Grow YOUR SOIL

Soil Science Spotlight

If we understand a soil, we can improve it

Nitrogen, Phosphorus, Sulfur and Soil Microorganisms

Mobilization

You test your soil to make sure that it has enough nutrients available to your plants for them to thrive. The lab provides you test results and may even include recommendations for adding nutrients to your soil. You make all the calculations needed to follow the recommendation only to find that your corn leaves are purple, indicating a lack of phosphorus. Why?

The simple answer is: recommendations provided directly from soil testing laboratories tend to lack depth. Determining whether your soil can provide sufficient available nutrients to your crop requires soil testing, but also requires additional in-depth analysis. Nutrient availability cannot be gauged with 100% accuracy by a soil test taken at one moment in time. For nutrients to be available to your crops, they need to be in the form of a positively or negatively charged molecule, and the availability of correctly charged molecules of vital nutrients can vary, depending on the current conditions in the soil. For example, phosphorus is taken up by plants as a molecule called *orthophosphate*, which has a charge of either -1 or -2, meaning it has 1 or 2 extra electrons that will combine with a positively charged molecule if it encounters one in the soil. Phosphorus also can exist in the soil as *phosphate*, which has a charge of -3 and also very readily combines with positively charged molecules, particularly calcium (Ca^{2+}) in alkaline soils and iron (Fe^{3+}), aluminum (Al^{3+}) and manganese (Mn^{2+}) in acidic soils. The thing is, if a negatively charged nutrient interacts with a positively charged molecule, it becomes unavailable to the plant and stays bound up in the soil. So, if plants need to take up charged molecules, and charged molecules want to combine with oppositely charged molecules they encounter in the soil and therefore become unavailable to plants, how are plants able to find any charged, available molecules?

When a charged molecule combines with another molecule of opposite charge, the bond can range from being very temporary to almost permanent, depending on the molecules and the conditions. Less permanent bonds allow nutrients to become bound and unbound, and in their unbound state they are available to crops. However, it is not just crops that seek these nutrients – soil microbes do as well. When a soil microorganism takes up a nutrient, it utilizes that nutrient temporarily and then excretes it as waste, or incorporates it into their body, releasing it only when the organism dies and decomposes. *This process of releasing a nutrient is called mobilization.*

Phosphorus

Because it is so inclined to bond with other positive molecules, there is generally not a lot of free phosphorus available in the soil at any given time: most of the available phosphorus is in the bodies of soil microorganisms. If the soil is warm and moist all year round, the soil microbes are living and dying and there is a fair amount of available phosphorus due to the continual turnover. If the soil is warm and moist and then suddenly gets much colder and/or drier, much of the phosphorus will not be available to crops until the microbe bodies containing it are decomposed (which happens at a slower rate in cold and/or dry soils). If the soil is generally not conducive to healthy microbial activity (too cold, too hot, too dry, too wet, and/or too compacted and lacking air), much less of the soil's phosphorus will be unavailable compared to the amount shown in the soil test results, and most of the phosphorus that *should* have been available through mobilization will be bound to positively charged molecules and unusable by plants. Thus, phosphorus availability is largely controlled by soil microbial activity and turnover. Those purple streaks in your corn leaves? Probably due to the soil being too cold, too hot, too dry, too wet, or too compacted. A soil test may show that phosphorus is there in the soil, but if you still get signs of deficiency, it's not available in a charged state that plants can take up.

Phosphorus availability can also be hindered by soil pH. When the soil pH is outside of the range of 6.5 to 7.5, phosphorus is inclined to bind to other soil minerals (iron, aluminum and calcium) and become unavailable to crops. Adding a pH adjuster like lime or elemental sulfur can help overcome this, and encouraging mycorrhizal associations also help crops take up available phosphorus in the soil. if phosphorus is deficient in the soil, adding rock phosphate or more readily available fish meal are options.

Nitrogen and Sulfur

Nitrogen and sulfur availability to plants is similarly controlled by microbial activity and turnover, but for opposite reasons. Where soil microbes help to keep phosphorus from being *bound* in the soil, they help prevent nitrogen and sulfur from *leaving* the soil. Unlike phosphorus which is resistant to leaving the soil, nitrogen, in the form of ammonia (NH4+) and nitrate (NO3-), and sulfur in the form of sulfate (SO42-) leave the soil very easily through leaching and as a gas (volatilization). Soil microbes act as reservoirs to hold these nutrients in their bodies, making them available to crops as they die and decompose. So, just as with phosphorus, the amount of available nitrogen and sulfur in the soil depends on the activity and population of the soil microbes. If the soil is not favorable for microbial activity, there will be much less available nitrogen and sulfur (and phosphorus) than would be predicted by soil test results alone. In soils that are too wet, too dry, too cold, too warm and/or too compacted, soil microbes are not able to decompose the soil organic matter to free up nitrogen and sulfur for plants at the expected rate. So, even though you may have added compost and alfalfa meal to your soil to provide nitrogen to your plants, if you see signs of nitrogen deficiency, such as yellowing in older leaves, it is possible that the nitrogen is present in the soil but not available due to low activity of the soil microbes.

The easiest way to overcome low microbial activity is to improve the soil environment by having a balance of air and water as well as plenty of organic matter. However, if low microbial activity is due to the soil being too cold or too hot, you may need to consider providing nitrogen in a more readily available form. Rather than providing nitrogen in the form of alfalfa meal, soybean meal or compost, all of which need to be decomposed to release their nitrogen, urine (properly and safely processed), or blood meal are examples of organic fertilizers with more readily available nitrogen. Sulfate is generally readily available when added as potassium sulfate or gypsum (calcium sulfate) since both dissolve fairly readily in soil water, making the sulfate available without microbial intervention.