Supelco®
Analytical Products

Application Note

Nitrate in Soil

Smartphone-based determination of nitrate after reduction to nitrite and reaction with Griess reagent

Introduction

Nitrate (NO_3^-) is a major form of inorganic nitrogen in agricultural soils and a primary nitrogen source for plant uptake. Its concentration is governed by fertilizer application, organic matter mineralization, climatic conditions, and crop management practices.[1,2] Due to its high solubility and mobility in the soil solution, nitrate readily leaches through the soil profile into groundwater and surface water, posing a risk recognized across agricultural systems worldwide.[1,2] Accurate determination of soil nitrate is therefore essential for optimizing fertilizer use, improving nitrogen-use efficiency, and mitigating environmental losses.[2]

For analysis, nitrate is extracted from soil using calcium chloride ($CaCl_2$), a mild extractant with an ionic strength comparable to that of natural soil solutions, enabling recovery of readily soluble, plant-available nutrients under field-representative conditions.[3]

Experimental

The following application note describes the determination of nitrate in soil samples using the MQuant® Nitrate Test in combination with the smartphone-based MQuant® StripScan app. This method offers a rapid, convenient, cost-effective, and easy-to-use approach to detecting nitrate in soil samples while also allowing comparisons with other methods such as visual evaluation, reflectometric and photometric methods, to ensure the accuracy and validity of results.

Method

Nitrate ions are reduced to nitrite ions by a reducing agent. In the presence of an acidic buffer, these nitrite ions react with an aromatic amine to form a diazonium salt, which in turn reacts with *N*-(1-naphthyl)-ethylene-diamine to form a red-violet azo dye.

Measuring Range

0–500 mg/L NO_3^-

0–500 mg/kg NO_3^-

Applicable Sample

Soil samples

Reagents and Accessories

Test/Reagent Kit(s)

- MQuant® Nitrate Test, 0–500 mg/L NO_3^- (**1.10020**)
- Calcium chloride dihydrate for analysis EMSURE® ACS, Reag. Ph Eur (**1.02382**)
- Distilled water (e.g., from a suitable Milli-Q® system) or water for analysis (**1.16754**)

Accessories

- MQuant® Card (provided with the test strip box)
- MQuant® StripScan App (can be downloaded via the Apple App Store or Google Play Store)
- Balance
- Standard laboratory glassware (e.g. volumetric flask, Erlenmeyer flask)
- Nitrate-free folded filter

Analytical Procedure

Reagent Preparation

- $CaCl_2$-solution 0.01 mol/L: Dissolve 0.735 g calcium chloride dihydrate in water for analysis and make up to 500 mL with water for analysis in a volumetric flask to prepare a 0.01 mol/L $CaCl_2$-solution.

Sample Preparation

- Homogenize approximately 100 g of soil sample with 100 mL of 0.01 mol/L $CaCl_2$-solution by shaking for 30 minutes. Filter through nitrate-free folded filter.

Measurement

For analysis, follow this procedure:

- Start the App.
- Get your MQuant® test strip and the MQuant® Card ready.
- Dip the test strip into the prepared sample (15–25 °C) for ca. 2 seconds, ensuring that the reaction zone is completely immersed.

MilliporeSigma

- Shake off excess liquid from the strip and dry the backside of the strip using a paper towel.
- Select the parameter NO_3^- (**1.10020**) in the app. Wait 60 seconds until the color of the nitrate strip is completely developed (a countdown is displayed on the screen, which begins immediately after selecting the parameter NO_3^-).
- Just before the end of the countdown, place the test strip on the MQuant® Card.
- After the waiting time is elapsed, place the MQuant® Card with the test strip within the viewfinder on your phone screen, and align the camera along the reference points.
- The picture is captured automatically by the camera of the smartphone.
- The result is displayed on the screen in mg/L NO_3^- and is equivalent in this procedure to mg/kg NO_3^-.

Calculation

$$\text{Nitrate content [mg/kg]} = \frac{\text{Measured value [mg/L] x Vol. } CaCl_2 \text{ sol.[mL]}}{\text{Weight of sample [g]}}$$

Conversion to kg NO_3^-N/hectare (layer of soil)

kg NO_3^-N/ha = A x BF x 3 x D x 0.226

where:

A = Measured value

BF = Factor for wetness of soil and extraction BF = 1.41 at an extraction ratio of 1 + 1 and 83% dry mass

3 = For a 30 cm thick layer of soil

D = Soil density (1.5 kg/dm³)

0.226 = Conversion factor NO_3^- into NO_3^-N

Results

Table 1. Comparison of MQuant® StripScan, visual evaluation, Reflectoquant® Nitrate Test, and Spectroquant® Nitrate Test

Sample	Nitrate concentration [mg/kg NO_3^-]			
	StripScan*	visual readout*	Reflectoquant® Nitrate Test*	Spectroquant® Nitrate Test*
1	100	100	159	144.8
2	50	50	67	73.0
3	50	50	77	73.4
4	10	10	15	15.6
5	20	25	24	23.0

*results are based on the average of a 5-fold determination

Note: Result graduation provided by MQuant® StripScan is identical with graduation on test strip package.

(The results above were obtained using the previous app version with its graduations:

0 – 5 – 10 – 15 – 20 – 25 – 35 – 50 – 75 – 100 – 250 – 500 - >500 mg/L NO_3^-)

Methods for comparison:

Reflectoquant® Nitrate Test, **(1.16971)**, sample preparation as described above.

Spectroquant® Nitrate Test, (**1.09713)**, sample preparation according to test-specific application (for more information see product page).

Conclusion

The MQuant® Nitrate Test in combination with the MQuant® StripScan app is a quick and easy way to analyze the nitrate concentration in soil samples. The measured values are comparable to those measured with the Reflectoquant® and the photometric Spectroquant® Nitrate Tests.

References

1. Fan, J.; Hao, M.; Malhi, S. S. Accumulation of Nitrate-N in the Soil Profile and Its Implications for the Environment under Dryland Agriculture in Northern China: A Review. Can. *J. Soil Sci.* **2010**, *90* (3), 429–440. **DOI: 10.4141/cjss09105**.
2. Cameron, K. C.; Di, H. J.; Moir, J. L. Nitrogen Losses from the Soil/Plant System: A Review. *Ann. Appl. Biol.* **2013**, 162 (2), 145–173. **DOI: 10.1111/aab.12014**.
3. Houba, V. J. G.; Temminghoff, E. J. M.; Gaikhorst, G. A.; van Vark, W. Soil Analysis Procedures Using 0.01 M Calcium Chloride as Extraction Reagent. *Commun. Soil Sci. Plant Anal.* **2000**, 31 (9–10), 1299–1396. **DOI: 10.1080/00103620009370514**.

For more information visit us at
SigmaAldrich.com/test-strips

For MQuant® StripScan see
SigmaAldrich.com/mquant-stripscan

Featured Products

Description	Cat. No.
MQuant® test strips	
MQuant® Nitrate Test	**1.10020**
Products for sample preparation	
Calcium chloride dihydrate for analysis EMSURE® ACS, Reag. Ph Eur	**1.02382**
Distilled water (e.g., from a suitable Milli-Q® system) or water for analysis	**1.16754**

To place an order or receive technical assistance:
SigmaAldrich.com/support

For local contact information:
SigmaAldrich.com/offices

MilliporeSigma
400 Summit Drive
Burlington, MA 01803

SigmaAldrich.com

MS_AN14475EN Ver. 1.0 71086 07/2026