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OPTIMISING SOIL NUTRITION

Key points

- Most soils contain reserves of nutrients that would otherwise have to be applied in fertilisers.
- Growers can minimise fertiliser inputs by optimising the use of these nutrient reserves by plants.
- Maximising root abundance and rooting depth means roots can take up nutrients and water in the subsoil.
- Use of soil reserves of nitrogen can be optimised by testing for the different forms of nitrogen and using the results when deciding on application rates for fertilisers.
- Good yield estimates are critical when estimating nitrogen requirements.

Maximising root abundance and rooting depth

One way to optimise plant uptake of nutrient reserves in soil is to maximise root abundance and rooting depth. This means that crop roots can explore more soil and ensures they can follow nutrients and water down the profile. This is especially important for leachable nutrients such as nitrogen and sulfur and nutrients with significant reserves in the subsoil. Root abundance and rooting depth can be increased by maintaining optimum soil pH and minimising soil compaction and plant root diseases.

Soil pH

Nutrient availability is optimised in soils with topsoil pH levels in the optimum range ($\text{pH}_{\text{CaCl}_2}$ 5.5–7.5). Maintaining pH above 4.8 in the subsurface will prevent aluminium toxicity which restricts root growth down the soil profile. Application of agricultural lime is effective in treating soil acidity and maintaining appropriate soil pH (see Soil Acidity and Making Sense of Chemical Indicators fact sheets).

Subsoil compaction

Subsoil compaction can reduce rooting depth of plants by slowing the rate of root penetration. This means roots are unable to access leachable nutrients such as nitrogen. This can result in poor nitrogen use efficiencies and higher rates of soil acidification.

Deep ripping is an effective method of decreasing subsoil compaction. Evidence suggests large areas of WA soils are responsive to deep ripping (table 1). Using deep working points at seeding time can also relieve some of the compaction (see Subsurface Compaction and Controlled Traffic Farming fact sheets).

Plant root diseases

Plant root diseases can severely decrease root exploration and nutrient uptake. In WA, rhizoctonia is thought to be the most significant of all root pathogens. There are few rotational options for controlling rhizoctonia. Cultivation is the most effective method and works by breaking up the fungal hyphae. Seed dressing with Dividend can also suppress the disease (see Rhizoctonia fact sheet). Other pathogens that can significantly decrease root exploration and nutrient uptake in particular districts of Western Australia are Cereal Cyst Nematode and Root Lesion Nematode (see Cereal Cyst Nematode and Root Lesion Nematode fact sheets).

Table 1: *Average increase in wheat grain yield after deep ripping. (Source: Steve Davies DAFWA, Crabtree 1989, Davies et al., 2006, Jarvis, 2000.)*

Soil type	Time period	Average increase in yield t/ha	%
Various, mostly sands	1990–2005	0.48	25
Yellow loamy sands	1981–1989	0.65	37
Duplex with A horizon <30 cm	1982–1986	0.06	4
Duplex with A horizon >30 cm	1982–1986	0.33	22

Optimising nitrogen use efficiency

Nitrogen fertilisers are a significant expense for broadacre farmers so optimising use of fertiliser inputs can reduce this cost. There are four main sources of nitrogen available to crops: stable organic nitrogen, rotational nitrogen, ammonium and nitrate.

To optimise plants' ability to use soil nitrogen, growers should first be aware of how much of each source there is. The best method of measuring these nitrogen sources is soil testing. These results can then be used to determine fertiliser rates with models such as "Select Your Nitrogen" (DAFWA) or NuLogic (CSBP).

Stable organic nitrogen

Stable organic nitrogen is a significant supply of nitrogen to cereal crops during the growing season. Approximately 2% of the stable organic nitrogen in soil is made available to the crop each year. This is greater in years when there is summer rainfall, because rainfall increases the period over which nitrogen is mineralised (table 2). Most nitrogen models estimate the amount of stable organic nitrogen in soil from the amount of total organic carbon in soil.

Rotational nitrogen

Legumes in the rotation can supply significant nitrogen to cereal crops for up to 4 years after they are grown (table 3). Generally the amount of nitrogen fixed by legume crops is proportional to the amount of vegetative growth and the amount of grain removed (i.e. the harvest index). In loam or clay soils, legumes in rotation will have slightly higher levels of available nitrogen due to less leaching than in sand soils. Growers need to take this nitrogen into account when comparing the benefits of a legume in rotation.

Table 2: *The estimated amount and value of nitrogen supplied by stable organic nitrogen in soils with different amounts of total organic carbon in years with and without summer rain (based on the price of urea being $500/t, derived from "Select Your Nitrogen" model DAFWA).*

Total organic carbon (%)	No summer rain		Summer rain	
	kg N/ha	$/ha	kg N/ha	$/ha
0.4	18	20	24	26
0.6	27	29	35	38
0.8	36	39	47	51
1.0	45	49	59	64
1.2	54	59	71	77
1.4	63	68	83	90
1.6	72	78	94	102
1.8	81	88	106	115
2.0	90	98	118	128

Estimating yield potential

Estimating cereal requirements for nitrogen (and other nutrients) requires an effective method of estimating yield potential. For every 1 tonne of grain, a cereal crop requires 45 kg N. Currently there are a number of methods of estimating yield including the online Wheat Yield Potential Calculator (soilquality.org.au) based on the French Schultz equation (French and Schultz, 1984) and the Yield Prophet model by CSIRO/Birchip Cropping Group (yieldprophet.com.au).

Table 3: *The amount and value of nitrogen supplied by legumes in the rotation in sand soils in Western Australia (derived from "Select Your Nitrogen" model DAFWA).*

Crop biomass (t/ha)	Amount and value of N in years after legume in rotation									
	1st year		2nd year		3rd year		4th year		Total over 4 years	
	Amount	Value	Amount	Value	Amount	Value	Amount	Value	Amount	Value
1	17 kg	$17–34	8 kg	$8–16	4 kg	$4–8	2 kg	$2–4	31 kg	$32–62
2	34 kg	$34–68	17 kg	$17–34	8 kg	$8–16	4 kg	$4–8	63 kg	$63–126
4	17 kg	$17–34	8 kg	$8–16	4 kg	$4–8	2 kg	$2–4	31 kg	$32–62

Further reading and references

Crabtree WL (1989) Cereal grain yield responses to deep ripping on duplex soils. *Australian Journal of Experimental Agriculture* **29:** 691-694.

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