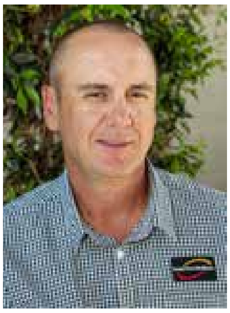
Nutrient replacement after a high yielding season



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This summer I've invested some time collecting grain and soil test data from out in the paddock to investigate nutrient budgeting with real nutrient removal figures, not just averages.

While it's unusual to engage in a full at-harvest sampling regime that includes grain sampling, actual yield by management zone and soil test results from the same paddock position, that's what I set out to do.

I'm not suggesting that all fertiliser recommendations should be based on this kind of in-depth data. Most of the time, agronomists do the best with the information they have, such as a well-timed shallow soil test, last season's yield and their experience with the grower.

But this was an interesting exercise.

It showed up the high levels of nutrient removal many growers might be facing after harvesting high yielding crops in 2016.

It also showed up the wide-ranging variability that can occur between crops, regions and within paddocks. If you really want to quantify how much phosphorus, sulphur or zinc has been removed from the paddock at harvest, grain sampling and testing is absolutely essential.

Most of all, I think this work highlights the potential to use grain sampling to refine recommendations based on removal, especially for growers interested in variable rate and precision ag systems.

Key messages

1. Average removal numbers mean nothing. The actual variations in nutrient removal in grain are too great to be standardised. If you want to know how much nutrient has been exported at harvest, grain sampling and yield recording are a must at harvest time.
2. Conducting grain sampling and recording yield for individual paddock locations provides additional information to review from the previous season and make better fertiliser recommendations for the coming season.
3. Soil tests are a great start in gathering information on paddocks and management zones within paddocks to make phosphorus and zinc fertiliser decisions. Assess Colwell P and PBI to make better phosphorus decisions.
4. Using the information from soil test data, grain sampling and yield all together allows considered decisions to be made on whether nutrient rates need to be increased, decreased or maintained.
5. There appears to be little correlation between soil test values and grain removal, but there may be some correlation between yield and grain nutrient concentration and applied nutrient rate and grain nutrient concentration.
6. While high yields may depress grain nutrient concentrations, total removal still tends to be higher in high yield seasons.
7. Nutrient removal was certainly significant in some of the high yielding crops sampled in 2016. More starter fertiliser may be needed following high yielding crops.

Back to the start

I have been looking at grain nutrient concentrations for a few years now. Grain sampling is relatively easy and the information adds another level to our understanding of crop nutrition.

The constant factor has been the wide variation in removal. Variations can occur because of crop type, variety, soil test nutrient value, nutrient application rate and importantly yield.

As the yields get higher, there can be a decrease in the concentration of nutrients within the grain due to dilution.

Here are a couple of examples. The first is from a phosphorous trial conducted at Dookie on Young wheat in 2012.

Table 1 – Dookie wheat trial 2012

		Grain Nutrient Removal / ha			Grain Nutrient Removal / t		
Treatment	Yield t/ha (12% moist)	kg P/ha	kg S/ha	g Zn/ha	kg p/t	kg S/t	g ZN/t
Control	4.7	9.6	6.4	128.8	2.25	1.53	30.5
MAP 4kgP/ha	5.46	11.2	7.3	125.5	2.28	1.5	25.8
MAP 8kgP/ha	5.92	11.9	7.8	117.7	2.25	1.48	22.8
MAP 16kgP/ha	6.31	11.3	8	103.7	2	1.43	18.5
MAP 24kgP/ha	6.6	12.4	7.9	105.9	2.1	1.35	18
MAP 32kgP/ha	6.86	12.8	8.1	106.8	2.1	1.33	17.5
MAP 40kgP/ha	6.9	14.7	8.6	116.6	2.4	1.4	19
LSD (P=0.05)	0.5	2.4	0.898	23	0.403	0.146	4
Treatment F.Pr	<0.001	0.024	<0.001	0.5178	0.722	0.398	<0.001
CV%	5.5	14.6	8.2	14.5	13.2	7.3	13.7

Note: Starting Colwell P 39 mg/kg and PBI 70.

There was a strong relationship here between increasing phosphorus rate and yield.

The concentration of phosphorus and sulphur in the grain remained relatively constant with increasing yields, so as yields increased, higher total nutrient removal occurred.

However, total zinc removal stayed constant with increasing yields because the concentration of zinc in the grain decreased with increasing yields.

Two years later on the same block it was a different story (see Table 2).

Table 2 – Dookie canola trial 2014

		Grain Nutrient Removal / ha			Grain Nutrient Removal / t		
Treatment	Yield t/ha (8% moist)	kg P/ha	kg S/ha	g Zn/ha	kg p/t	kg S/t	g ZN/t
Control	2.76 b	11.2 c	10.5 b	114.2 c	4.3 d	4.1 a	44.3 a
MAP 8kgP/ha	3 ab	13 bc	11.3 ab	121.9 ac	4.6 cd	4.1 a	43.5 a
MAP 16kgP/ha	3.13 a	14.5 ab	11.7 a	131.4 ab	4.9 bc	4.0 a	44.8 a
MAP 24kgP/ha	3.1 ab	14.6 ab	11.9 a	130.3 ab	5 ab	4.1 a	44.8 a
MAP 32kgP/ha	3.08 ab	15.4 a	11.5 ab	126.9 ac	5.3 ab	4.0 a	44 a
MAP 40kgP/ha	2.92 ab	14.8 ab	11.2 ab	119.6 bc	5.4 a	4.1 a	43.5 a
LSD (P=0.05)	0.358	2.4	1.2	14.8	0.418	0.296	2.6
Treatment F.Pr	0.171	0.012	0.153	0.079	<0.001	0.992	0.889
CV%	8	10.8	7.3	7.9	5.7	4.9	4

The yield responses to phosphorus were flat, but grain phosphorus concentrations increased with increasing fertiliser rates. This increased the total phosphorus removal from those areas.

Sulphur and zinc grain concentrations remained constant, and due to the small variation in yield from this trial, there were only small differences in total nutrient removal.

We can see from these examples that grain nutrient removal is difficult to predict without testing, as every year and every paddock is different.

What was the removal from 2016?

Table 3 – At harvest paddock sampling in the Mallee and Riverine Plains

	Region	Paddock	Crop	Yield t/ha	Protein (oil) %	Colwell P mg/kg	Zinc (DTPA) mg/kg	Residual N KgS/ha	Residual S KgS/ha	Grain Nutrient Removal kgP/ha	Grain Nutrient Removal kg/S/ha	Grain Nutrient Removal gZn/ha	Grain Nutrient Concentration kgP/t	Grain Nutrient Concentration kgs/t	Grain Nutrient Concentration gZn/t
1 paddock	Mallee	Sand	Barley	3.7	9.1	16	0.72	12	13	12.2	3.5	51.8	3.3	0.95	14
		SCL		5.2	9	33	1.3	17	997	16.6	5	67.6	3.2	0.97	13
		Limestone		5.1	8.7	28	0.56	16	61	11.2	4.9	66.3	2.2	0.96	13
2 paddock	Mallee	East 120	Wheat	3.9	11.6	17	1	11	5	7.8	4.8	40.8	2.3	1.4	12
		West 140		3.4	11.8	21	3.2	7	0	8.6	5.1	42.9	2.2	1.3	11
1 paddock	Mallee	Hill	Wheat	5.1	8.8	16	0.47	9	75	11.2	6.1	45.4	2.2	1.2	8.9
		Flat		4.9	8.7	43	0.36	7	294	10.2	5.9	30.3	2.1	1.2	6.2
	Riverine Plains	Murch	Wheat	8	11.9	49	2.3	33	68	14.4	10.4	120	1.8	1.3	15
		Arca	Canola	3.6	20.3	33	3.3	28	45	24.1	10.1	104.4	6.7	2.8	29

To explore nutrient removal further and attempt to gather more insights into factors affecting grain nutrient concentrations, at-harvest sampling was undertaken in the Mallee and Riverine Plains last season.

The sampling was taken in three crops – wheat, barley and canola – on different soil types and in different landscape positions.

The analysis included grain quality and nutrient testing, shallow soil tests and deep soil tests for nitrogen and sulphur, an instant yield reading and stubble nutrient tissue testing.

In the Mallee barley paddock, zinc and sulphur grain concentration and total removal remained relatively stable given some reasonable variations in the soil test data and yield.

Phosphorus grain concentrations varied considerably from 2.2 kgP/t to 3.3 kgP/t with the higher concentration occurring on the lowest yield and also what might be considered a low soil P value of 16 mg/kg.

The higher yielding SCL area (5.2 t/ha) also had a high grain P concentration (3.2 kgP/t) and gave a very high removal figure when multiplied together.

Does that mean that 16.6 kg/ha of phosphorus needs to be applied at sowing?

To maintain the current phosphorus level in the soil, yes it does, but a Colwell P of 33 mg/kg in this region may be considered high so applying a lower rate to allow the soil P value to fall might be appropriate.

Conversely, on the sand area, the recommendation may be to use higher phosphorus rates at sowing than the removal level would suggest, to increase the Colwell P value.

The limestone area of the paddock had an appreciably higher P buffer index (90 versus the very low 19-28 PBIs in the sand and SCL areas) which may explain the lower grain phosphorus concentration, i.e. the soil in this more highly buffered zone held on to more phosphorus.

The two Mallee wheat paddocks had two sample areas within each paddock and they varied considerably.

The “flat” paddock area had a low soil zinc value of 0.36 mg/kg which was also reflected in a low zinc grain concentration of 6.2 gZn/t and total removal of 30.3 gZn/ha. This was 30% lower than the other Mallee wheat paddocks.

The phosphorus and sulphur concentrations across the four wheat areas showed little variation, even though soil Colwell P values and residual deep S values differed.

Dilution of phosphorus and sulphur due to high yields did not play out in these samples, but yield was the key driver for total nutrient removal.

The wheat samples from the Riverine Plains differed from those in the Mallee with a higher grain zinc concentration (a much higher soil test value), similar grain sulphur concentration and significantly lower grain phosphorus concentration, which could have been due to the higher yield (8 t/ha).

Total sulphur and zinc removal was approximately twice as much as in the Mallee. Phosphorus removal was higher, but not by the same factor.

Comparing the data to the Dookie 2012 trial, phosphorus and zinc grain concentrations were considerably lower while sulphur was similar. Grain nutrient removal for phosphorus, sulphur and zinc lined up after taking the yield variations into account.

Comparing the 2016 canola paddock to the 2014 Dookie trial data, there were differences in phosphorus (higher in 2016), sulphur (lower in 2016) and zinc (lower in 2016) grain concentrations.

Total nutrient removal for sulphur and zinc was similar, but phosphorus was significantly higher at 24.1 kgP/ha removed compared with the highest yielding treatment from the 2014 trial of 3.13 t/ha removing 14.5 kgP/ha.