2019

Soil and plant testing for profitable fertiliser use

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Key Messages

- Soil P and N status are highly variable across paddocks. Depending on variability, soil sampling intensity should be increased to sample more than one zone in a paddock.
- Low production zones tended to have lower soil P and higher soil N levels, suggesting that nutrient inputs might require adjustment to improve profitability.
- In 2019 the yield response in the Mallee to P fertiliser was highly variable across the paddock and was closely correlated to soil P status (Colwell with inclusion of PBI interpretation /DGT – proviso, only one paddock had been analysed at the time of writing).

Background

Precision Agriculture for variable rate fertiliser application demands a knowledge of the soil available nutrient variation across a paddock and an understanding of the likely responses to applied nutrients. Soil testing is shifting from surface sampling (0-10cm) to deep sampling (GRDC farm survey 2016) however, farmers and advisers appear to be unsure on how to interpret soil test results to optimise fertiliser returns, especially with variable rate application of fertiliser. In 2016, it was estimated 15% of paddocks were regularly tested, as opposed to 40% in 2008 (GRDC farm survey 2016).
Dry conditions which prevailed in both 2018 and 2019 cropping seasons has resulted in paddocks with very little stubble cover in some areas. Higher than normal severe wind events have caused significant soil movement within paddock and between paddocks. Very little information exists around the result of soil movement and subsequent nutrition profiles. In 2020 the GRDC project targeted paddocks which had experienced wind erosion to enable a better understanding of the nutrient profiles of selected zones potentially newly created for management decisions in 2020.

About the trial

Landmark, Independent consultants and Farming Systems Groups including EPARF are partners in the project to raise understanding and awareness around issues dealing with N and P responses with variable rate fertiliser application, inclusive of undertaking intensive soil testing in different production zones across paddocks. APAL laboratories are undertaking the soil and plant analysis. CSIRO are analysing yield maps, performing the statistical analysis of yields achieved on the P and N rate strips, and reviewing the economic implications of 'informed' P rate applications based on soil testing.

(i) Paddock trials 2019

Over 300 paddock-based trials were established in 2019 in SA and Victoria from close to 700 sampling zones. Production zones in paddocks were defined either by using historical yield maps or the farmers' long-term knowledge of the paddock. For two production zones in each paddock, a 1 ha soil sampling area was selected – the two zones were located in-line with the sowing direction. Sampling intensity for each 1 ha soil sampling area were 36 topsoil samples for available P (0-10cm: Colwell, DGT, PBI) and six deep cores (0-10, 10-30, 30-60, 60-90 cm) for Available N (NO_3 and NH_4) with the samples combined for each depth to generate one soil test value. Chloride was included in the analysis to determine whether sub-soil salinity inhibited yield.

In 150 of the 333 paddocks sampled in 2019, farmers sowed P rate strips across the paddock, ensuring the strips crossed the 1 ha soil sampling grids. Available soil P status and likely fertiliser P response rates were calculated from Colwell and DGT in association with PBI. The rates of P applied were informed by the soil test result and most sown strips included a 0 rate, farmer rate and double the farmer rate of applied P in situations predicted to be P responsive and the inclusion of a half farmer rate for situations predicted to be non-P responsive. The P strips received the same N as applied by the farmer for the rest of the paddock. Tissue samples to check on tissue P status and possible nutrient deficiencies along with dry matter estimates were collected from each fertiliser rate strip between GS16 and 32.

Fertiliser N response

In 2019 several paddocks also had different top-dressed N strips applied to generate N rate trials in paddocks where soil N variability was high, these were applied at the same time as the farmers applied in-crop Urea. As with the P scenario, N trials had rates of N applied as informed by the starting soil N profile and most sown strips included a 0 rate, farmer rate and double the farmer rate of applied N in responsive situations and the inclusion of half farmer rate for non-responsive situations.

Harvest and statistical analysis

Yield monitor data were used to calculate the yield for each P and N fertiliser rate strip. The yield achieved for each fertiliser rate strip within each 1 ha soil sampling area was used to correlate crop yield to soil P and N status. Harvest strip data within each of the two soil sampling zones was analysed for significant difference using a moving average t-test (Lawes and Bramley 2012) enabling the evaluation of nutrient treatment responses between zones and within zones. A partial gross margin analysis will be undertaken to calculate the change in income achieved from the different fertiliser rate strips.

2020 pre-sowing sampling on eroded paddocks

In the Mallee region 18 paddocks had been sampled at the time of writing this report. Sampling targeted mainly three zones of the paddock each had experienced a range of erosion severity, these zones were labelled Sand (Dune), Mid (Mid-slope) and Flat (Swale). A summary of the results are presented below.

Results & Discussion

(i) Soil Nitrogen and Phosphorus status 2019

A brief snapshot of the nutrient status across the Southern region revealed high variability of both N and P between the two production zones in each sampled paddock. There were opportunities identified within each agroecological zone for the establishment of both N and P trials. As an overall summary the N status was generally good and supported at least the production of a 2 t/ha wheat crop, without factoring in immobilisation/mineralisation. In general, the N status was higher (102 vs 79 kg N/ha) for the low production areas which indicates N build up due to lower N removal caused by a soil constraint or low yields in seasons prior.

At a paddock level P deficiency is driven by the ability of different soils to fix/absorb P sources as estimated from the PBI (Phosphorus Buffer Index). Quite often low production zones were associated with low extractable P, high PBI and relatively high soil N due to less utilisation of N sources and subsequent removal. In these circumstances simple replacement fertiliser strategies are unbalanced and are creating a wider gap between yield production zones.

Improved gross margins from more efficient fertiliser applications are expected if different production zones are assessed for the ability of the soil to provide the crop with adequate nutrients.

(ii) Paddock trials 2019

An example of the experimentation is presented for a paddock sown to wheat (Scepter - sowing date 15/5/2019) in the Victorian Mallee.

Soil P results

Soil P results for Colwell and DGT P, and PBI (Phosphorus Buffering Index, see Burkitt et al. 2002) are detailed in Table 1. In Zone 1 both soil tests predicted marginal P while in Zone 2 the DGT P soil test predicted deficient soil P. PBI was relatively high in Zone 2.

Table 1. Mallee paddock - P test result pre-sowing 2019 (Colwell, DGT and PBI) for Zone 1 and 2

P Test	Zone 1	Zone 2
Colwell P (mg/kg)	22	30
DGT P (µg/L)	42	12
PBI	64	135

P rate trial

Four rates of P (as MESZ) were applied at sowing with double seeder width strips across the paddock through each zone (fertiliser applied at 0, 4.4. 8.8 and 17.6 kg P/ha) (all strips had urea at 45 kg/ha, 20.7 kg N/ha, applied at sowing). Urea at 75 kg/ha (34.5 kg N/ha) was top-dressed on the trial area on 28/6/2019.

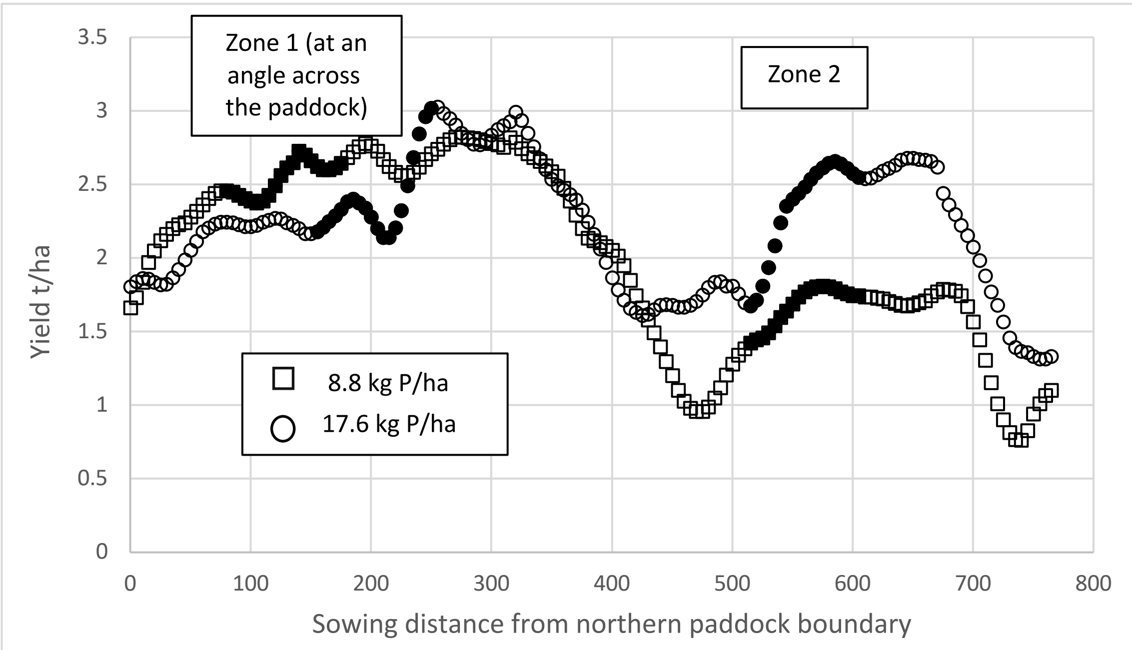

Figure 3. *Strip yield (t/ha) for two rates of fertiliser P applied from paddock boundary to boundary, crossing two soil sampling areas. Solid black circles and squares indicate the yield achieved within the soil sampling areas for Zone 1 and 2.*

Harvest yield map data was used to analyse the yield differences between P treatments in each of the two soil sampling areas (1 ha areas located in two distinct production zones in line of sowing). Statistical analysis was based on the t-test for comparing two strips (example Figure 3).

A significant difference in yield gain was found only in Zone 2 for the high rate of P applied (17.6 kg P/ha) (Table 2).

Table 2. Yield response to four rates of fertiliser P applied at sowing in two zones

	Average yield (t/ha) within production zone		**Ave yield (t/ha) entire strip**
Rate (P kg/ha)	**Zone 1**	**Zone 2**	
0	2.51	1.76[a]	2.16
4.4	2.60	1.76[a]	2.24
8.8	2.59	1.67[a]	2.01
17.6	2.32	**2.34[b]**	**2.22**
Sign. difference	NS	**$P<0.05$**	

Zone 2: [a] and [b] denote significant difference

(iii) Soil Nitrogen and Phosphorus status 2020 – Eroded paddocks

Nitrogen and Phosphorus levels on eroded paddocks sampled in 2020 were as expected with current known trends (Table 3). While there was no specific control of sampling in the same point before and after an erosion event there are no immediate changes to fertiliser strategies between zones that haven't already been established. Sands of dune systems have very low organic carbon (OC) levels but reasonable mineral N levels potentially due to carryover N of failed pulse crops of 2019. Low OC indicates that these systems are heavily reliant on fertiliser N inputs to meet crop N demand in a favourable season. The mid-slope area had very similar results to the dune zone with slightly higher OC levels and associated higher mineral N values. Phosphorus status of these two zones were generally quite good and is an indication that replacement strategies are appropriate. There were some inflated mineral N values for the flat (swale) zone which indicated an accumulation of N due to subsoil constraints (salt and Boron). This provides more evidence of the value of ground truthing different soil zones as there are opportunities to improve fertiliser efficiencies. Other paddocks without constraints had moderate N levels on the swales which provides an opportunity for significant crop N uptake in a favourable year. Phosphorus was highly variable in the swale zone; low P was mostly associated with higher fixation potential of fertiliser inputs as measured by PBI where there is an opportunity to build P reserves. Other swale zones had low to moderate PBI values and good soil P status.

Table 3. Mean nutrition results for 18 paddocks that have experienced soil erosion sampled in three zones represented by Dune, Mid-Slope and Swale. *N yield potential calculated based on requiring 40 kg N/ha per tonne grain/ha. #DGT critical range for wheat is 48-70 ug/L.

Sampling Zone		**OC %**	**Profile Mineral N kg N/ha**	***N yield potential t/ha**	**Colwell P mg/kg**	**PBI**	**#DGT P ug/L**
Sand - Dune	Mean	0.27	69	1.723	19	20	75
	Minimum	0.08	30	0.750	11	13	20
	Maximum	0.34	183	4.575	32	38	153
Mid Slope	Mean	0.44	81	2.021	20	34	77
	Minimum	0.18	37	0.925	11	12	22
	Maximum	0.92	210	5.250	29	93	186
Flat - Swale	Mean	0.70	150	3.746	25	62	79
	Minimum	0.45	67	1.675	11	16	24
	Maximum	1.11	246	6.150	51	112	167

Implications for commercial practice

Soil nutrient status is highly variable across paddocks and these initial results indicate that we need to sample more than one soil type/ production zone in a paddock. Indicative results indicate that intensive soil sampling of different production zones provides significant benefit in terms of P application (results from the N rate application strips had not been analysed at the time of writing).
This research project is ongoing until 2022, so further information and results will be available for paddocks monitored on Eyre Peninsula during the season.

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