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418-016

Nitrogen Soil Testing for Corn in Virginia

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Nitrogen and Corn Production

An adequate supply of plant-available nitrogen is crucial for efficient corn production, and corn requires more nitrogen than it does any other nutrient. The nitrogen recommendation for a corn crop yielding 150 bushels per acre is 150 pounds of nitrogen per acre, or 1 pound of nitrogen per bushel of grain.

Nitrogen use efficiency is the percentage of applied nitrogen (N) that is actually taken up by the crop. Nitrogen use efficiency is normally 50-60 percent but can be as high as 75 percent with proper N timing and placement. Costs of N fertilizer and environmental concerns about nitrate (NO_3) from fertilizer, manure, and other nutrient sources leaching into groundwater require that farm managers implement any tool possible to improve the use of all N sources available to the corn crop.

Many sources of N can be used by corn. Residual N is N that is carried over in the soil from one growing season to the next, and this N source may supply as little as 10 percent or as much as 100 percent of the crop's total N need. Residual N in plant-available forms is generally low under Virginia's climatic conditions because it tends to leach out of the root zone as NO_3-N during the winter and early spring months; however, residual N can meet a significant portion of a subsequent corn crop's need in silty and clayey soils, which retain more N than sandy soils. Most residual N is found in organic forms such as animal manure, legume forage and cover crops, and biosolids (municipal wastewater treatment sewage sludge).

In organic forms, N becomes available to the crop as the organic matter is mineralized (decomposed) by soil organisms. Mineralization of organic matter and release of N increases as soil warms in the spring.

When little N is available from animal manure, biosolids, or legumes, the majority of the crop N requirement must be supplied by mineral fertilizer sources such as urea ammonium nitrate solution, urea, ammonium nitrate, or ammonium sulfate.

Nitrogen Behavior and Soil Testing

Soil testing is an economically and environmentally beneficial practice for determining the availability of phosphorus, potassium, and other nutrients. However, in contrast to recommendations for other nutrients, nitrogen recommendations for corn grown in the middle Atlantic and southeastern states have not been based on traditional soil test calibration methods for two reasons. First, predicting the availability of organic N to crops has not been successful due to variability in weather and other factors. Second, the storage of soil mineral N is often too brief due to the winter and spring leaching losses of the mobile NO_3-N form that occur during the season's high rainfall and moderate soil temperatures. Nitrogen analysis of animal manures, biosolids, and legumes to predict the amounts of N available for crops has been only partly successful, which accentuates the need for a soil N test.

Nitrogen behavior in the soil is difficult to predict because N transformations in soil are very complex (figure 1). Over 98 percent of the N in most soils is unavailable for plant uptake at any specific time because it is fixed in soil organic matter or in clay minerals. Nitrogen in organic matter (e.g., plant residue, cover crops, animal manure, or biosolids) may undergo microbial transformations that convert it to a plant-available form. The end result of this process is the NO_3 form of N. The transformation rate of organic

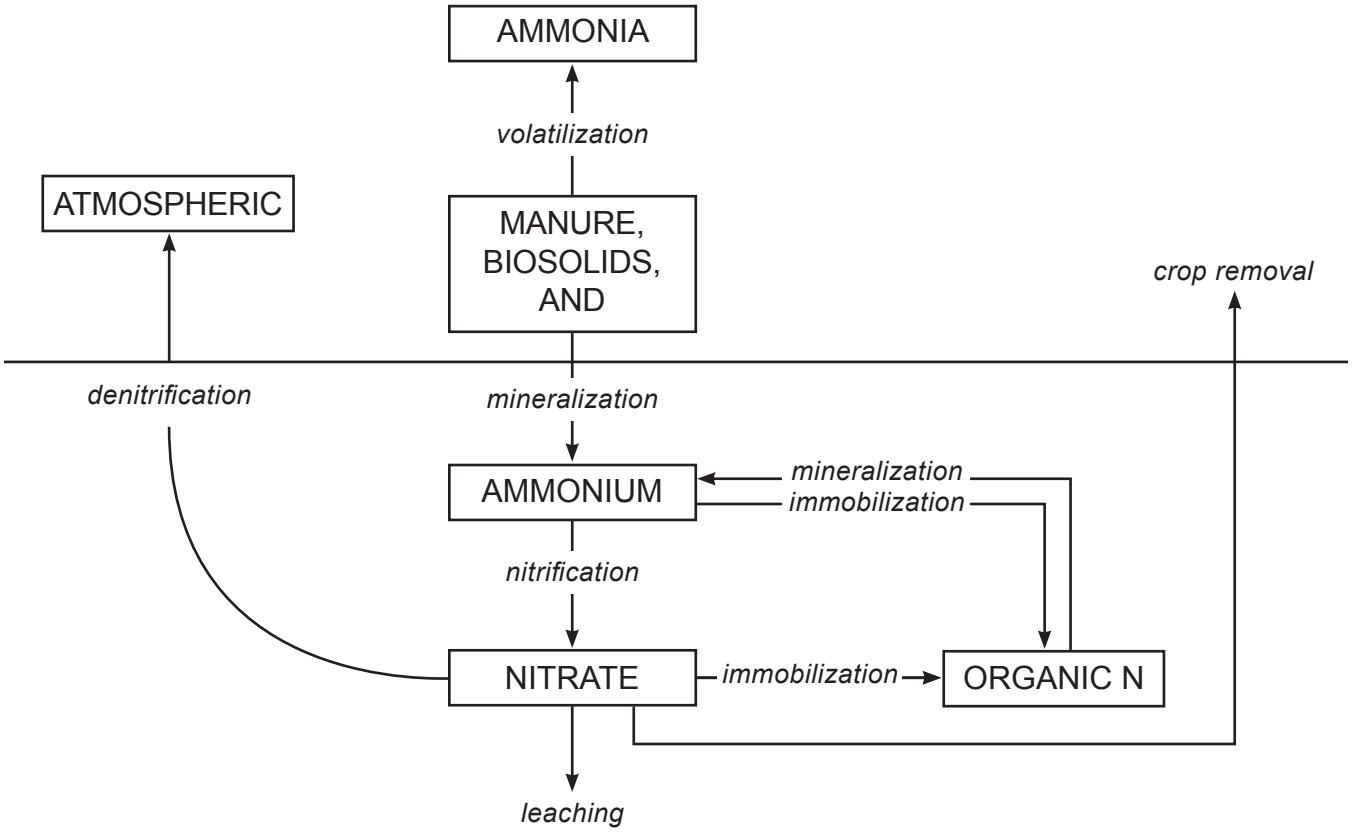

Figure 1. Nitrogen transformations in soil

N to plant-available NO_3 in the spring increases as the soil temperature increases, and meaningful amounts of plant-available N can be mineralized from organic N beginning in mid-May in eastern Virginia to mid-June in western Virginia.

The behavior of N in the soil has several important implications for efficient N management of corn. Corn requires only small amounts of N during the first month of growth because the plants are small (figure 2). Nitrogen applied before planting or released from organic matter during early spring can be lost by leaching during this time when the plants' N requirements are low, soil moisture is high, and root systems are small. Therefore, only small amounts of starter N (less than 50 pounds per acre) should be applied prior to or at corn planting to meet the N needs of the crop for the first 30-45 days following emergence. Any additionally required N can be applied as a sidedressing when the corn is 12 to 24 inches tall.

In Virginia, soil testing before the growing season, as is practiced for other nutrients, does not accurately reflect the availability of N when it is most important to the crop (i.e., 30 to 45 days after emergence). The NO_3-N soil test procedure outlined below is more effective because it relies on sampling and testing after the crop has emerged and grown for several weeks. The concentrations of soil NO_3-N measured by this procedure are the result of many complex reactions affecting soil N and are more closely related to the need for supplemental N fertilization than any other procedure tested to date.

Pre-sidedress Soil Nitrate Test

The pre-sidedress soil nitrate test (PSNT) is based on sampling of the surface 1 foot of soil after the soil has begun to warm and before the corn begins its most rapid growth rate (i.e., when corn is 10 to 15 inches tall at the whorl). The amount of NO_3-N in the

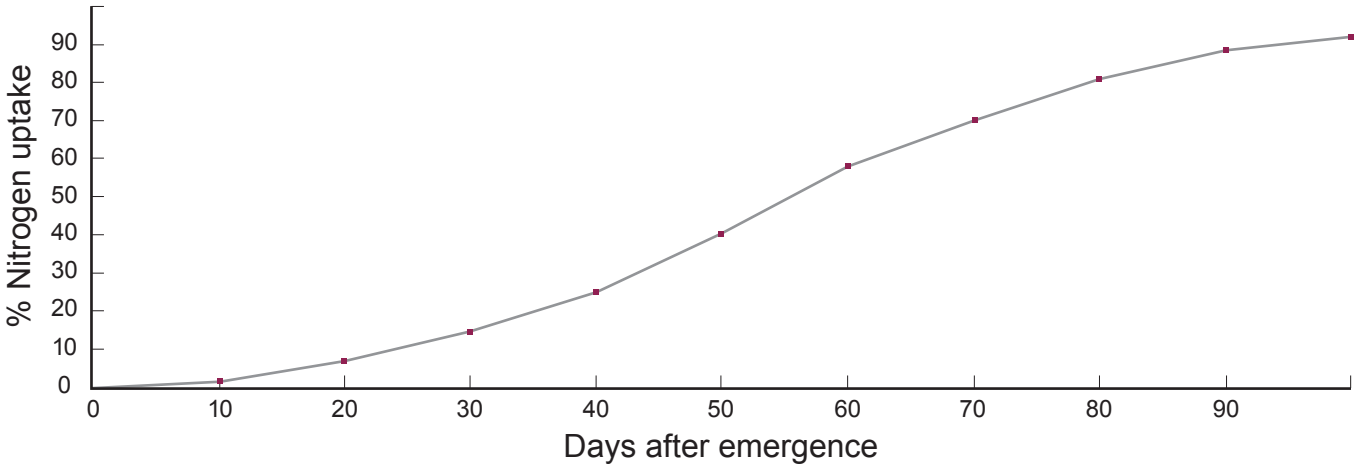

Figure 2: Corn's nitrogen uptake after emergence

soil sample is an accurate index of plant-available N, and sidedress fertilizer N recommendations can be modified depending on the concentration of NO_3-N found in the soil. Data from 47 field research experiments conducted in the Coastal Plain, Piedmont, and Ridge and Valley soil provinces in Virginia during 1990 and 1991 and 10 studies in the Piedmont and Ridge and Valley areas in 2014 and 2015 demonstrated that corn grain yields were maximized at soil NO_3-N concentrations above 26 parts per million (ppm) (figure 3). Twenty-eight long-term (>3 years) cover crop studies in the Coastal Plain, Piedmont, and Ridge and Valley in 2021 and 2022 also had maximum yield above 26 ppm of soil NO3-N concentrations (Figure 4). Enough N was mineralized or made available from decomposing organic N in the soil and legume cover crops on the surface at the locations where NO3-N concentrations were above 26 ppm to supply the seasonal N needs of the corn. Below 26 ppm, supplemental N was often needed to attain maximum yields.

High relative yields occurred where soil had received considerable contributions of organic N, such as from animal manures, biosolids, and legume cover crops with > 2400 lbs/ac biomass dry weight. The PSNT threshold of 26 ppm is recommended primarily on soils that have received significant amounts of manures, biosolids and high biomass legume cover crops in fields with long-term cover crop and no-till

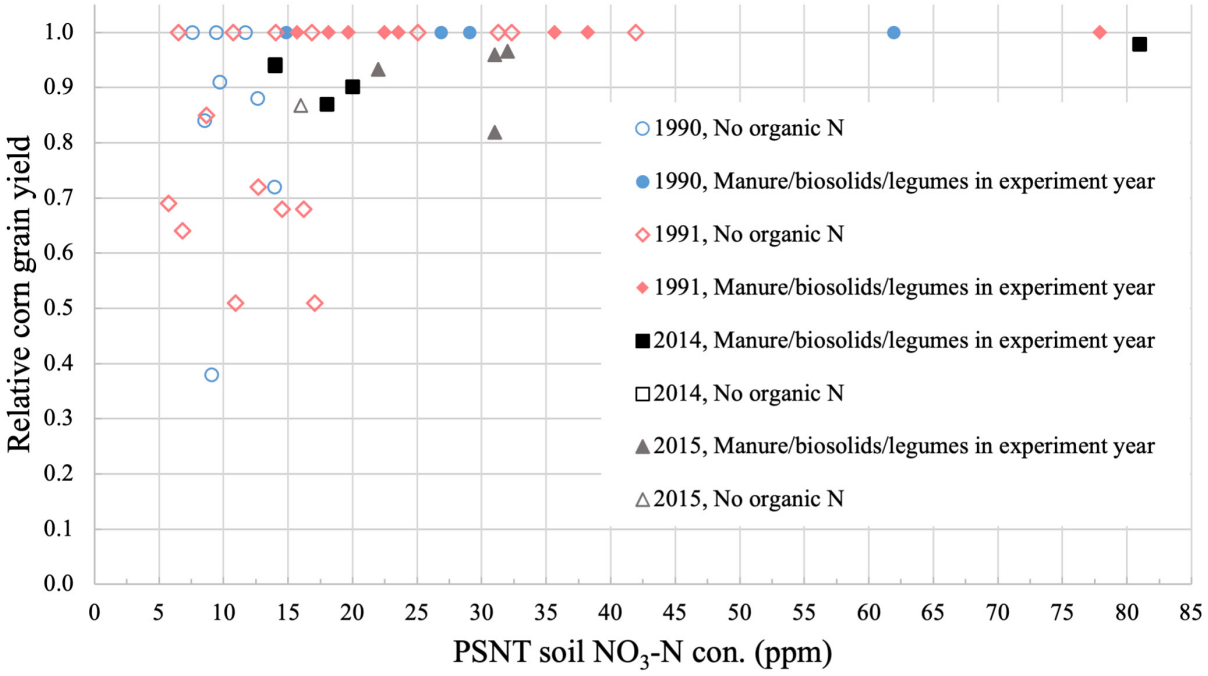

Figure 3: Relative corn yields at different NO_3-N soil concentrations

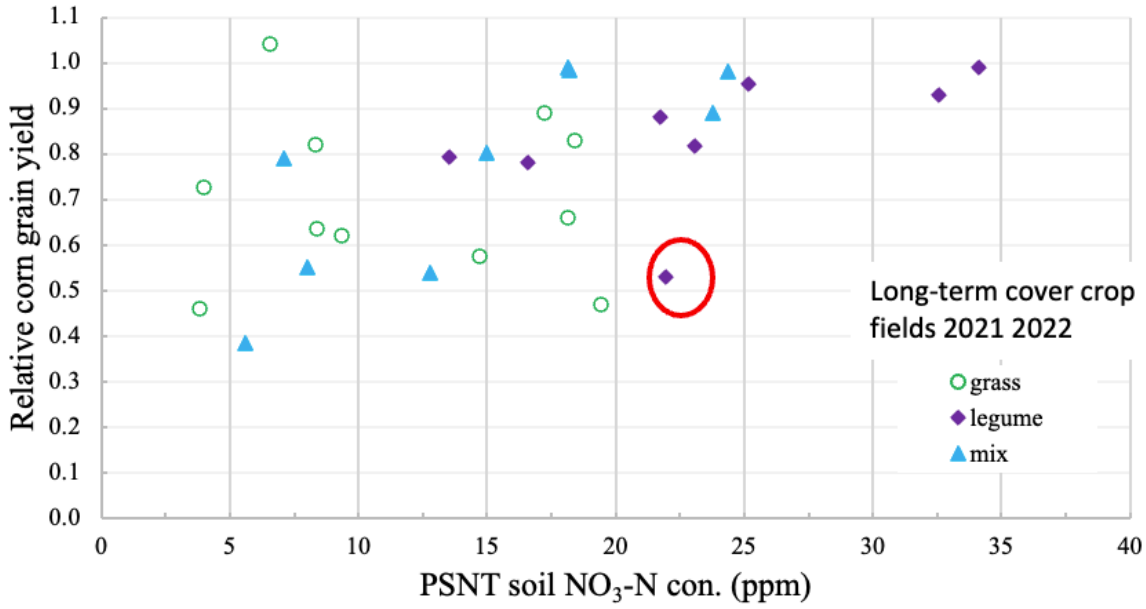

Figure 4. Relative corn grain yield at different NO3-N concentrations in long-term cover cropping fields with no sidedress N application. Legume site in red circle had low biomass of only 534 lb/ac dry weight due to late planting.

practice. Fields with legume cover crops except for one site (planted in March) had a relative yield above 0.78 with no sidedress N (Figure 4). The cover crop biomass, proportion of legume in the mixture, cover crop planting, and termination dates should be kept in mind. These factors result in different C/N ratios and the C/N ratio highly influences the decomposition rate of cover crops and N release (Sievers and Cook, 2018).

Nitrogen Soil Test Procedure

1. The test is primarily designed to be conducted on soils that have received no more N than a starter N fertilizer application (less than 50 pounds per acre); however, the test has been shown to be accurate in some situations where high rates of pre-plant fertilizer N have been applied. Fields that have received manure can and should be tested prior to making any supplemental N fertilizer applications at sidedress time. Where starter N has been banded at planting, avoid collecting PSNT from the band area.

2. Take soil samples when corn height reaches 10 to 15 inches at the whorl, not with an upper leaf extended.

3. Sample soil by taking 10 to 20 cores across the field to a depth of 12 inches, if possible, or as deep as possible. Sample between rows to avoid starter fertilizer bands and areas where roots have depleted soil N.

4. Combine, mix, crumble, and dry samples as quickly as possible by spreading the mixed soil in a thin layer on newspaper in a warm place. Samples can also be dried in an oven at low heat (200 to 225 degrees F) or in a microwave for 5 to 8 minutes at the high-power setting.

5. Use a reliable field test kit to determine soil NO_3-N concentration. Kits must be carefully calibrated and maintained in order to obtain consistently reliable results. Alternately, some local laboratories offer PSNT tests, as do some state agencies. However, unlike routine soil testing, mailing samples for PSNT can cause problems due to the short turnaround time required between sampling, receiving a recommendation, and applying any sidedress N.

NO_3-N	N RATE RECOMMENDATION
<15 ppm	Apply full rate of sidedress N that is needed for the realistic yield estimate for the particular soil as specified by VALUES, nutrient management plan and/or yield records.
15-26 ppm	Possible reduction of the sidedress N application by 25-50%. The decision to reduce the recommended N rate must be made on a site-by-site basis and should take into account previous field history, organic N additions, and management practices.
>26 ppm	No sidedress N is needed.

Table 1: N rate recommendations at different NO_3-N concentrations

Nitrogen Recommendations

Nitrogen recommendations for corn can be calculated from the Virginia Agronomic Land Use Evaluation System, or VALUES (DCR 2014), with adjustments from the results of the PSNT as outlined above (table 1). Alternately, N recommendations can be made from realistic yield expectations based on site history.

These recommendations should not substitute for common sense and an understanding of the effects of soil properties and management practices on N availability to corn.

References

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Sievers, T., and R. L. Cook. 2018. Aboveground and Root Decomposition of Cereal Rye and Hairy Vetch Cover Crops. Soil Science Society of America Journal 82(1): 147–155.

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Produced by Virginia Cooperative Extension, Virginia Tech, 2023

VT/0423/418-016 (SPES-484P)