HOW TO USE THE NITRATE QUICK TEST

Standard Operating Procedures prepared for the Grower-Shipper Association of Central California by Stefanie Kortman with the assistance of Marc Los Huertos
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Purpose of On-farm Nitrate Testing

In-field nitrate quick tests (NQTs) can be a cost effective tool to determine residual soil nitrate-nitrogen concentration and make fertilizer management decisions to match crop demand. Performing the NQT method requires no formal training, but does require the proper equipment and careful attention to follow the method. When done correctly, the test can provide a reasonably accurate estimate of residual soil nitrate-nitrogen, which can be used to improve fertilizer management decisions to meet crop needs.

DISCLAIMER

This is provided as a guide. As a compilation of existing research and resources, the GSA and its consultants can provide no guarantees regarding the performance of the test or the crops that the tool is being used to manage.

Overview of Method

The method for using in-field NQTs involves five main steps, and generally requires 30-60 minutes to complete:

1) Prepare a simple solution to extract nitrate from the soil.

2) Sample the soil in a field.

3) Add soil to the extracting solution.

4) Dip a test strip in solution and read the result.

5) Interpret the result for nitrate-nitrogen according to soil type and moisture.

Recommended Frequency of Performing Nitrate Quick Tests

The University of California Cooperative Extension (UCCE) has determined that testing for nitrate during early growing season and prior to the first in-season N application may provide potential to reduce fertilization rates and increase N efficiency. On the other hand, for maximum N efficiency NQT sampling can occur as often as necessary to reduce unnecessary fertilization. Table 1 provides a summary of the recommended frequency of NQT sampling according to experience with on-farm nitrate testing.

Table 1. General recommendations from the UC Cooperative Extension for when to perform NQT sampling based on experience with on-farm sampling and testing.

Experience with NQT Sampling	Frequency of NQT Sampling
Beginner	Early growing season prior to first in-season fertilization.
Experienced	At minimum- early growing season prior to first in-season fertilization. Additionally, as often as necessary[1,2] or resources permit.

[1]Longer-season crops may require up to 3 samplings to inform fertilization decisions.
[2]Lettuce growers will benefit from the early season sampling prior to first in-season fertilization in addition to a second test 2-3 weeks later.

Materials[1]

Supply	Retailer
Distilled Water	Orchard Supply
Calcium chloride (aquarium grade OK)	Pet stores or Amazon
Volumetrically marked centrifuge tubes	Cole Parmer
Soil sampling probe	Amazon
Bucket	Home Depot
Nitrate quick test strips[2]	Hach, Ben Meadows, Cole Parmer

[1]For more information on materials, please refer to the Cost Analysis of Nitrate Quick Test Program
[2]Retailer information corresponds to Hach, LaMotte, and Merckoquant test strips, respectively.

Soil Sampling Procedure

The goal for soil sampling is to collect many representative samples from the crop field or area in which nitrate assessment is needed, consolidate the soil samples, and combine subsamples of the soil with the extracting solution to determine nitrate and/or nitrate-nitrogen (crop-available nitrogen) concentration in soil. **If soil samples do not cover a representative area of the field, NQT results may be unreliable.**

Step 1: Using a soil probe and bucket, collect soil from throughout a crop field or area of interest, sampling soil in an "X" or "N" shape pattern that covers the sides of a field and through the middle. Field-scale results from the NQT will be more accurate the more random the sampling, and the greater the area from which samples are taken. Use Table 2 to determine how many soil samples to collect.

Table 2. Collect soil samples according to observed degree of spatial variability in your crop area/field.

Degree of spatial variability	# Soil Cores to Collect
Low variability	8-12
High variability*	15-20

**High spatial variability includes differences in soil type and/or texture (e.g. sandy, rocky, clay sections of a block); unevenness in plant establishment, irrigation and/or fertilization uniformity; uneven pest pressure; differences in drainage, slope, and/or crop residue present in the soil. If any of these factors of variability are present, or there is concern for nitrate-nitrogen differences, consider dividing the field into separate sections for soil sampling, or at the very least collect the recommended number of soil cores for high variability.*

If you do not know the soil type on your farm, you can use this link to navigate to the NRCS Web Soil Survey where you can easily input your region or even specific address to find the soil type(s) on your farm. Additionally, you can obtain a printed soil survey from the NRCS, USDA office, or local conservation office, or access a Web version. There is also a free smartphone app called SoilWeb, maintained by the Soil Resource Laboratory at UC Davis, and will provide the soil type for the ground over which you stand while using the app.

Step 2: Insert the soil probe at an angle starting at the seedline and toward the fertilizer band or drip tape (Figures 1, 2, 3). The degree of the angle will depend on where in the bed the seedline and fertilizer band or drip tape are. Collect soil at a depth according to root zone depth, as described in Table 3. A soil probe may be difficult to use in heavy clay soil; an alternative to the soil probe is a sampling trowel that can be used to obtain soil samples to the recommended depth.

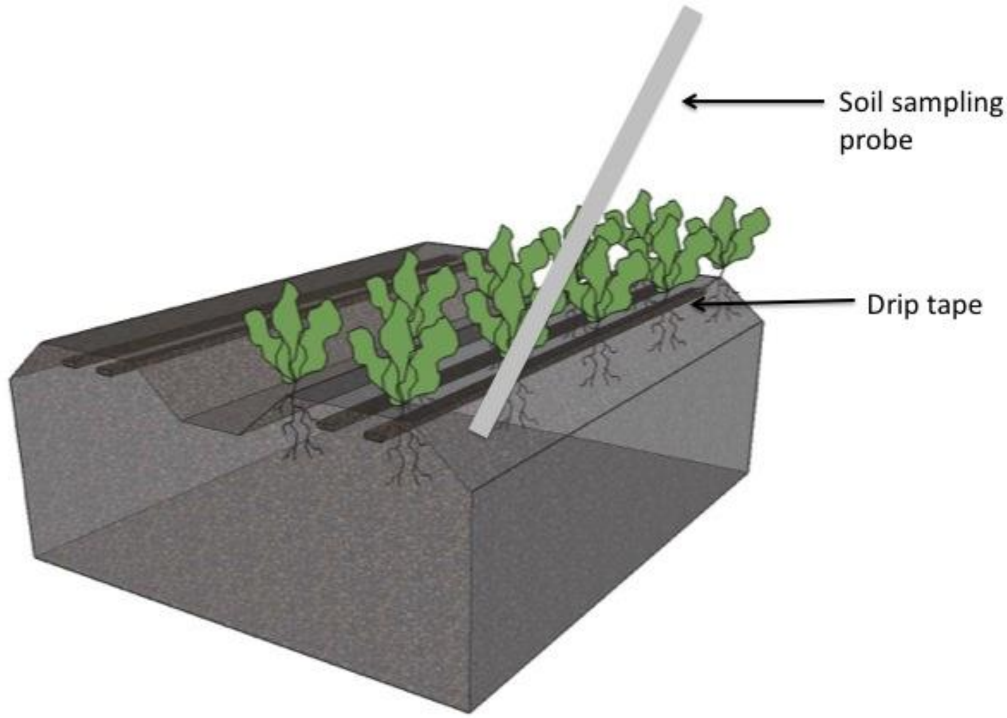

Figure 1. Example of proper soil probe placement in a bed with two lines of subsurface drip tape, where soil probe is inserted at an angle starting at the seedline and extending into the bed below the drip tape. Soil probe insertion depth depends on if plant is shallow vs. deeper rooted; 12-inch depth for deeper rooted, 6-inch for shallow. Sampling should not be restricted to one side of the bed, but should alternate either side throughout the field. Soil sampling technique would be the same with surface drip tape, or with a trowel in place of a soil probe.

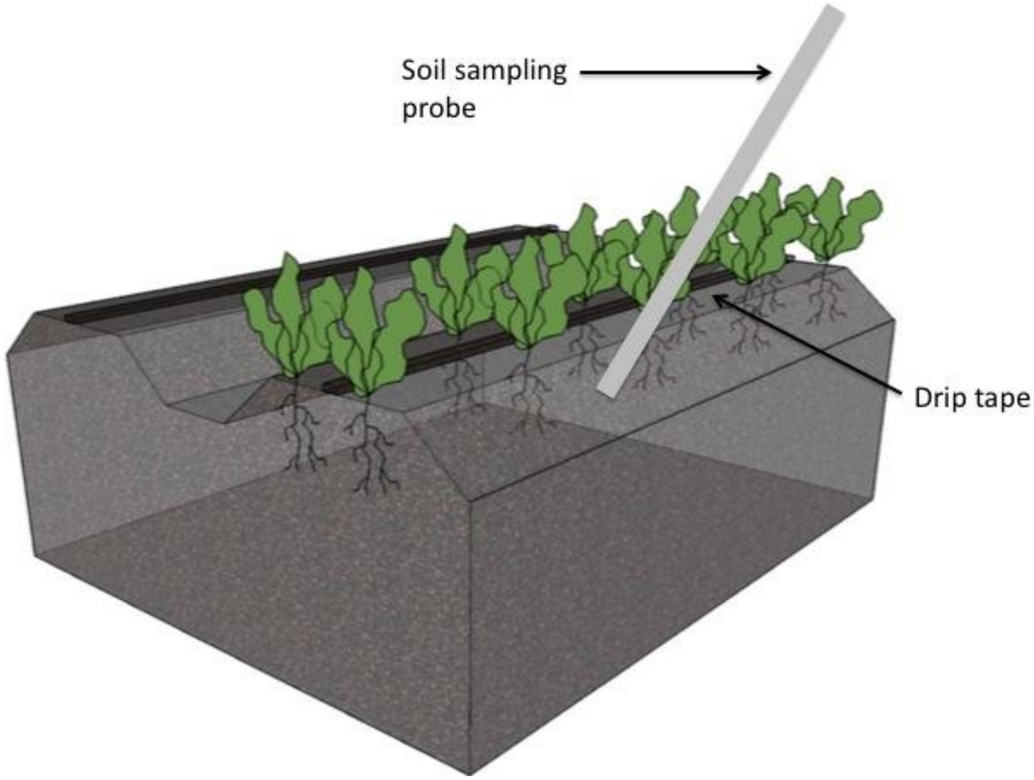

Figure 2. Example of proper soil probe placement in a bed with one line of surface drip tape, where soil probe is inserted at an angle starting at the seedline and extending into the bed below the drip tape. Soil probe insertion depth depends on if plant is shallow vs. deeper rooted; 12-inch depth for deeper rooted, 6-inch for shallow. Sampling should not be restricted to one side of the bed, but should alternate either side throughout the field. Soil sampling technique would be the same with sub-surface drip tape, or with a trowel in place of a soil probe.

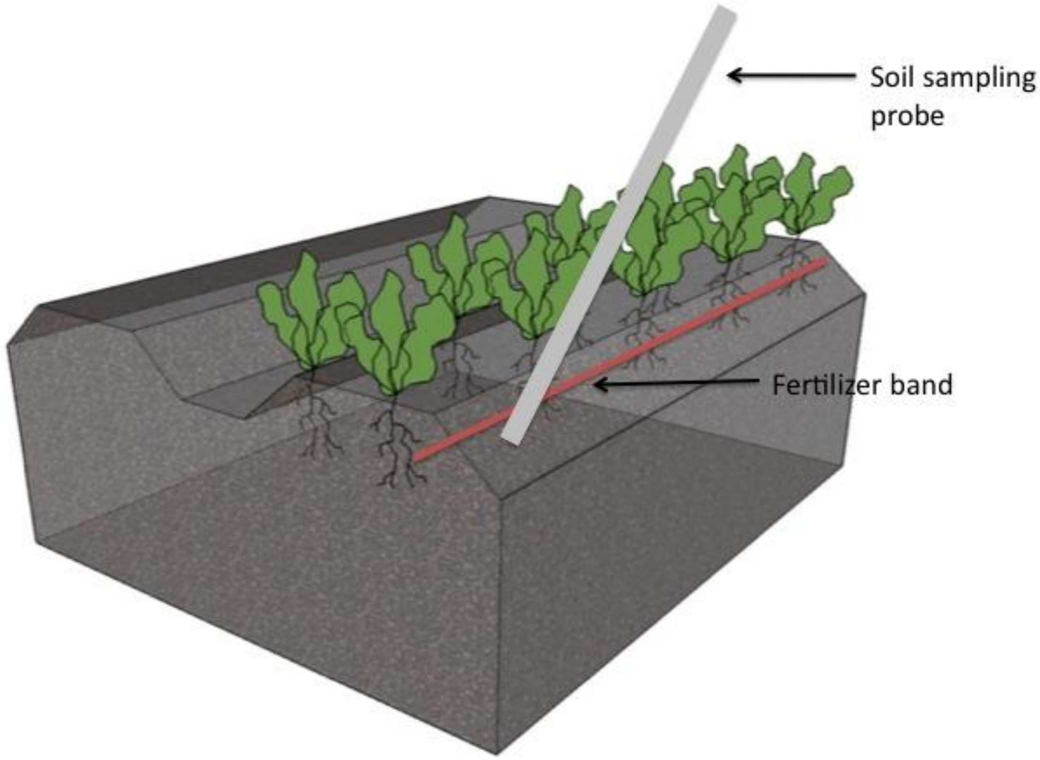

Figure 3. Example of proper soil probe placement in a sprinkler-irrigated system, where soil probe is inserted at an angle starting at the seedline and extending into the bed below the fertilizer band (but NOT immediately after fertilization). Sampling should not be restricted to one side of the bed or fertilizer band, but should alternate either side throughout the field. Soil probe insertion depth depends on if plant is shallow vs. deeper rooted; 12-inch depth for deeper rooted, 6-inch for shallow, or with a trowel in place of a soil probe.

Table 3. Depth at which to collect soil sample according to crop type

General Root Depth	Depth of Soil Sample
Non-shallow rooted crops	12 inches
Shallow-rooted crops (beans, baby lettuce, beets, grains, spinach)	6 inches

Avoid sampling from zones where fertilizer was recently applied, and where soil is too dry for root activity.

Step 3: Accumulate soil cores in a bucket. *For all soil cores, the top 2 inches of soil should be removed from the core before consolidating*, as the soil from this zone may contain high nitrate, but is unavailable for plants to access if soil is dry. When sampling is complete, homogenize soil cores by thoroughly mixing and breaking up clods. Remove any large plant material and/or rocks.

If soil is too difficult to homogenize, such as with heavy clay or gummy wet loam soils, use the "pinch" method:

1) Lay out soil cores, remove top 2 inches of each core, and pinch off small amounts from up and down the cores.

2) Mix the pinches together to equal the amount needed to add to the extracting solution (as described in "Nitrate Testing" section below).

Nitrate Testing Procedure

Step 1: Make the extracting solution by adding roughly 6 grams (about 1 teaspoon) of the calcium chloride to one gallon of distilled water, and mix thoroughly until dissolved. One gallon of distilled water and 5.6 grams of calcium chloride will be sufficient for approximately 125 tests.

Step 2: Fill volumetric container to 30 mL mark with the solution.

The above two steps can be done in advance, where the extracting solution is stored in a fridge or at room temperature for several months.

Step 3: Add soil to the container until the solution level is at the 40 mL mark. Cap container tightly and shake vigorously until all soil is broken up and dispersed in solution.

Step 4: Allow sample to sit and soil particles to settle out. This may take a few minutes or up to an hour depending on the soil type; clay soils take longer.

Soil **should not** sit in solution for more than an hour, as soil microbes continue to transform nitrogen into the nitrate form even in solution. If soil sits in solution too long, the nitrate quick test results may reflect a final nitrate concentration that is more than what is actually present in the field, and results may not be representative of the soil you sampled.

Step 5: Dip the nitrate test strip into the clear solution near the top of the container, remove after one second and shake off excess solution on the strip. Wait 60 seconds, then compare the color on the test strip to the standard color chart provided by the test strip manufacturer. It is very important this comparison be done in good light, with a test strip that is NOT expired (expiration date is on test strip container), and IMMEDIATELY after 60 seconds from the time the test strip was dipped in solution, as the test strips may continue to develop color with time. If the color on the test strip is between 2 of the standard color chips, estimate the value of NO3/NO3-N based on the intensity of color on the test strip. For more accurate results, run duplicate samples for each field/soil type.

Interpreting the Results of Nitrate Quick Test Strips

Nitrate test strips may be calibrated in different units; the LaMotte Instatest and Hach Aquacheck test strips show results in equivalents of parts per million (ppm) nitrate-nitrogen (NO3-N); the Merckoquant test strips show results in ppm of nitrate (NO3). The following calculations in Steps 1-2 apply to the test strips that show results in ppm of nitrate (NO3). You must perform basic calculations to determine what the test strip result means for your soil/crop/field.

For more detailed information from the UCCE on what NQT result may mean for your crop and soil in terms of the rate of crop N uptake and how to time fertilizer application accordingly, please refer to the document in Appendix A. Additionally, the Nitrate Groundwater Pollution Hazard Index can provide information to farmers interested in voluntary management practices that reduce nitrogen contamination potential in groundwater.

Determine the Correction Factor

Step 1. **Skip this step if the test strip provides results in ppm nitrate-nitrogen (NO3-N), such as with LaMotte Instatest and Hach Aquacheck test strips.*

If the test strips are calibrated in parts per million (ppm) of nitrate (NO3), you will need to convert the strip reading to ppm nitrate-nitrogen (NO3-N) on a dry soil basis to determine the amount of nitrogen available to the crop. First, find the correction factor for your soil type using the chart below, and considering if your soil was wet or dry when you sampled. Dry soil will appear lighter in color, will break up more easily, and may be powdery. Moist soil will be darker in color and should hold together well.

Table 4. Correction factors for converting results from NQT to ppm nitrate-nitrogen. Use the correction factor based on soil condition at time of sample (moist or dry) and soil texture. Take an average of correction factors for multiple soil texture types if your soil includes those.

	Correction Factor	
Soil Texture	**Moist Soil**	**Dry Soil**
Sand	2.3	2.6
Loam	2	2.4
Clay	1.7	2.2

Example 1: The soil you sampled from is classified as Chualar loam, and the soil was moist when you collected the sample, thus the correction factor would be 2.

2 (for moist loam) = <u>2 correction factor</u>

Example 2: If your soil is classified as more than one texture type, calculate the average of the correction factors for each texture. To do this, add the correction factors for each soil texture present in your soil and divide by the number of soil types.

Your soil is moist Gorgonio **sandy loam**, so your correction factor can be found by:

2.3 (for moist sandy) + 2 (for moist loam)= 4.3

4.3 ÷ 2 (for 2 soil texture types) = 2.15 correction factor

Determine the concentration (ppm) of nitrate-nitrogen (NO3-N) on a dry soil basis

Step 2. **Skip this step if the test strip provides results in ppm nitrate-nitrogen (NO3-N), such as with LaMotte Instatest and Hach Aquacheck test strips.* Convert the strip reading to ppm nitrate-nitrogen (NO3-N) on a dry soil basis by dividing by the correction factor. Test strip reading (ppm NO3) ÷ correction factor = ppm NO3-N in dry soil

Example 1. Using the soil from Step 1 Example 1 (Chualar loam, correction factor=2), and a nitrate quick test trip reading of 15 ppm NO3, the calculation would be:

15 ÷ 2 = 7.5 <u>ppm NO3-N in dry soil</u>

Convert test strip result from ppm NO3-N in dry soil to pounds of available nitrogen per acre available to the crop

Step 3. [Optional] Determine the pounds of available nitrogen per acre in your sample. To do this, use the result from Step 2 (7.5 ppm NO3-N) to convert Nitrate-N in the soil to pounds of available nitrogen per acre in a 12" sample by multiplying the result from Step 2 by a correction factor of 4.

ppm NO3-N in dry soil × 4 = pounds of nitrogen per acre available to the crop

7.5 × 4 = 30 pounds of nitrogen per acre available to the crop

If you collected soil sampled to a 6-inch depth, multiply by a correction factor of 2 instead of 4.

7.5 × 2 = 15 pounds of nitrogen per acre available to the crop

Sample Scenarios

Scenario 1: Moist soil is collected at a 12" depth from a crop field. You know your soil is silty clay loam, and assume equal parts clay and loam. You used nitrate test strips calibrated in parts per million (ppm) of nitrate (NO3), and the result on the test trip was 35 ppm NO3.

Step 1.
Determine the correction factor for your soil.

2 (for moist loam) + 1.7 (for moist clay)= 3.7

3.7 ÷ 2 (for 2 soil texture types) = 1.85 correction factor

Step 2.
Convert the strip reading of 35 ppm NO3 to ppm Nitrate-N (NO3-N) on a dry soil basis by dividing the strip result by the soil correction factor.

35 ÷ 1.85 = 19 ppm NO3-N in dry soil

Step 3.
Determine the pounds of available nitrogen per acre in your sample by multiplying the result from Step 2 by 4 (for 12" soil sampling depth).

19 × 4 = 76 pounds of nitrogen per acre available to the crop

Scenario 2: You used the Web Soil Survey to determine the soil type on your field. The result, as seen in Figure 2 below, is that your crop block includes two different soil types, Clear Lake clay and Pico fine sandy loam, distributed unevenly throughout the field. For the most accurate NQT results possible, at a minimum the field should be sampled in 2 parts, thus you collect 15-20 random soil samples across the two sections of Pico fine sandy loam, and another 15-20 random soil samples throughout the Clear Lake clay section.* You assume 40% of the field is Pico fine sandy loam, and 60% is Clear Lake clay. Dry soil is collected at a 6" depth. You used nitrate test strips calibrated in parts per million (ppm) of nitrate (NO3) (Merckoquant test strips) and the result on the test trip was 15 ppm NO3.

**It is also important to use your own knowledge of your farm system to determine sampling needs. Consider how NQT soil sampling could be achieved to account for differences in management and/or in the soil environment that may influence the presence or absence of nitrogen available to the crops. An additional consideration is to redesign a block of field for planting based on one, or similar, soil type.*

Map Unit Legend

Monterey County, California (CA053)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Cg	Clear Lake clay, moderately wet	5.2	60.3%
Pf	Pico fine sandy loam	3.4	39.7%
Totals for Area of Interest		**8.6**	**100.0%**

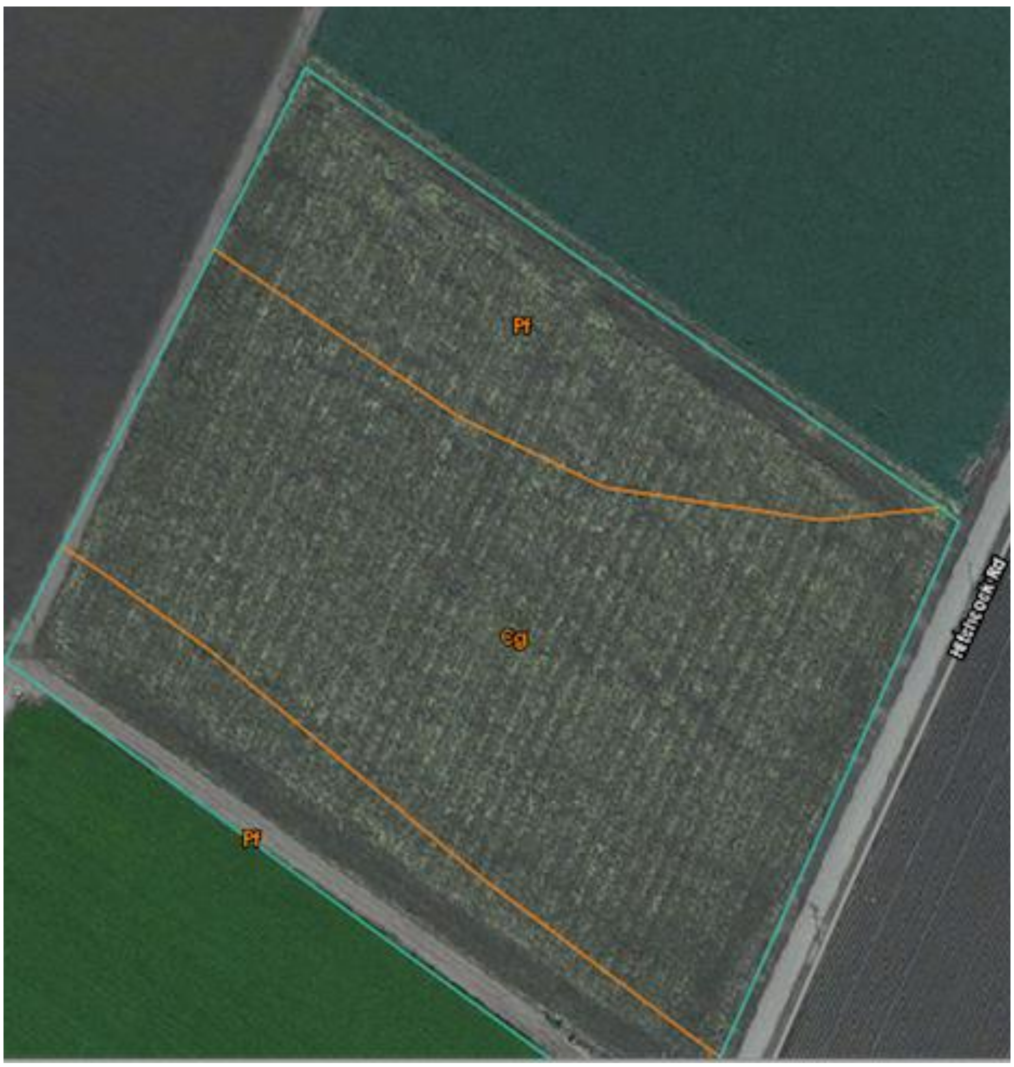

Figure 4. Example of output (cropped for better viewing) from the Web Soil Survey, including a table and a map of the soil types in a user-defined area.

Step 1.

Determine the correction factor for your soil based on dry soil constituents and estimated percent cover.

Pico fine sandy loam (estimated 30% cover in field):

2.6 (for dry sand) + 2.4 (for dry loam) = 5

5 x 0.4 (for 40% cover) = 2

Clear Lake clay (estimated 60% cover in field):

2.2 (for dry clay)

2.2 x 0.6 (for 60% cover) = 1.3

Add correction factors for different soil types together to get the total correction factor:

2 (correction factor for Pico fine sandy loam) +

1.3 (correction factor for Clear Lake clay) = 3.3 total correction factor

Step 2.

Convert the strip reading of 15 ppm NO3 to ppm Nitrate-N (NO3-N) on a dry soil basis by dividing the strip result by the soil correction factor.

15 ÷ 3.3 = 4.5 ppm NO3-N in dry soil

Step 3.

Determine the pounds of available nitrogen per acre in your sample by multiplying the result from Step 2 by 2 (for 6" soil sampling depth).

4.5 × 2 = 9 pounds of nitrogen per acre available to the crop

References

- Details on the Nitrate Quick Test - Salinas Valley Agriculture. Richard Smith, ANR Blogs. Click here for link to blog.
- Soil Nitrate-Nitrogen Quick Test. Agriculture Water Quality Alliance. Click here for link to PDF.
- Accuracy of test strips for assessing nitrate concentration in soil and water. Michael Cahn, Thomas Lockhart, Laura Murphy, UC Cooperative Extension. Click here for link to PDF.

This document is a synthesis of the works cited above, and respectful credit is given to these authors and organizations for their contributions to establishing NQT protocols and interpreting results.

Appendix A

Cost Analysis of Nitrate Quick Test Program: What are the True Costs to Growers? Click here for link to PDF in English or Spanish.

Appendix B

In-season soil nitrate testing explained. Tim Hartz, UC Davis, and Richard Smith, Monterey County UCCE. Click here for link to PDF in English or Spanish.