What will it take to restore soil fertility?

Malcolm McCaskill

A series of nutrient trials conducted in high rainfall cropping zones in 2016 is showing high levels of nutrient removal with high yields.

Lead researcher on the project, Dr Malcolm McCaskill, Soil Research Scientist with DEDJTR Victoria, shares a preview of the results with Agronomy Community members and asks: what will it take to restore soil fertility for 2017?

We have seen some eye popping nutrient removals recently in a new joint research project between GRDC, Agriculture Victoria, Southern Farming Systems, the MacKillop Farm Management Group and SARDI.

In some cases, the full replacement of these losses would require over half a tonne per hectare of urea and a quarter of a tonne per hectare of muriate of potash.

The project is examining the responses of wheat and canola to various nutrients and includes an 'all nutrients' and a 'nil nutrients' comparison.

As part of our work, we sent samples of grain and stubble from the all and nil treatments to the Nutrient Advantage laboratory for analysis.

This exercise showed us that nutrient quantities in grain are highly variable.

We believe it is worth collecting grain samples at harvest and arranging nutrient balance analysis. Relying on standard values may lead to over or under fertilisation.

The following information is a selection of the data, showing nutrient replacement budgets for the all and nil treatments.

In estimating nutrient replacement, we have used literature values to estimate the proportion of stubble nutrient lost during burning, but all other values are from field measurements.

Inverleigh, Victoria

This site was highly fertile before sowing. A wheat yield of 9.8 t/ha at 13.6% protein was achieved in the all treatment, compared with 9.6 t/ha at 10.9% protein for the nil treatment.

Nutrient replacement was estimated at 254 kg/ha of nitrogen, 26 kg/ha of phosphorus and 114 kg/ha of potassium for the all treatment.

Due to the site's high soil fertility, it would not be necessary to replace all this nutrient through fertiliser in the following year. Nevertheless, soil mineral nitrogen to a depth of 60 cm declined from 390 kg/ha of nitrogen prior to sowing to 163 kg/ha of nitrogen after harvest on the all treatment and to 109 kg/ha of nitrogen on the nil treatment.

At Inverleigh the wheat trial showed little visual difference between the nil treatment (left) and the all treatment (right) in early November 2016.

Table 1: Nutrient replacement budgets following wheat at Inverleigh, Victoria, 2016

Crop Component	Dry matter (t/ha)	Nutrient (kg/ha)					
		N	P	K	S	Cu	Zn
"All" treatment							
Grain	9.8	203	24	36	13	0.055	0.155
Stubble	10.8	62	5	196	11	0.057	0.039
Replacement if burned		254	26	114	20	0.077	0.171
"Nil" treatment							
Grain	9.6	159	22	33	10	0.098	0.108
Stubble	10.3	37	3	111	6	0.043	0.037
Replacement if burned		189	23	77	14	0.115	0.123

Note: All = 133 kg/ha of N, 50 kg/ha of P, 50 kg/ha of K, 20 kg/ha of S, 1.1 kg/ha Zn and 2 kg/ha of Cu. Nil = 30 kg/ha of N. Wheat grain yield is shown at 12% reference moisture, and stubbles at 100°C drying.

Bool Lagoon, South Australia

The canola trial at Bool Lagoon showed significant (about double) yield responses in the all treatment compared with the nil treatment.

The site was inundated for over four weeks, restricting nutrient uptake. A final nitrogen application was used in the all treatment shortly after the inundation finished.

Replacement nutrients for the all treatment were estimated at 103 kg/ha of nitrogen, 15 kg/ha of phosphorus and 13 kg/ha of sulphur. These nutrients would need to be replaced for the 2017 growing season.

Replacement potassium was not recommended because no potassium responses were observed at the site and the soil showed high levels of available potassium (> 1000 mg/kg).

The canola trial at Bool Lagoon, SA, in late October 2016, showing (from left to right) nil, all potassium, all phosphorus, and all-micronutrients (copper and zinc). The trial showed grain yield responses to nitrogen, phosphorus and sulphur.

Table 2: Nutrient replacement budgets following canola at Bool Lagoon, SA, 2016

Crop Component	Dry matter (t/ha)	Nutrient (kg/ha)					
		N	P	K	S	Cu	Zn
"All" treatment							
Grain	1.9	63	13	17	6	0.219	0.060
Stubble	5.0	49	6	73	11	0.005	0.028
Replacement if burned		103	15	46	13	0.221	0.071
"Nil" treatment							
Grain	1.0	27	6	8	2	0.003	0.022
Stubble	2.2	11	2	32	7	0.002	0.014
Replacement if burned		36	7	21	7	0.004	0.027

Note: All = 251 kg/ha of N, 50 kg/ha of P, 50 kg/ha of K, 20 kg/ha of S, 1.1 kg/ha of Zn and 2 kg/ha of Cu. Nil = 30 kg/ha of N. Canola grain yield is shown at 6% reference moisture, and stubbles at 100°C drying.

Tarrington, Victoria

The all treatment resulted in a high yielding canola crop (5.4 t/ha) on the well-drained site at Tarrington near Hamilton last year. The nil treatment yielded 2.4 t/ha.

We estimated replacement nutrients for the all treatment at 247 kg/ha of nitrogen, 28 kg/ha of phosphorus, 73 kg/ha of potassium and 44 kg/ha of sulphur.

Post-harvest mineral nitrogen samples (0-60 cm) showed soil nitrogen levels had been depleted to 88 kg/ha of nitrogen beneath the all treatment, compared with 380 kg/ha of nitrogen before sowing.

Unless the harvested nutrients are replaced in 2017, crop yields may be similar to the nil treatment of 2016.

Table 3: Nutrient replacement budgets following canola at Tarrington, Victoria, 2016

Crop Component	Dry matter (t/ha)	Nutrient (kg/ha)					
		N	P	K	S	Cu	Zn
"All" treatment							
Grain	5.4	176	26	36	19	0.247	0.174
Stubble	10.8	87	5	92	32	0.005	0.076
Replacement if burned		247	28	73	44	0.249	0.205
"Nil" treatment							
Grain	2.4	78	10	15	8	0.161	0.075
Stubble	7.4	39	2	71	21	0.004	0.027
Replacement if burned		109	11	44	23	0.162	0.086

Note: All = 215 kg/ha of N, 50 kg/ha of P, 50 kg/ha of K, 20 kg/ha of S, 1.1. kg/ha of Zn and 2 kg/ha of Cu. Nil = 30 kg/ha of N. Canola grain yield is shown at 6% reference moisture, and stubbles at 100°C drying.

Rutherglen, Victoria

Prolonged waterlogging followed by rapid drying of the soil during grain fill led to low canola yields, a low harvest index and small grain sizes in the Rutherglen trial.

Large amounts of nitrogen from the all treatment at this site are thought to have been leached or denitrified. Soil testing to a depth of one metre post-harvest showed there was only 29 kg/ha more mineral nitrogen under the all treatment than the nil treatment.

Most of this was in the 60-80 cm layer.

Where there is a risk of nitrogen being leached through the profile, the safest place for nitrogen is in the plant and applied early.

Table 4: Nutrient replacement budgets following wheat at Rutherglen, Victoria, 2016

Crop Component	Dry matter (t/ha)	Nutrient (kg/ha)					
		N	P	K	S	Cu	Zn
"All" treatment							
Grain	0.7	23	3.9	5.3	1.8	0.008	0.017
Stubble	3.1	23.1	2.2	53.4	4.7	0.002	0.027
Replacement if burned		41.9	4.9	26.7	5	0.009	0.028
"Nil" treatment							
Grain	0.2	4.5	1.4	1.5	0.4	0.009	0.004
Stubble	0.7	2.1	0.3	7.7	1.1	0.001	0.003
Replacement if burned		6.2	1.5	4.6	1.1	0.009	0.005

Note: All = 396 kg/ha of N, 50 kg/ha of P, 50 kg/ha of K, 20 kg/ha of S, 1.1 kg/ha of Zn and 2 kg/ha of Cu. Nil = 30 kg/ha of N. Canola grain yield is shown at 6% reference moisture, and stubbles at 100°C drying.

Summary

A focus on restoring fertility will be essential for many growers with high yielding crops in 2016.

Even in low yielding crops, like the Rutherglen site affected by waterlogging, there may have been significant leaching losses depleting mobile nutrients such as nitrogen and sulphur, or nitrogen losses through denitrification.

Across our two wheat trials, nutrient replacement was estimated at 22 kg N/tonne grain, 3 kg P/t and 8 kg K/t. This includes an allowance for nutrient losses during stubble burning.

Across our four canola trials, nutrient replacement was estimated as 42 kg N/t grain, 6 kg P/t and 20 kg K/t.

Nutrient removal rates (kg/t) in our study varied almost two-fold, so grain testing is advisable to understand your balance. If that is not possible, arrange soil testing to quantify nutrient depletion.

Want to know more?

For any additional information, feel free to send me an email at Malcolm.McCaskill@ecodev.vic.gov.au.

Acknowledgements

Funding for this project is from GRDC, Agriculture Victoria and IPNI. The research team includes Amanda Pearce (SARDI, Struan), Aaron Vague (Southern Farming Systems, Inverleigh), Brendan Christy (Agriculture Victoria, Rutherglen), Rob Norton (IPNI, Horsham), and Penny Riffkin (Agriculture Victoria, Hamilton).