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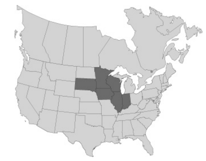

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Crop Nutrition Following the 2012 Drought: Northcentral U.S.

The drought that affected many areas in the Midwest has created several questions about nutrient management, especially looking forward to next season. Here are a few of the most commonly asked questions and some thoughts about them.

How has the drought affected soil nitrate levels?

Where corn was grown, it is likely that nitrate (NO_3^-) levels in the soil are higher than normal (Randall et al., 2003). Higher levels arise from decreased downward movement of soil water and from reduced fertilizer nitrogen (N) uptake by the drought-stressed plant (Rimski-Korsakov et al., 2009). A 6-yr study in Minnesota, conducted on a Canisteo clay loam with 0 to 1% slope and 5.5% organic matter (Randall et al., 2003), measured generally higher soil nitrate levels when seasonal precipitation dropped below average.

Pulses of N can also occur any time dry soils are rewetted. As soils dry, the microbial decomposition of organic matter that releases N (mineralization) slows, approaching zero under very dry conditions (less than 10-15% moisture; Ford et al., 2007). In addition, some soil microbes are killed (Marumoto et al., 1982a; Murumoto et al., 1982b). When dry soils are rewetted, a sudden pulse of inorganic N may occur, termed a “flush” or a “hot moment” (Cabrera, 1993; McClain et al., 2003). This pulse can last for days to weeks. A significant portion of this flush is thought to come from the decomposition of the microbes recently killed during the dry spell (Marumoto et al., 1982a; Marumoto et al., 1982b). Another contributor to the flush is the release of organic compounds from the reactive sites at clay mineral surfaces (van Gestel et al., 1991).

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Whether or not residual nitrate will be available for next season’s crop depends greatly upon the precipitation that occurs between cropping seasons. In the Midwest, nitrate losses can be substantial during the fall, winter, and early spring months (Dabney et al., 2010). For example, the same Minnesota study cited above (Randall et al, 2003) demonstrated higher losses of nitrate to tile drainage with precipitation occurring in spring to early summer months. Corn and soybean crops have less above- and below-ground biomass during those months, resulting in greater chances that N will move below the root system before being taken up.

Should I consider planting cover crops?

Regardless of whether corn or soybean is planted next year, consider planting a catch crop. A catch crop is a cover crop planted for the express purpose of taking up soil nitrate to keep it from leaching to tile drains or to deeper zones in the profile that are out of reach by crop roots (Dabney et al., 2010). A summary of studies conducted in the Midwest showed that catch crops can reduce nitrate losses to tile lines by 6 to 58 lb NO_3-N/A (Dabney et al., 2010). The following are a few general considerations for catch crops. For more information visit the Midwest Cover Crops Council’s Cover Crop Decision Tool (http://www.mccc.msu.edu/selectorINTRO.html) and also consult local expertise for needed details and guidance.

Cover crop selection

Crops with deep roots that grow quickly are key. Small grains that have been more widely used in the Midwest are cereal rye, winter wheat, and oats. Annual ryegrass is a forage grass that has been widely used too. Popular brassicas are turnips and radishes. Of these cover crops, brassicas and oats do not survive the winter and need no chemical killing in the spring. Cover crop combinations are also possible. For instance, it is recommended that radishes be planted with another cover crop, such as cereal rye or oats, and many other combinations are possible (Meisinger et al., 2012).

Planting date

Crops should be planted as soon as possible in later summer or early fall to maximize root growth and N uptake. Different cover crops require different planting dates (Midwest Cover Crop Council, 2012). Planting dates also depend on what cash crop is being grown. For instance, for corn it is recommended that cereal rye or oats be aerially seeded just before black layer (R5) and before September 15 (Meisinger et al., 2012). For soybean, cereal rye or oats should be sown as the plants begin to dry down after maturity (Meisinger et al., 2012).

Planting method

Aerial seeding, tractor-driven broadcast spreading, and drilling are some of the planting possibilities (Meisinger et al., 2012). When planting into dry soils, a firm seedbed with good seed-soil contact is needed, so drilling is preferable. Drilling limits cultivar selection to those crops that can be established after harvesting corn or soybean. Aerial seeding and broadcast spreading provides more options for earlier sowing dates and cover crop selection.

Killing date

Proper times to kill cover crops that overwinter depend on whether corn or soybean is to be planted. Another consideration is soil moisture in the spring. For corn, cover crops should be killed at least two weeks prior to planting (Meisinger et. al., 2012; Dabney et al., 2010). If soils are dry, earlier killing may be needed, such as four weeks prior to planting. Soybean is less sensitive to the time when cover crops are killed. Up to three days ahead of planting is acceptable unless dry conditions exist, then earlier killing is needed (Meisinger et al., 2012).

Long-term catch crop management

Although catch crops are getting a lot of attention this year, they have been shown to be important for reducing N losses over the long term. Regularly growing catch crops after each crop of corn and soybean has been shown to reduce nitrate losses by an average of 20 lb N/A/yr, which represents a 53% reduction (Meisinger et al., 2012). Long term management also keeps N cycling through the system, building organic N reserves.

How do soil nitrate tests change how much N is recommended?

Soil nitrate tests are the best early-season diagnostic tool for assessing the quantity of residual soil N. There are basically two different types of soil nitrate tests. Both measure nitrate present at the time of sampling; however, they differ in the way the nitrate levels are interpreted.

The first type of test, often referred to as a **soil nitrate test,** uses an N budget interpretation. The amount of nitrate in the soil (or proportion thereof) is simply subtracted from the base N rate, resulting in less total recommended N. Tests in this category are: South Dakota and western Minnesota - the deep nitrate test (Gerwing and Gelderman, 2005; Rehm et al., 2006); and Wisconsin - pre-plant soil nitrate test (Bundy et al., 2001).

The second type of test, often termed a **soil N test,** uses an interpretation based on calibration with crop response to N (Khan et al., 2001; Magdoff, 1991; Magdoff et al, 1984). Consequently, the nitrate levels are used not only to measure soil N present at the time of sampling but also to account for the N supplying capacity of the soil during the season. Calibration data are used either to configure the base N recommendation or to figure an N credit that is subtracted from the base N recommendation. Tests in this category are: Indiana – pre-sidedress soil nitrate test (Brouder and Mengel, 2003); Iowa - the late spring nitrate test (Blackmer et al., 1997; Sawyer et al., 2003); Minnesota – soil N test (Schmitt et al., 1998); Illinois and Wisconsin – pre-sidedress soil nitrate test (Bundy, 1998; Fernandez et al., 2009).

A large, regional research effort was conducted in 1988-92 that examined the efficacy of using the soil N tests (Bundy et al., 1999). This evaluation did not consider the more recently developed Illinois Soil Nitrogen Test (Khan et al., 2001). The study was conducted in 307 site-years across North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, Wisconsin, Illinois, Michigan, and Ohio. Results showed that this test seldom failed to identify sites responsive to N. Consequently, there appears to be little chance that the use of this type of test will result in a missed application of required N. If anything, such tests may incorrectly recommend too much N.

States vary considerably in their suggestions for use of soil N tests, so consulting local guidance is required.

Will higher nitrate levels impact next year's N program?

Here are some options for addressing the uncertainty in N rate for next year, caused by residual soil nitrate and unpredictable weather conditions:

- Take soil nitrate tests to assess levels, paying attention to within-field variability.
- Move from fall to spring and in-season applications. This provides better synchrony between N supply and N uptake by the crop.
- Use a chlorophyll meter, such as a SPAD meter, or active crop reflectance sensors, to determine rates of N to side-dress.

Will higher nitrate levels adversely affect next year's soybean crop?

If a soybean crop is planned for next year, it will simply scavenge the nitrate left. Higher nitrate levels do not adversely affect soybean yields (Schmidt et al., 2000). Under higher nitrate supplies, soybean derives less of its N from biological fixation, and total N uptake will likely be the same or somewhat higher (Herridge and Peoples, 1990).

Will the drought affect soybean N credits for next year's corn?

The soybean N credit is a reduction in the N recommended for corn following soybean compared to corn following corn. While the exact causes of this reduction are still under investigation, several contributing factors have been identified.

The most commonly cited factor in the N credit is biological N fixation. Under drought stress, there may be lower numbers of nodules on soybean roots, and N_2 fixation in the nodules themselves may be reduced (Serraj et al., 1999). This reduction may arise from decreased N demand by the drought-stressed soybean plant (Streeter, 2003) and decreased phloem flow (Serraj et al., 1999).

In a study comparing nodulated to non-nodulated soybean isolines, soil N supplies were higher after nodulated soybeans than after non-nodulated soybeans (Bergerou et al., 2004). However, both types of soybeans produced higher N supplies than when corn was grown. Consequently, factors other than biological N fixation are important for determining the N credit.

There is evidence that soybean increases readily mineralizable organic N supplies in soils while corn decreases them (Martens et al., 2006). The additional supplies provided by soybean appear to come from micro-roots as well as from organic compounds exuded by the roots themselves, such as amino acids, hormones, and enzymes (Mayer et al., 2003). It is expected that drought would reduce the quantity of these contributions to the organic N pool.

Rate of N mineralization from soybean residues is also important. Nitrogen mineralizes more rapidly from soybean residue than from corn residue (Gentry et al., 2001). The lower C:N ratio explains part of this difference, but not all. As discussed, there are many other factors at work.

Finally, the biological transformation of soil inorganic nitrogen into organic forms (immobilization) is faster for soybean residues than for those of corn. When corn and soybean are harvested, N is initially immobilized by their residues, making it unavailable for uptake by the next crop. After this initial phase, N is mineralized from the residues, creating N that is available (Green and Blackmer, 1995). Soybeans immobilize N more quickly than corn, allowing the N mineralization phase to start earlier, providing N to the succeeding crop more rapidly. Additionally, the lower quantity of soybean residue compared to corn means less overall N is immobilized. In dry conditions, immobilization is slowed, which can delay final N release.

Considering the impact that drought has upon all the various factors that contribute to the soybean N credit, it is hypothesized that some, but perhaps not all, of the credit should be taken if corn is to be grown after this year's soybean crop. A conservative approach would be to apply a basal amount of N that is reduced by the full credit and then monitor the corn crop and apply additional N if diagnostic tests (tissue tests, chlorophyll meter readings, or active crop reflectance sensors) indicate a deficiency.

How much phosphorus (P) and potassium (K) carryover can be expected?

On most soils in the Midwest, both P and K form chemical bonds with soil minerals that keep them from moving very far from the point of application. Unlike N, they are not subject to as many losses. Primary pathways for loss are erosion and runoff, and then, only the P and K near the soil surface. In mucks and sandy soils, K can be lost through leaching. So in most situations, P and K not taken up by the crop carry over for use in future years.

Lower yields caused by the drought mean less P and K will be removed with grain harvest. If, on the other hand, corn that was intended for grain harvest was instead cut for silage, P and K removal will be greater than planned.

Some average rates of removal by corn and soybean are given in the **Table 1.** Multiplying these rates by harvested yield estimates total removal.

Table 1. Average P and K nutrient removal by corn and soybean (Phillips and Majumdar, 2012).

Crop	Harvested portion	Unit	Nutrient removal	
			P_2O_5	K_2O
			-------(lb/unit)-------	
corn	grain	bu	0.35	0.25
	stover	ton	5.8	40
corn silage (67% water)	whole plant	ton	3.1	7.3
soybean	grain	bu	0.73	1.18
	stover	ton	8.8	37

Drought can cause changes in nutrient concentrations of various plant organs. The magnitude of these changes depends upon when the drought occurred and how long it lasted. Measuring nutrient concentrations in harvested crop portions can provide more accurate assessments than average rates.

Comparing the amount of P and K applied before this season to the amount actually removed by crops this year provides an estimate of the P and K carrying over.

How will the drought affect P and K soil test levels?

Drought can change soil tests in several ways.

- Reduced grain yield results in lower nutrient removal, damping reductions in soil test P and K;
- Corn planned for grain harvest but instead cut for forage increases nutrient removal, amplifying reductions in soil test P and K;
- Low moisture affects the reactions K has with soil minerals. These reactions impact the amount of K measured by soil tests and create swings in readings that cannot be explained solely by comparing K application rates with nutrient removals. In some cases, soil tests levels may be lower than expected and in some cases they may be higher.

Keeping good records of nutrient application rates and conducting tissue nutrient analyses create good nutrient budget estimates. If soil tests don't change as expected based on budgets, drought-induced changes in soil chemical reactions are likely a significant part of the explanation.

Summary

The drought this season impacts next season's nutrient management planning. Some key factors to consider are:

- soil nitrate levels can be higher than normal, but whether or not this additional N is available to crops next year depends a lot on the precipitation this winter and next spring;
- catch crops can capture a significant amount of this nitrate and convert it to organic forms that become available to subsequent crops;
- soil nitrate tests can be used to adjust N application rates to those that more closely match what the plant needs but the soil lacks;
- higher soil nitrate levels will not adversely affect a soybean crop;
- drought may reduce the N credit normally used following soybean, but the probability and magnitude of this effect is not well defined;
- P and K not taken up by the crop this year remain in the soil for uptake by future crops;
- the quantity of P and K carryover can be estimated by comparing nutrient application rates to the quantity removed by crop harvest;
- soil test changes normally follow nutrient budgets over time, but drought can cause unexpected swings in soil test K and the magnitude and direction of those swings depend in large part on soil mineralogy and soil chemical reactions.

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