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Plant & Food Research
Rangahau Ahumāra Kai

FACT SHEET

Guidelines for Soil Nitrogen Testing and Predicting Soil Nitrogen Supply

Soil nitrogen (N) testing is important for forecasting how much additional fertiliser N may be needed to meet, but not exceed, the demand of a growing crop. The N supplied directly by soil can be divided into two forms:

Mineral N = the plant-available N in soil at the time of sampling

Mineralised N = the N released (mineralised) from soil organic matter during the growing season.

Mineral N

Mineral N is the ammonium and nitrate in soil that is immediately available for crop uptake. In most cases, the majority of the mineral N that is accessible to the crop will be found in the top 30 cm of soil. Whereas some established crops can take up N from well below 30 cm depth (e.g. wheat, barley, maize), many crops (e.g. broccoli, carrot, onion, potato, peas) take up most of their N from the top 30 cm of soil and a few (e.g. salad greens) rely on mineral N from the top 15 cm of soil.

Most commercial laboratories report soil mineral N as ammonium, nitrate and total mineral N. The soil Nitrate Quick Test offers a simple method for on-farm testing of soil nitrate concentrations (excludes ammonium) that can be useful for monitoring changes in mineral N during the growing season. Further details on the soil Nitrate Quick Test can be found here: **https://bit.ly/3KKwQ3X**

Mineralised N

Mineralisation is a microbial process that involves the gradual breakdown of soil organic matter to release mineral N during the growing season. In cropping soils, mineralisation can contribute a large amount of plant-available N (40–300+ kg N/ha/year) that varies depending on soil type, land-use history, and soil environmental conditions (especially temperature and moisture). In general, the soil organic matter that breaks down during mineralisation is also replenished during the decay of crop residues, roots and other organic wastes (e.g. compost, animal dung).

The amount of N that mineralises under field conditions is not easily measurable. However, it can be estimated from (1) a test of the soil's N mineralisation potential (i.e. the mineral N released under "optimal" conditions in the laboratory), and (2) an understanding of how soil temperature and moisture during the growing season affect the actual rate of N mineralisation under field conditions.

The new potentially mineralisable N (PMN) test, developed by The New Zealand Institute for Plant and Food Research Limited, provides a relatively rapid and accurate measure of how much mineral N can be released (mineralised) from a given soil, under "optimal" conditions. The PMN test is now available through most commercial soil testing laboratories in New Zealand and is more reliable than the traditional anaerobically mineralisable N (AMN) test (also known as the Available Nitrogen test).

How and when to soil test

Testing for soil mineral N and potentially mineralisable N (PMN) at the start of the main (spring/summer) growing season is important for forecasting how much additional fertiliser N may be required to meet crop demand. The calculations needed to estimate the mineral N and mineralised N in soils are given in the sections below, along with an example of how these can be applied to forecast the fertiliser N requirement of a crop.

Soil sampling for mineral N and PMN testing should be completed just prior to sowing/planting for spring/summer planted crops or prior to the first fertiliser application of the main growing season (in early spring) for autumn/winter sown crops. The sample should comprise 15–20 soil cores collected along a transect (Z or W pattern) across the paddock (or the area to be planted) and sent immediately to a commercial testing lab for analysis. In most cases, the recommended sample depth is 0–30 cm (or separate 0–15 and 15–30 cm samples), though 0–15 cm sampling will be more appropriate for shallow rooting crops or very shallow soils (soils over gravels or stones).

Testing for mineral N and mineralisable N below 30 cm depth (e.g. 30–60 cm "deep mineral N testing") is not recommended for forecasting fertiliser N rates at the start of the growing season. However, it can be useful for determining how much mineral N remains in the soil at crop harvest and, therefore, the effectiveness of the previous crop's N management practices.

Table 1. The calculation for estimating the total mineral N in the soil at time of sampling.

	Column A		Column B						
Sample depth	Mineral N (mg/kg)	X	Bulk Density	X	Sample depth (cm)	÷	Unit Factor	=	Mineral N (kg N/ha)
0–15 cm		X		X	15	÷	10	=	
15–30 cm		X		X	15	÷	10	=	
or									
0–30 cm		X		X	30	÷	10	=	
Total	→								

Estimating Mineral N and Mineralised N

Use the guidelines above to collect a soil sample(s) and obtain mineral N and PMN test values from a commercial laboratory.

Calculating Mineral N

The mineral N test values are normally reported as mg/kg of soil and can be converted to kg N/ha by adjusting for sample depth and the soil bulk density as follows:

1. Enter the total mineral N test value(s) at the appropriate depth(s) in Column A of Table 1.
2. Select a bulk density value(s) from Table 2 that is consistent with the soil order and sample depth that you have tested and enter this value in Column B of Table 1. Alternatively, you can enter a field measured, soil bulk density value, if you have one.
3. Calculate the total mineral N in kg N/ha.

Table 2. Average bulk density values (g/cm^3) for common New Zealand agricultural soil orders[1].

	Allophanic	Brown	Gley	Granular	Pallic	Recent
0–15 cm	0.70	1.15	1.15	0.80	1.17	1.16
15–30 cm	0.82	1.30	1.28	0.86	1.32	1.22
0–30 cm	0.76	1.22	1.20	0.83	1.24	1.19

[1]Obtained from the Land Management Index dataset.

Calculating Mineralised N

As noted above, the PMN test provides a measure of how much N could be mineralised from a given soil under optimal conditions of soil temperature and moisture. However, conditions in the field are rarely optimal, so the actual amount of N mineralised under field conditions will depend on the local climate during the crop growing season at the site where the soil test is conducted.

The estimated amount N that will be supplied from mineralisation over a crop's growing season (i.e. the months of active plant growth and N uptake) can be calculated as follows:

1. Enter the PMN test value(s) (mg/kg) at the appropriate depth(s) in Column A of Table 3 below.
2. Select a bulk density value(s) from Table 2 (above) that is consistent with the soil order and sample depth that you have tested and enter this value in Column B of Table 3. Alternatively, you can enter a field measured, soil bulk density value, if you have one.
3. Enter a regional/seasonal climate factor for each month of active crop growth during the main growing season (i.e. from the soil testing month to the start of crop senescence) in Table 4. The regional/seasonal climate factors to select from can be found in Table 5. The climate factors for irrigated soils should only be used in months where the crop is fully irrigated, otherwise use the climate factors for dryland soils.
4. Enter the sum from Table 4 at the appropriate depth in Column C of Table 3.
5. Calculate the estimated amount of N that would be mineralised over the period of active crop N uptake at the sampled site using the formula in Table 3.

Note: the regional/seasonal climate factors are based on average climate data at each location. The actual conditions in the season(s) where these climate factors are applied may differ somewhat from the average conditions, which may affect the accuracy of the mineralised N estimate.

Table 3. The calculation for estimating the total amount of N that will be mineralised and made available during the active period of crop growth (and N uptake) at a given site.

	Column A		Column B		Column C				
Sample depth	PMN (mg/kg)	X	Bulk Density	X	Total Climate Factor	÷	Unit Factor	=	Mineralised N (kg N/ha)
0–15 cm		X		X		÷	100	=	
15–30 cm		X		X		÷	100	=	
or									
0–30 cm		X		X		÷	50	=	
Total	→								

Table 4. Enter the values obtained from Table 5 to calculate your total climate factor.

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May		Sum
Enter here										=	

Table 5. Regional/seasonal climate factors for calculating in-field N mineralisation under dryland and irrigated conditions in many of the primary cropping regions of New Zealand.

Region	Dryland			Irrigated		
	Spring (Sep–Nov)	Summer (Dec–Feb)	Autumn (Mar–May)	Spring (Sep–Nov)	Summer (Dec–Feb)	Autumn (Mar–May)
Auckland (Pukekohe)	14.0	15.0	12.5	14.5	16.5	15.0
Waikato (Matamata)	14.0	15.0	12.5	14.5	16.5	15.0
Taranaki (Stratford)	13.0	16.5	15.0	13.0	16.5	15.0
Bay of Plenty (Whakatane)	13.0	14.0	13.0	14.5	17.0	15.0
Gisborne (Matawhero)	12.5	13.5	15.0	13.0	17.0	15.0
Hawke's Bay (Whakatu)	9.5	12.0	10.0	12.5	17.0	14.5
Manawatū (Levin)	10.5	12.5	10.0	12.0	15.0	13.0
Tasman (Riwaka)	9.0	11.5	10.0	10.0	15.0	13.0
Marlborough (Blenheim)	8.5	10.5	7.5	10.0	15.0	12.0
North Canterbury (Waiau)	8.0	9.5	7.5	9.5	14.5	11.5
Mid Canterbury (Lincoln)	7.5	10.0	8.5	9.0	14.0	11.5
Mid Canterbury (Ashburton)	8.0	10.5	8.5	9.0	15.0	11.5
South Canterbury (Waimate)	7.5	9.5	8.0	8.0	14.0	10.0
Southland (Gore)	7.0	9.5	7.5	7.0	13.0	9.5

Example calculations for Mineral N and Mineralised N

For this example, an autumn sown wheat crop is established in Mid Canterbury (near Ashburton) with an expected harvest date in late January. The paddock is located on a Brown soil. The crop will be irrigated in November and December to achieve the target grain yield of 12 t/ha. The soil is sampled and tested for mineral N and PMN in late August.

The mineral N tests (mg/kg) reported by the commercial laboratory and the calculation of mineral N (kg N/ha) are given in Table 6, based on the guidelines given above.

The PMN tests (mg/kg) reported by the commercial laboratory and the calculation of mineralised N (kg N/ha) are given in Table 7, based on the guidelines given above.

Table 6. The calculation of **total mineral N** in the soil at time of sampling.

	Column A		Column B						
Sample depth	Mineral N (mg/kg)	X	Bulk Density	X	Sample depth (cm)	÷	Unit Factor	=	Mineral N (kg N/ha)
0–15 cm	10	X	1.15	X	15	÷	10	=	17
15–30 cm	8	X	1.30	X	15	÷	10	=	16
or									
0–30 cm		X		X	30	÷	10	=	
Total	→								33

Table 7. Calculation of the **N mineralised** and made available for crop uptake during the period of active N uptake (Sep–Dec) by the wheat crop at this site.

	Column A		Column B		Column C				
Sample depth	PMN (mg/kg)	X	Bulk Density	X	Total Climate Factor[1]	÷	Unit Factor	=	Mineralised N (kg N/ha)
0–15 cm	65	X	1.15	X	40	÷	100	=	30
15–30 cm	45	X	1.30	X	40	÷	100	=	23
or									
0–30 cm		X		X		÷	50	=	
Total	→								53

[1] Climate factor calculated from Table 8, as discussed above.

Table 8. Calculation of the total climate factor for this crop (applied to Column C, Table 7).

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May		Sum
Enter here	8.0	8.0	9.0	15.0						=	40.0

Using soil N tests to forecast N fertiliser requirements

If the total N requirement to achieve a designated crop yield is known, then the calculated soil N supply (from mineral N plus mineralised N, as discussed above) can be used to forecast how much additional fertiliser N may be required to meet the crop's N requirements.

For example, the arable industry guideline for wheat is to supply 25 kg N/ha for each tonne of target grain yield. If the target grain yield for an irrigated wheat crop is 12 t/ha, then the N required to achieve that yield is estimated to be 300 kg N/ha. Using the example calculations above, the total soil N supply is predicted to be 86 kg N/ha (33 kg N/ha from mineral N, 53 kg N/ha from mineralised N) during the period of crop N uptake (Sep–Dec).

Where no adjustment is made for soil N supply, a typical split of N fertiliser for this crop is shown in Row A of Table 9 below. The N fertiliser rates given in Row B show how the fertiliser applications could be proportionally adjusted for the predicted soil N supply. By accounting for the soil N supply (Row B), the fertiliser applied to this crop is reduced by 86 kg N/ha, lowering the cost of applied fertiliser and reducing the risk of N losses.

Table 9. A simple example of how fertiliser N rates can be adjusted for soil N supply (from estimates of mineral N and mineralised N) to meet crop N demand. All units are in kg N/ha.

Row	Nitrogen Management	Soil N Supply	Fertiliser N applied (kg N/ha)[1]			Total N Supply
			Early N	GS 32	GS 39	
A	All N as fertiliser	0	40	175	85	300
B	Fertiliser adjusted for soil N	86	28	125	60	300

[1]GS, growth stage

Where do I learn more?

These guidelines were developed as part of the Sustainable Farming Fund Project: *Mineralisable N to Improve On-Farm N Management*. Further information on the project and the testing of these guidelines can be found in the report given here: https://bit.ly/3bUUopG.

For more information email:

mike.beare@plantandfood.co.nz

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