

In-season soil nitrate testing explained

Tim Hartz, UC Davis and Richard Smith, Monterey County UCCE

The recent adoption of the new 'Ag Order' by the Central Coast Region Water Quality Control Board has increased interest in management practices that can help growers reduce nitrogen fertilization. In-season soil nitrate testing is one such practice; we have conducted dozens of field trials showing that testing soil for residual nitrate-nitrogen ($\text{NO}_3\text{-N}$) prior to sidedressing or fertigation can reliably identify fields in which N application can be reduced or postponed. UC has promoted a value of 20 parts per million (PPM) residual soil $\text{NO}_3\text{-N}$ in the root zone of vegetable crops as the action threshold. Above that level no N fertilization is required *at that time*; below that threshold, some application may be appropriate. In our contacts with growers and consultants it is clear that there are a number of questions about how to safely and efficiently use in-season soil nitrate testing. Here are answers to some questions that we have been asked repeatedly.

1. Does the 20 PPM $\text{NO}_3\text{-N}$ threshold work for all crops?

This threshold is broadly applicable across a range of common vegetable crops. That is because 20 PPM represents enough N to supply crop N uptake requirements for an extended period of time. If you take a sample of the top 12 inches of soil, that sample will represent approximately 4,000,000 lb of soil per acre; if that soil has a $\text{NO}_3\text{-N}$ concentration of 20 PPM, then the soil contains about 80 lb $\text{NO}_3\text{-N}$ per acre. Cool season vegetable crops have a characteristic N uptake pattern. During the first half of the growing season plants take up N slowly, typically no more than 1-2lb N/acre/day. Therefore, when a soil nitrate test is taken prior to first sidedressing, a 20 PPM $\text{NO}_3\text{-N}$ value means that crop N uptake can be easily met for at least 2-3 weeks just from residual soil nitrate. From midseason until harvest, crop N uptake is much faster, 3-4 lb N/acre/day for lettuce and up to perhaps 5-6 lb N/acre/day for celery and brassica crops. A soil test taken at midseason would indicate that sufficient N is available for a couple of weeks. *The 20 PPM threshold does not apply to strawberries, which have a low N uptake rate, and can thrive with a lower level of available soil N. Also, spinach presents special challenges, which we will address in a subsequent article.*

2. Does a 20 PPM $\text{NO}_3\text{-N}$ test result mean the same thing in all fields?

Two field characteristics should be considered when evaluating an in-season soil $\text{NO}_3\text{-N}$ test result. First, what is the nitrogen supplying power of the soil? In general, soil with higher organic matter content, or in which a large amount of vegetable crop residue has recently been incorporated, will supply more nitrogen over time, thereby reducing the rate at which the current crop will deplete the residual soil $\text{NO}_3\text{-N}$. A soil with > 2% organic matter will mineralize more crop-available N than a soil with < 1%; a field in which the prior crop was spring mix will mineralize less N than a field in which the prior crop was broccoli (which leaves vastly more crop residue than spring mix). The other major factor is irrigation. A heavy textured soil being drip irrigated is likely to have much less leaching than a sandy soil being sprinkler irrigated. Where heavy leaching is experienced, the soil nitrate test would have to be repeated to ensure accuracy.

3. Do I need to maintain at least 20 PPM NO₃-N in soil throughout the growth cycle for crops to grow at a peak rate?

Absolutely not. The whole point of the test is to determine whether there is enough available soil N to carry the crop for an extended period of time. Vegetable crops can grow at peak rates until soil NO₃-N concentration is depleted to a much lower level. In evaluating the soil NO₃-N concentration at harvest in the many lettuce fertilization trials we have run, high yields were often achieved with N treatments in which soil NO₃-N ended up between 5-10 PPM at harvest. This is an important point, because if fields are managed to maintain at least 20 PPM NO₃-N right up to harvest, then a large amount of soil nitrate will be available to be leached by the germination water of the following crop, or by winter rainfall.

4. If my residual soil NO₃-N is below 20 PPM, does that mean I should apply my full N sidedress rate?

For maximum efficiency of fertilizer N recovery by the crop, it makes more sense to scale your application depending on the soil value. As previously explained, a foot of soil weighs about 4,000,000 lb/acre, so each PPM NO₃-N on a soil test represents about 4 lb N/acre. In theory, you could tailor your N application rates exactly using this relationship. However, it is more realistic to use a system in which you apply a half rate if the soil test is between 10-20 PPM, and a full rate if the test is less than 10 PPM.

5. How do I collect a sample that is representative of the root zone?

This can be a complicated topic. When sampling is performed at an early growth stage, before a sidedress or fertigation has been done, sampling in the plant row will generally do a good job. However, once an N application has been made, the soil nitrate is not uniformly distributed throughout the bed, and your sampling technique must attempt to represent the overall condition. Because different growers use different configurations of knives on sidedress rigs, and have different combinations of bed width/number of plant rows/number of drip tapes, there is no sampling protocol that works for everyone. Obviously, zones of recent banded application need to be avoided and, in the case of drip irrigation, areas of the bed that remain too dry for root activity should be avoided as well.

6. How often should soil NO₃-N sampling be done?

From the standpoint of achieving maximum N efficiency, the answer is as often as necessary to ensure that unnecessary N fertilization is minimized. For lettuce, a system of soil sampling prior to the first sidedress or fertigation, and a second test 2-3 weeks later, would provide sufficient information with which to efficiently schedule N applications throughout the season. Longer season crops like celery or cauliflower may require up to 3 samplings to inform fertilization decisions. As a practical matter, soil sampling prior to the first in-season N application offers the greatest potential for reducing fertilization rates, and increasing N efficiency. While repeat samplings can be beneficial, the logistics of sampling multiple times per crop, and responding to those results, can be challenging. Particularly for growers who have no experience with in-season soil sampling, we recommend beginning with only an early season sample. Once that practice has been integrated into your management routine, in-season sampling can be expanded.