

The Nitrate Quick Test Mass Balance Tool

User Guide



Preface

The National Policy Statement for Fresh Water provides direction to regional authorities about safe-guarding the quality of our fresh water. Regional Council Land and Water plans are encouraging farmers to adopt industry agreed good management practices (GMP) to reduce the risk of nutrients being lost from the farm. There is a strong focus on nitrogen. The industry-agreed GMP for nutrient management is to meet the crop's demand for nutrients, first with the supply from the soil, then with a fertiliser application.

A nitrogen mass balance budget is a method to determine how much nitrogen fertiliser should be applied to the crop to achieve its potential yield. However, for the budget to be developed, estimates are required for the crop's demand for nitrogen and how much of this will be supplied by the soil.

Currently, there are two tests used to quantify soil nitrogen supply.

- The mineral N test, which provides a measure of how much nitrogen is immediately available for plant uptake.
- The anaerobically mineralisable N (AMN) test. This is an estimate of the N supply from the mineralisation of organic N.

For an effective nitrogen mass balance, **both** sources of nitrogen need to be measured. The amount of mineral N in the soil can change quickly over a short period of time, especially as crops take up nitrogen. It is useful to have quick and inexpensive methods for estimating soil mineral nitrogen levels throughout the season. Previous work in New Zealand has shown that Nitrate Quick Test strips are efficient and inexpensive.

This Guide provides guidance to growers on how to measure the soil nitrogen supply with Nitrate Quick Test strips and make an informed fertiliser decision for the crop.



Figure 1. Lettuce.

How to use this guide

This is a step by step guide on how to use the Nitrate Quick Test Mass Balance Tool to inform an N fertiliser decision:

- How to use the mass balance equation.
- Taking the soil sample.
- Using the Nitrate Quick Test to estimate the mineral N levels in your soil.
- Crop nutrient demands.
- Using the Nitrate Quick Test Mass Balance Tool.

The Nitrate Quick Test Mass Balance Tool is an easy to use electronic tool available on the industry websites.

Mass balance budget

A nutrient mass balance is a useful way of determining fertiliser requirements, enabling fertiliser applications to be better matched to the crop's nutrient requirements. For N, the mass balance equation is:

$$\mathbf{N\ Fertiliser = Crop\ N\ Demand - Soil\ Mineral\ N - Soil\ Organic\ N}$$

Where:

- 1. N Fertiliser** is the amount of nitrogen to be supplied from the fertiliser. The amount of fertiliser applied depends on its nitrogen content, e.g. the nitrogen content of urea is 46%.
- 2. Crop N** demand is the amount of nitrogen the crop will need to reach its target yield.
- 3. Soil Mineral N** is a measure of how much nitrogen is immediately available for plant uptake and includes both nitrate and ammonium. Quick test nitrate may be used as a proxy for soil mineral N supply at any time during the crop's growth.
- 4. Soil Organic N** is an estimate of the nitrogen that could become available as soil organic nitrogen is mineralised. This is estimated with an AMN test taken before the crop is planted.

All of these are estimates and have a level of uncertainty in the results to keep in mind. Regular soil tests and consideration of seasonal weather will enable you to get a feel for the reliability of your soil test results.

The crop's nitrogen demand relates to its planned yield. When working this out, the long term average yield for the crop is a good place to start. This can be reviewed throughout the season with in-season assessments of how the crop is performing.

Crop demand

Nitrogen is an essential nutrient for plant growth and is found in all plant cells.

The supply of nitrogen to the crop comes mainly from soluble nitrate ions which are absorbed by the plant roots as they absorb water. Plants with diseased roots or roots restricted by compaction may show signs of nitrogen deficiency even when adequate nitrogen is present in the soil.

Efficient nitrogen use depends on maintaining healthy root systems with a focus on good soil structure and effective pest and disease management. The root zone, where the roots are active, is the key management zone for reducing nitrogen losses to the environment.

Each crop has a characteristic demand for nitrogen and as the yield increases so does the demand for nitrogen.

Detailed information about the nitrogen requirements for arable and vegetable crops can be found on industry websites.

For arable crops: www.far.org.nz

For vegetable crops: www.fertiliser.org.nz/includes/download.ashx?ID=154153



Figure 2. Maize.

Nitrogen supply from the soil

Soil nitrogen levels are dynamic. The nitrogen cycle has ongoing immobilisation and mineralisation processes which either lock up nitrogen into organic forms or release it into soluble plant available forms.

In the mineralisation process nitrogen is converted from the organic form to mineral forms through the decomposition of organic soil compounds by microbial activity. The soluble mineral forms of nitrogen comprise only 2-3 % of the total soil nitrogen and it is these that are available to the plant.

There are two tests that provide information about the availability of nitrogen for the crop. AMN and mineral N tests provide different information about the soil nitrogen supply.

1. Mineral Nitrogen (MinN) Tests

MinN or Deep Soil Mineral N tests, measure the inorganic or mineral nitrogen fractions in freshly collected soil. These mineral fractions are nitrate-N (NO_3^-) and ammonium-N (NH_4^+), the forms of nitrogen that are immediately available to the plant. In most cultivated cropping soils, nitrate-N is the predominant form of mineral N (> 90%) unless an ammoniacal based fertiliser (e.g. calcium ammonium nitrate) has been applied recently, in which case ammonium-N levels will be elevated.

The soil samples collected for Mineral N tests can be submitted to the laboratory for testing or tested on the farm with Nitrate Quick Test strips.

Samples must be chilled, but not frozen, to prevent mineralisation occurring while in transit to the lab. Samples must be < 4°C when they arrive at the lab.

2. Anaerobic Mineralisable N (AMN) Test

The AMN test is a laboratory test that estimates the amount of nitrogen that could be mineralised from the organic matter in the soil over the growing season. It is also known as the Available Nitrogen (AN) test.

The AMN and AN results come from the same soil sample and test procedure.

The actual amount of nitrogen that becomes available depends on the soil's mineralisation processes which depend on soil temperature and moisture.

Testing the soil for nitrogen

Regular soil testing is important and the most important part of the soil profile to sample is the crop root zone. Management of the nutrients where the roots are active is the key to reducing nitrogen losses during drainage. For most arable and vegetable crops the majority of roots actively taking up nutrients are in the top 60 cm, with the densest concentration of roots in the 0-30 cm zone.

In combined arable and pastoral systems there are times when the soil will have high residual fertility and the first crop on these soils is likely to need minimal amounts of applied inorganic fertiliser to reach its yield.

High mineral nitrogen situations include:

- Recently cultivated long-term pastures;
- Paddocks that have been intensely grazed, e.g. following winter dairy grazing;
- Paddocks where the previous crop did not reach its planned yield;
- Paddocks where a large amount of crop residues with a high N content (e.g. trimmings and leaf residues from brassicas) has recently been returned to the soil.

It is important to test fertility levels in these soils before the next crop in the rotation is established so that an efficient fertiliser plan can be developed.

Sampling methodology and equipment

Timing

- The best time to collect a soil sample for mineral N analysis is in the week prior to base, planting or side dress nitrogen fertiliser applications. The longer the period between sampling and fertiliser application, the less useful the mineral N test result will be for informing a nitrogen mass balance. This is because inorganic N may be lost in drainage if there is a big rainfall event or levels may quickly change if a crop is rapidly growing. One of the main benefits of Nitrate Quick Test strips is that the results from the soil test are available within a couple of hours, so they can be used on the same day as the fertiliser application if required.
- For AMN testing, the best time to collect a sample is after harvest and before the ground work for the next crop is started. The standard turnaround time for this test at commercial laboratories is 3 to 10 days. For the nitrogen mass balance, samples for AMN analysis would only need to be taken once (before crop establishment) to give an estimate of potential nitrogen supply from mineralisation of organic N.
- When using the Nitrate Quick Test, avoid sampling immediately after a fertiliser application that includes urea or ammonium compounds. The Nitrate Quick Test strips do not measure ammonium-N and in this case the test results will under-estimate the plant available nitrogen in the soil sample. In most contexts, nitrate-N is the predominant form of soil mineral N and this means that Quick Test nitrate is an effective proxy for plant available N.

Sampling

- Collect 10 to 20 cores across the paddock. Develop a pattern of sampling that can be repeated and record where the sampling points are, with GPS or visual cues, so that the sampling pattern can be repeated in subsequent years.
- Avoid atypical areas such as gateways and headlands and old stock camps and fire sites. If there are a number of different soil types within the paddock, sample from each soil-type area.
- For bed crops (e.g. onions, lettuce, brassicas), avoid taking samples from the inter-rows or wheel tracks where crop root growth is usually restricted.
- Banded applications of fertiliser result in a more concentrated nutrient zone close to the plant rows. If a soil test is required for a side dressing decision take half the cores from the banding zone and the other half from outside this area. The sample will represent the average fertility across the area in question.
- Allow at least 10 days after the application of nitrogenous fertilisers to reduce the risk of high ammonium concentrations in the sample. Increase this time to at least two weeks in winter, particularly if ammoniacal based products are being used (e.g. CAN). Avoid sampling when soils are waterlogged.

Equipment

The equipment required is:

- A 15 cm corer for basic soil tests and/or an auger for deep mineral N tests (up to 60 cm depth).
- Buckets for mixing the samples for a composite sub-sample.
- Sample bags that seal.
- Labels and a water resistant pen.
- Chilly bin with ice and cooler bags.

A spade can be used for the sampling, but make sure the sample is representative of the whole soil profile for the sample depth being measured.

Collect samples to a minimum depth of 60 cm. It can be useful to keep the different depth increments separate (i.e. 0-15 cm, 15-30 cm, 30-60 cm) as this gives an indication of where the available nutrients are in the soil profile. Nutrients at depth are not available to shallow rooting crops or those that just establishing.

Soil samples should be kept chilled until they can be tested. Use a chilly-bin with ice packs and a water-resistant pen for labeling.

Nitrate Quick Test strips - How do they work?

The Nitrate Quick Test strips are similar to the litmus strips used for pH testing but are coated with a chemical that changes colour when it reacts with nitrate. A simple colorimetric scale is used to quantify concentrations. Measured NO_3^- concentrations are then converted to a gravimetric basis (mg NO-N/kg DM) using correction factors which account for soil moisture and texture.

Materials

- For the soil sample.
- Soil auger and buckets.
- 4 mm sieve.
- Sealable plastic bags and waterproof marker.

For the Nitrate Quick Test

- Spoon or spatula.
- Storage rack for tubes.
- Stop watch.
- MQuant® Nitrate Test Strips (0-500 mg/L NO_3^-).
- 50 ml plastic extraction tubes (10 ml graduations).
- 0.01 M CaCl_2 solution (1.47 g Calcium chloride dehydrate in 1 L bottled spring water).
[Details on where to obtain the required supplies are provided in Appendix 1]

The Nitrate Quick Test Analytical Protocol

The testing process starts with a set of in-field soil samples, collected as described on page 9-10. Thoroughly mix and sieve the samples to less than 4 mm before testing.

Always include a 'blank' in your analyses to ensure there is no 'background' nitrate in the extract solution.

Method

1. Begin with 30 ml CaCl_2 solution
2. Add 10 ml of sieved soil to give a total volume of 40 ml
3. Shake vigorously for 1-2 minutes
4. Allow the soil to settle (about 30 minutes)

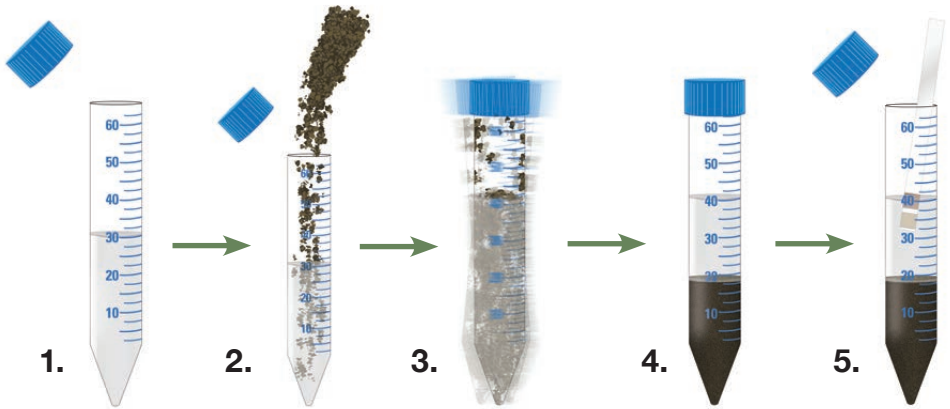


Figure 3. The Nitrate Quick Test Analytical Protocol method steps 1-5.

5. Dip the test strip in for 2 seconds then remove it
6. Allow the colour to develop for exactly one minute.
7. Compare the colour to the nitrate concentration scale on the container
8. Use the NO_3^- scale which shows concentrations from 0 to 500 mg/L.
9. Record the result.

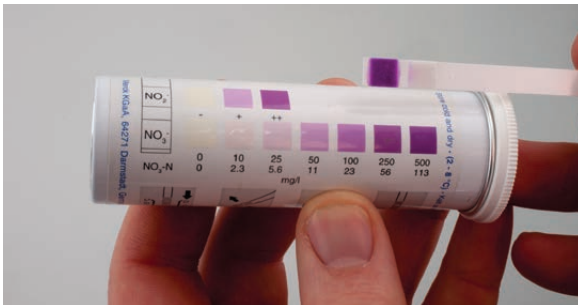


Figure 4. Quick N strips

If the test strip colour falls in between a colour range, you will need to estimate the concentration based on closest colour range. For example, if the reading is between 25 and 50 mg/L NO_3^- but closest to 50 mg/L, a value of 40 would be appropriate.

The concentration result (mg/L) needs to be converted to a more useful measure relating the nitrate level in the test solution to the amount of NO_3^- -N in the soil.

Use the Nitrate Quick Test Mass Balance Tool (page 12) to do this or use the soil correction factors and follow the calculation example on the following page.

The soil correction table

Soil Correction Table

Texture	Dry	Moist	Wet
Clay	1.8	1.5	1.3
Clay loam	1.7	1.4	1.3
Loam	2.0	1.5	1.3
Loamy sand	1.8	1.5	1.4
Sand	1.8	1.5	1.4
Sandy clay	1.8	1.4	1.3
Sandy clay loam	1.9	1.6	1.4
Sandy loam	2.1	1.8	1.5
Silt	1.9	1.4	1.3
Silt loam	1.7	1.4	1.3
Silty clay	1.9	1.6	1.4
Silty clay loam	1.9	1.5	1.4

The results in this table have been validated for New Zealand cropping soils as part of the Plant & Food Research science programme. Use the table to identify your soil correction factor.

1. Identify the texture of your soil. If this is not known use the “feel method”.
<https://soils.landcareresearch.co.nz/understanding-soils/get-dirty/#st>
2. Determine how dry the soil is at the time of testing.
 - A dry soil will crumble and not form a ball.
 - A moist soil will form a ball that is not overly wet, unless it is sandy.
 - A wet soil forms a ball which releases moisture when squeezed.

A calculation example:

The calculation converts the nitrate concentration from a volumetric measure (mg NO₃-N/L) to a gravimetric measure (mg NO₃-N/kg soil dry matter).

In our example the soil that has been sampled is a moist silt loam. From the correction table the correction factor is **1.4**. Following extraction, the Nitrate Quick Test strip gives a NO₃⁻ reading of **25 mg/L**.

To convert to a **gravimetric basis** divide this value by the relevant correction factor from the table: **25 mg/L ÷ 1.4 = 17.9 mg NO₃-N/kg soil dry matter**.

To convert to a field basis (kg N/ha), multiply the gravimetric value by the sample depth factor and the field bulk density.

The sample depth factor is the sample depth ÷ 10. In this example **15 cm** sample depth ÷ 10 = **1.5**.

The bulk density is a characteristic of the soil type. In this example the bulk density is **1.05 g/cm³**. If the bulk density is unknown use a value of 1.0.

The calculation is: **17.9 mg NO₃-N/kg DM × 1.5 × 1.05 = 28 kg N/ha** in the 0-15 cm soil profile.

The Nitrate Quick Test Mass Balance Tool

The Quick Test Mass Balance Tool is an MS Excel® based interface and the great thing about it is **that it does the calculation for you**.

In the tool, the N mass balance equation is used to estimate the nitrogen fertiliser requirement for the crop at the time of soil testing.

- Crop N demand (in season and total) is estimated using a nitrogen uptake curve for the crop which is dependent on yield potential.
- Soil mineral N supply is estimated from Nitrate Quick Test results.
- Nitrogen supply from mineralisation of organic N is estimated from the AMN test or, if this isn't available, a default value based on land management history.

The Tool is freely available on the FAR website: www.far.org.nz

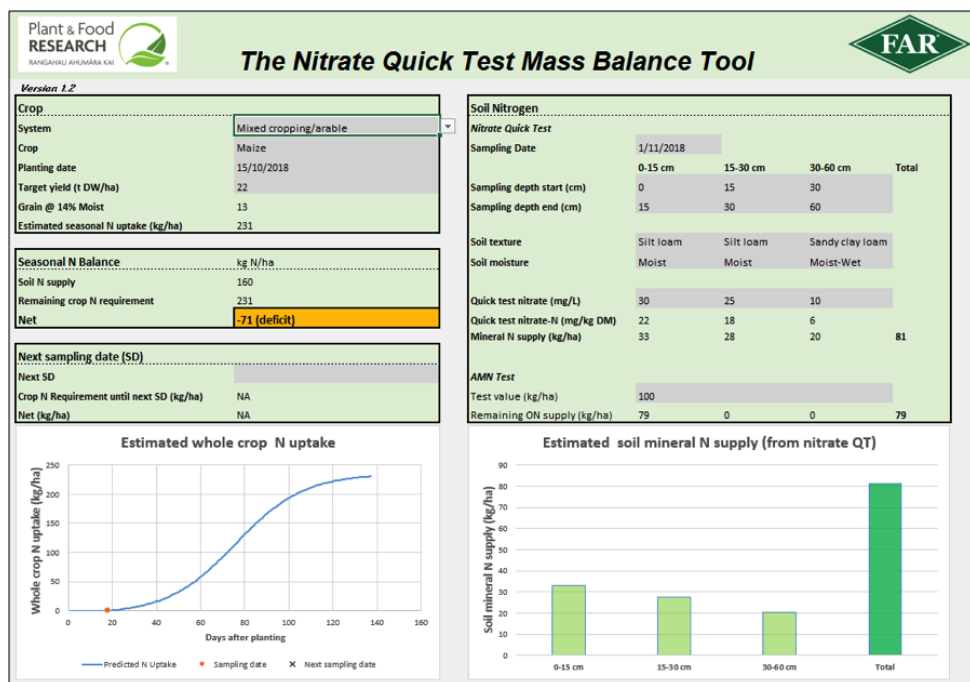


Figure 5. Diagramme of the user page in the Mass Balance Tool.

Instructions for using the tool

Refer to the Figure 5 above. Cells highlighted grey indicate where information is to be entered or selected from the drop down boxes.

There are four data frames within the tool named **Crop**, **Soil Nitrogen**, **Seasonal N Balance** and **Next Sampling Date** (SD).

Entering information into the Crop window

1. Select the most relevant cropping system from the drop down list.
2. Select crop type from drop down list.
3. Enter the planting date (format must be day/month/year).
4. Select a target yield from the drop down list.

OUTPUT: An 'estimated seasonal N uptake (kg N/ha)' value will be generated based on this information.

Entering information into the Soil Nitrogen window

Nitrate Quick Test

1. Enter the sampling date (day/month/year).
2. Enter the sampling depths. Start depth must match the end depth from the previous soil sample fraction. The tool allows for three depth fractions to be entered (leave cells where less sampling is required).
3. From the drop down lists, select soil texture and soil moisture for each sampling depth.
4. Enter the nitrate test strip concentration results for each sampling depth.

OUTPUT: The tool calculates quick test nitrate on dry soil basis (**Quick test nitrate-N (mg/kg DM)**) and then converts this to estimated mineral N supply for each soil depth sampled. The sum of mineral N supply for the sampled depths is listed in the **Total** column. Estimated mineral N supply results are displayed in the bar graph.

Use the top row of numbers.



AMN test

If available, enter the N mineralisation measure (this could be an AMN result). Otherwise, leave this cell blank. Note: Ensure AMN input values represent the QT sampling depth. AMN results are typically reported on a 0-15 cm soil core basis. If a 30 cm core is analysed for AMN, the lab result (reported in kg N/ha; 0-15 cm) will need to be doubled.

OUTPUT: The tool estimates the N supply from the organic pool (**Remaining ON supply (kg/ha)**) for the period between the most recent quick test and harvest.

Seasonal N Balance

OUTPUT: The following measures are calculated.

- 1. Soil N supply** – this is the sum of mineral N supply at the time of testing and estimated future N supply from the organic N pool.
- 2. Remaining crop N requirement** – this is the estimated amount of N the crop needs to reach the selected yield potential at the time of soil sampling.
- 3. Net** – this is the difference between ‘soil N supply’ and ‘remaining crop N requirement’. A positive value indicates a net N surplus relative to crop N demand while a negative value indicates a net N deficit.

Next Sampling Date

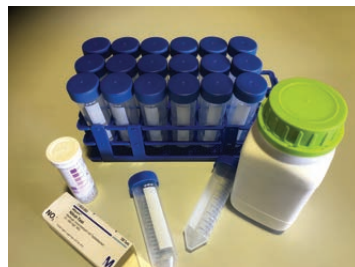
This window may be used to evaluate N requirements between the current sampling date and a future sampling date which may be an upcoming side dressing application. Enter this future date into the **Next Sampling Date (SD)** cell, otherwise leave blank. If a date is entered, this will be displayed as a cross on the N uptake curve; the current sampling date is displayed as the orange marker.

Appendix 1

Nitrate Quick Test kits

Complete test kits can be purchased from Lab Supply Ltd. Kits include:

- A tube rack,
- 20 extract tubes,
- A container of 100 MQuant® Nitrate Test Strips,
- 500 g Calcium chloride dihydrate.



Cost for the kit is \$189.75 including GST and delivery (rural areas included) (reference: 'CHENITRATE-N'). Items may also be purchased individually.

Contact details

Website: www.labsupply.co.nz

Email contact: info@labsupply.co.nz

Tel: 0800 522 787

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