SOILS AND FERTILISERS

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Understanding and interpreting soil N tests

Key Points

- Several different soil N tests are available with different purposes for each. Understanding these differences is important and the test required must be clearly identified for the laboratory.
- Mineral N is available now for the plant to use. Take samples to 60 cm depth and use for calculating fertiliser N requirements. This method is needed for the Sirius wheat calculator.
- The mineral N test does not account for the N that is mineralised during the growing season.
- Mineralisable N is the amount that becomes available during the season. Fertiliser recommendations based on mineralisable N are only useful when there is a good relationship between the mineralisable N and the amount of N the soil will actually supply to the crop, as in the maize calculator.
- The N index has promise for determining fertiliser N requirements, but it needs updating for current management practices and cultivars.

Why measure soil N?

The basic reason for doing a soil N (nitrogen) test is to improve fertiliser N predictions. Without information on soil N status, too much (or too little) fertiliser may be applied. This reduces profits and there is an increased risk of nitrate leaching to groundwater when N supply exceeds crop demand. To work properly, decision support systems which predict crop yield based on fertiliser and water (e.g. Sirius wheat calculator and maize calculator) need a reliable measure of soil N availability.

Forms of N in soil (see Fig. 1)

Organic N The majority (98-99%) of N in soil is present as organic N. Most of the organic N is very stable and locked up in the soil organic matter. Topsoil commonly contains a very large amount of organic N (5-6000 kg N/ha).

Mineralisable N (available N) This is the small portion (1-4%) of the organic N that is broken down each year (by a process called mineralisation) to mineral N by the action of soil microbes. Mineralisation occurs most rapidly when soil is warm and moist. The mineralisable N is replenished each year, mainly by freshly-returned plant residues. Topsoils commonly contain 50-200 kg mineralisable N/ha.

Mineral N This N is present as ammonium or nitrate (1-2% of soil N). It is the only form of N that is taken up by plants or lost by leaching. The amount in the soil varies during the year in relation to its rate of production and rate of removal by plants and through leaching. At sowing, topsoils commonly contain 50-100 kg mineral N/ha.

Description and interpretation of soil N tests

Total N This measures the total amount of organic and mineral N in the soil. Because there is so much stable organic N in the soil it is not possible to measure a change in total N from one year to the next. It is not a useful test for growers.

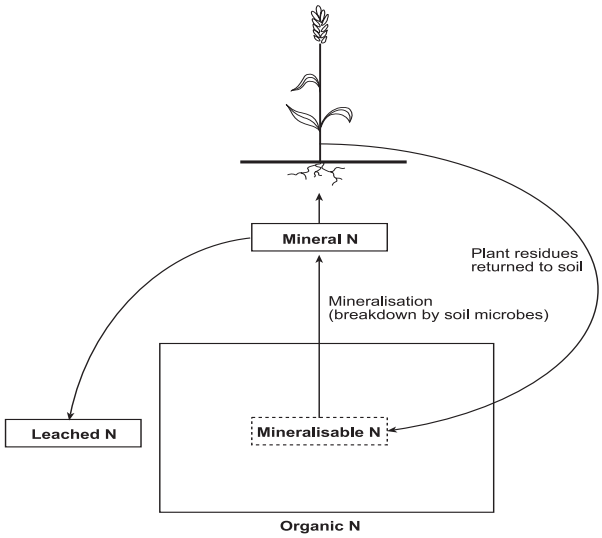

Fig 1: Simplified diagram of the main forms of soil N.

Mineral N This measures the combined amount of ammonium and nitrate in a soil sample. Mineral N must be measured as soon as possible after sampling. Either refrigerate or freeze the sample if it cannot be delivered to the laboratory immediately.

Mineral N results will have units of ppm or μg/g or mg/kg (all the same thing!). These units need to be converted to kg N/ha to be useful by:

ppm x 1.3 = kg N/ha

The amount of mineral N in the soil is used to calculate the amount of fertiliser N required by the crop (all in units of kg N/ha) as:

fertiliser N = (crop N needed – mineral N) ÷ 0.6

The calculation assumes that only 60% of the applied fertiliser can be taken up by the crop. This calculation may overestimate the amount of fertiliser that is

required, as it ignores the N that will be mineralised during the growing season. For this test to be useful, the soil needs to be sampled to at least 60 cm depth.

Shallower samples may seriously underestimate the amount of mineral N in the soil. For example, mineral N contents of soil from 2 field trials sown in 2001 were both 12 kg N/ha at 0-15cm, but from 15-60cm were 76 kg N/ha at 1 site and 230 kg N/ha at the other. To run the Sirius wheat calculator you need a measure of the soil mineral N at sowing.

Mineralisable N This measures mineral N released (by soil microbes) from organic matter when soil is waterlogged and incubated at 40°C for 1 week. In this test the measurement conditions are artificial, so the results may not be applicable in the field.

Used on its own, the test only gives a general index of soil N fertility (i.e. high, medium or low) rather than a guide to the fertiliser N requirement. Experiments done by Crop & Food Research show that mineralisable N is a poor predictor of how much N is taken up by crops. Used in the maize calculator, mineralisable N results are useful as the test has been calibrated and scaled for this crop.

Soil sampling procedures

Time of sampling

a. *Total N.* At any time during the year.
b. *Mineral N and mineralisable N.* The best time is usually early in the spring after winter leaching. Plant demand for N at this time will still be low and there will be enough time to apply fertiliser after the test results are received. Samples sometimes need to be taken before sowing if the results are to be used in crop models (e.g. the Sirius wheat calculator or the maize calculator).

Type of sampler. The type of sampler is not really important. Any type of corer or auger can be used that gives uncontaminated samples. A 2.5 cm diameter corer is commonly used, that is either pushed in by hand or driven in using a maul.

Depth of sample

a. *Mineralisable N.* Sample 0-15 cm depth.
b. *Mineral N.* Sample 0-60 cm depth. It is often easier to take samples in several stages down the soil (e.g. 0-20, 20-40, 40-60 cm) and then mix them together. In NZ, samples for mineral N are usually only taken to 15 cm. However, this misses a lot of mineral N that is in the soil and can be taken up by the crop. A sampling depth of at least 60 cm is used overseas.

Number of samples. Randomly take about 15-20 samples per paddock and mix them together. Avoid gateways, headlands, stock camp areas and double-drilled areas. Send to the lab as soon as possible.

Other methods

N index The N index was developed by MAF in the 1980s and needs updating to be useful today – it may be available through FAR next year. It predicts the amount of N supplied by the soil by using information from the previous 10 years on the paddock's cropping history, N fertiliser application rates and heavy winter rainfall events (causing leaching losses). All paddocks are given an initial N index of 0, with the effects of crop, fertiliser and leaching accumulated with time. The N index has an allowable range of 0-10, and this value is used to estimate the amount of N supplied by the soil (in kg N/ha).

Example N index calculation: Values in brackets are the separate effects of crop, fertiliser or leaching on the N index in each year. These effects are summed and added to the value from the previous year.

Year	Separate N index values for crop, N fertiliser and leaching	N index
1993	Starting year	0
1994	3 years pasture (+6)	6
1995	Autumn wheat (-3), 200 kg N/ha (+2)	5
1996	Autumn greenfeed (-1), peas (0)	4
1997	Autumn wheat (-3), 200 kg N/ha (+2), wet winter (-1)	2
1998	Autumn greenfeed (-1), barley (-2), 100 kg N/ha (+1)	0
1999	Ryegrass seed (-1), 100 kg N/ha (+1)	0
2000	Clover seed (+3)	3
2001	Autumn wheat (-3), 200 kg N/ha (+2)	2

In this example, the crop sown in 2002 could expect to obtain 101 kg N/ha from the soil during the season.

N index	0	1	2	3	4	5	6	7	8	9	10
N supplied by soil	58	80	101	119	136	151	165	177	188	198	208

ADAS method This method has been developed for use with winter wheat crops in the UK. It assumes that the crop will take up 180 kg N/ha during its growth and that there is no mineralisable N in the soil. The amount of mineral N in the soil to 90 cm depth is measured after winter leaching and used to calculate the amount of fertiliser that is needed, as in the mineral N test. This calculation may also overestimate the amount of fertiliser that is required, as it ignores the N that will be mineralised during the growing season.

Plant N tests

Plant tests are sometimes used instead of soil tests:

Herbage N. This is used to estimate protein content and is a useful indicator of forage quality for milk production. A disadvantage is that several days are needed to complete the measurement, delaying treatment of any N shortage.

Chlorophyll meter. This measures the 'greenness' of plant leaves and is used to estimate leaf N. The meter easily identifies crops that are highly N deficient, but is unreliable where N levels are only moderately to slightly low. In some crops, greenness varies by cultivar so individual calibrations are required.

Sap test. This measures the concentration of nitrate in sap extruded from plant tissue (e.g. petioles of potato plants). It can be done in the field using a kit, but results are difficult to interpret (values vary depending on time-of-day, crop growth stage, and other factors). The sap test has not been shown to be a reliable guide to crop fertiliser N requirement.

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