Science Societies

Drought demonstrates value of fall soil nitrate-nitrogen testing in the Northern Great Plains

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Figure 1, Hydraulic probe in truck cab to sample soil to 24 inches.

For the 2021 growing season, we had limited stored soil water and much below-average rainfall across the Northern Great Plains. As a result, crop yields were disastrously lower than normal, and the regional median residual soil nitrate-nitrogen after wheat was two to three times higher than the running average. This drought brings new light (and old memories) to soil testing for nitrogen along with new challenges and opportunities.

The fall soil nitrate-nitrogen test is the backbone of nitrogen fertilizer recommendations in the Northern Great Plains (NGP). It is collected for the 0- to 24-inch soil profile, reflecting the typical rooting depth of nitrogen-requiring crops (Figure **1**). Preceding many frozen winter months, the fall soil-sampling time frame provides a good measure of soil nitrogen (N) availability for the upcoming crop. It also provides a valuable opportunity to review nitrogen management of the previous year.

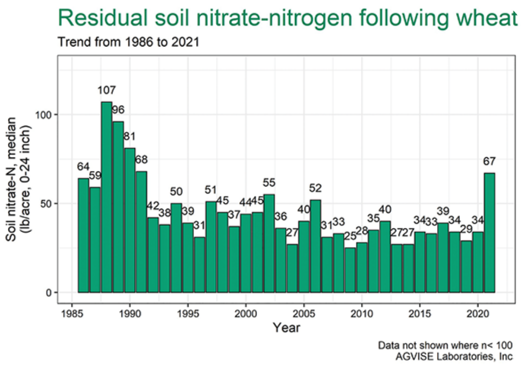

Figure 2, *Residual soil nitrate-nitrogen following wheat.*

The amount of residual soil nitrate is affected primarily by crop N uptake and removal, soil N losses, and mineralization. Since these factors can fluctuate from year to year and field to field, annual soil sampling in the fall is important. Historical soil test records are often helpful in examining these relationships, highlighting that drought years will also leave behind substantial amounts of residual soil nitrate. In the NGP, higher residual soil nitrate occurs in the widespread severe drought years of 1988 and 1989 as well as more localized drought years like 2002, 2006, 2012, and 2017 (Figure **2**).

High Residual Soil Nitrate Presents Challenges and Opportunities

For the 2021 growing season, we had limited stored soil water and much below-average rainfall across the NGP. As a result, crop yields were disastrously lower than normal. Following the drought, the regional median residual soil nitrate-nitrogen after wheat was 67 lb/ac nitrate-N (0- to 24-inch soil profile), which is two to three times higher than the running average near 25 to 40 lb/ac nitrate-N. The last time such high residual soil nitrate-nitrogen was observed was the landmark droughts in the late 1980s.

Such high amounts of residual soil nitrate present growers and CCAs with some challenges and opportunities for 2022. Are such high residual soil nitrate-nitrogen amounts even real? Can we trust them for fertilizer planning next spring? What other cropping challenges come with high soil nitrate-nitrogen?

The good news first. The fall residual soil nitrate-nitrogen test has been a reliable tool for adjusting nitrogen fertilizer rates. With high nitrogen fertilizer prices and possible tight spring fertilizer supplies, the large soil nitrate-nitrogen reserve is a welcome sight for nitrogen-requiring crops like canola, corn, and wheat. For most growers, a good crop in 2022 could still be achieved with a modest fertilizer nitrogen input.

To explore these relationships further, let's examine some soil test summary data for the region (AGVISE Laboratories, Inc.; www.agvise.com/resources/soil-test-summaries/). In 2021, 23% of wheat fields in the NGP had more than 100 lb/ac nitrate-N (0- to 24-inch soil profile). Yet, another 60% of wheat fields had residual soil nitrate-nitrogen ranging from 20 to 100 lb/ac nitrate-N (0- to 24-inch soil profile). Throughout the region, residual soil nitrate-nitrogen was higher than normal, but some locales were hit harder with drought (Figure 3). For example, the Interlake region of Manitoba had a stagging median value of 102 lb/ac nitrate-N (0- to 24-inch soil profile). Recall that the median value is the midpoint in the dataset, so 50% of wheat fields in that region had more than 102 lb/ac nitrate-N.

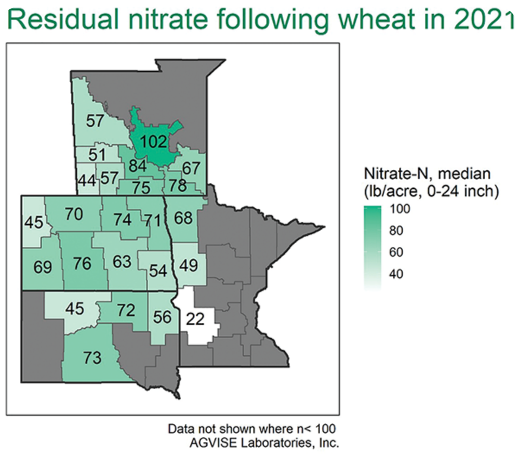

***Figure 3,** Residual nitrate following wheat in 2021.*

Some Changes in Soil Nitrate-Nitrogen May Occur

But, we must recognize that some changes in soil nitrate-nitrogen may occur. Soils across the NGP still require substantial rainfall and snowmelt to recharge the depleted subsoil-stored soil water supply after the 2021 drought. However, excessive soil water can cause soil nitrogen losses through nitrate leaching on well-drained soils and denitrification on poorly drained soils. While we still have some space to store additional soil water, be aware that too much precipitation through fall and spring may cause some soil nitrate-nitrogen loss.

Drought also induces variability, exacerbating microscale differences in soil water-holding capacity and stored soil water across the landscape. Some zones within a field may have produced a fair crop yield, leaving behind less soil nitrate while other zones had a very poor crop yield and left behind considerable amounts of soil nitrate. Hard lessons from the 1980s taught us that applying zero nitrogen was a mistake because the more productive zones still required some base rate of nitrogen fertilizer to mask field variability and ensure that next year's crop had a good start. Through zone soil sampling, we can begin to make sense of the field variability that drives crop productivity and choose the right fertilizer rate for next year.

Figure 4, *Post-harvest regrowth and volunteer growth in a 2021 oat field with some 80 lb N/ac in 1 ton/ac biomass.*

Following the summer drought, some crops did receive late-season rain in August 2021. For cereal and oilseed crops, the rain was enough to germinate volunteer seed and initiate plant regrowth from original stems. Some volunteer regrowth had reached the heading stage in cereals and the flowering stage in canola. The nitrogen uptake of these "free" cover crops can be substantial (Figure 4). People are now wondering how much of that immobilized nitrogen will be available for next year. Recent studies in the Midwest and Great Plains have demonstrated that cover crops are effective in accumulating nitrogen and reducing soil nitrate, but that nitrogen is slow to return to the following crop if any at all (**https://doi.org/10.1002/crso.20003**). Often, the following crop has reduced crop yield and may require additional nitrogen to reach full crop yield potential. The nitrogen is not lost, but it seems to be released too late for the next crop. Therefore, some people are reluctant and uneasy to offer any nitrogen credits for the volunteer crops.

Special Challenges for Soybean

Over the past 20 years, soybean acreage has marched farther west and north, now occupying a sizeable percentage of cropland across the NGP. Such high amounts of soil nitrate present special challenges for soybean production. When soybean was first grown in Manitoba, agronomists observed poor nodulation if soybean was grown on soils with high soil nitrate. So, a rule of thumb was adopted to avoid planting first-year soybean on soil with more than 60 to 70 lb/ac nitrate-N. Subsequent observations on fields with two or more years of soybean production and successful nodulation showed that, although nodule number may be reduced with high soil nitrate, the soybean plants typically had at least 10 nodules per plant. Nevertheless, other crop species could have made better use of the extra soil nitrogen than soybean.

The calcareous soils of the NGP also throw another challenge at soybean production. Soybean iron deficiency chlorosis (IDC) is a common problem on soils with high amounts of calcium carbonate and/or salinity. Figure **5** Soil nitrate is another causative factor in soybean IDC severity (**https://doi.org/10.2136/sssaj2010.0391**). The best management recommendation is to avoid planting soybean on soils with high IDC risk or choose soybean varieties with better IDC tolerance.

Figure 5, *Iron deficiency chlorosis (IDC) of soybeans triggered by high soil nitrate levels.*

Other crops also require scrutiny when planting on soils with high soil nitrate. Malting barley quality is impaired if kernel protein concentration is high, a possible consequence of high nitrogen supply. Likewise, all cereal crops have a greater risk of lodging with high nitrogen supply. Therefore, soil testing for soil nitrate-nitrogen is necessary to account for soil nitrogen reserves, along with variety selection and possible plant growth regulator (PGR) use.

Amid wet years and dry years, agronomists and growers in the NGP observe large fluxes in residual soil nitrate-nitrogen from year to year and field to field, highlighting the need to collect soil samples for soil nitrate-nitrogen each year. It is among our best tools for calculating responsible nitrogen fertilizer rates for next year as well as providing a retrospective insight in our previous nitrogen management plan. A severe drought brings new light (and old memories) to soil testing for nitrogen along with new challenges and opportunities.

More nutrient management

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