

On-farm Soil Nitrate Test

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Summary. A simple on-farm test for determining residual soil nitrate has been developed. The procedure is reliable, rapid, inexpensive and requires only small investments. Soil samples representative of the field site and the crop specific soil depths are composited and well mixed. A 1:2 moist soil/0.01 M CaCl₂ extractant ratio is used. The mixture is vigorously hand-shaken for one minute and then allowed to settle for 15-30 minutes. Nitrate is directly measured in the unfiltered supernatant. Close agreement between ion chromatography and quick test was obtained at concentrations of 2-90 mg L⁻¹ NO₃⁻. Soil water content is measured on a separate subsample by weighing before and after drying soil samples. By using estimates for soil bulk density and coarse gravel content, nitrate concentrations in the extract can easily be converted to kg NO₃-N ha⁻¹.

Introduction. Numerous studies have demonstrated that crop yield and quality can be improved when N fertilizer recommendations take residual NO₃⁻ measurements into account. A soil N test that accurately accounts for different N mineralization in soils would greatly aid in the development of N management systems that minimize environmental impacts. At present, there is no model available which reliably predicts N mineralization in soils. Computer models need estimations of soil NO₃⁻ levels to initialize the model. A rapid, simple and inexpensive test could repeatedly be used for estimating temporal and spatial variability of soil nitrate content and thus reflect N mineralization in soils. Currently recommended rapid nitrate tests are too imprecise at nitrate levels most frequently encountered in soil and laboratory measurements are unattractive to many farmers because of costs and time constraints. On-farm measurements could be highly instructive for farmers and lead to significant improvements in N management.

Results and Discussion. The measuring method is similar to a recently described reflectometric quick test method (1,2,3). However, this test is appropriate only for detecting fairly high soil nitrate contents (detection limit 5 mg NO₃-N kg⁻¹ dry soil) and yields rather semi-quantitative information according to our experience. Very recently, substantial technical improvements have resulted in significantly improved nitrate test strips (Reflectoquant 16995, E. Merck, Darmstadt, Germany) and an improved reflectometer (RQflex, E. Merck, Darmstadt, Germany). The method suggested in this paper has been developed for measuring nitrate contents in field-moist soil samples immediately after sampling. This procedure is to be preferred because drying of soil samples or unsuitable handling of moist soil samples can increase nitrate content due to unwanted mineralization.

Soil samples representative of the field site have to be taken in crop specific depths as recommended by the N_{min}-method or the pre-side N-test. Whereas a shovel is well suited for sampling the surface 30 cm of soil, an auger is needed for sampling lower soil depths (30-60 cm, 60-90 cm). Composite moist soil samples should be well mixed which is best achieved by sieving (e.g. with a 10 mm mesh width sieve). Extraction of nitrate from soil samples is immediately performed after sampling. Otherwise, soil samples should be transferred to cooling

boxes. For longer storage times, freezing of moist soil samples is required. A subsample of 75 g moist soil, weighed to 1 g precision, is placed into a 250 mL flask and 150 mL extractant (0.005-0.01 M CaCl_2 or distilled water) added and the capped vial thoroughly shaken for 1 minute. CaCl_2 is preferred as extractant because it flocculates suspended soil. With loamy soils, a sufficient amount of clear supernatant is obtained after 15 to 30 minutes settling time. Nitrate is either directly measured in the supernatant or in an approximately 10 mL aliquot decanted in a clean vial cap. The nitrate test strip is immersed for 2 seconds in the sample solution and thereafter inserted into the strip adapter. The stored reaction time is 60 seconds. No filtering is required. Yellow-brownish coloration of the test solution caused by humic/ferrous compounds did not interfere with the measurement. Comparable nitrate values could also be obtained with distilled water as extractant but required longer settling times. Close agreement between ion chromatography and quick test was obtained at concentrations of 2-90 $\text{mg L}^{-1} \text{NO}_3^-$. For converting nitrate contents to kg N ha^{-1} estimates of the water content, bulk density and gravel content are required. As an example, in a stoneless soil (with 25 % gravimetric water content and a bulk density of 1.2 g cm^{-3}) $1 \text{ mg L}^{-1} \text{NO}_3^-$ corresponds to $1.5 \text{ kg NO}_3\text{-N ha}^{-1}$ for a 20 cm soil layer. Soil water content is determined on a separate subsample by weighing before and after drying soil samples. We have further developed a procedure using a graduated specimen vial technique which does not require any weighing for determining soil water content, weight of soil samples and amount of extracting solution. As a result, the method has considerable potential for use by field consultants, fertilizer dealers or farmers.

Literature Cited.

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