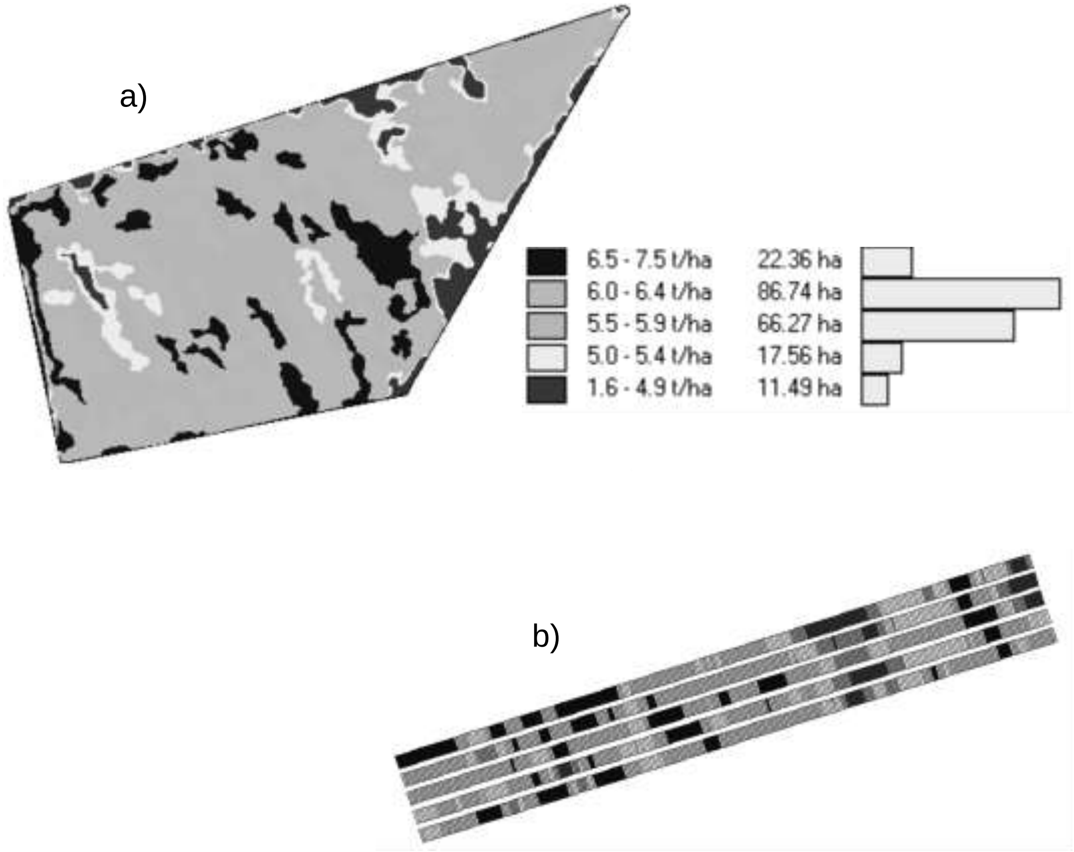


Figure 4: a) barley yield map for 2010,b) yield data for trial strips in 5m segments.

Yield differences between the trial strips were not significant.

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. 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.

Acknowledgements
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