# MATCHING NITROGEN AVAILABILITY TO PLANT NEED

## *Striving for Tightly Coupled Organic Systems*

**Doug Collins, Craig Cogger, and Andy Bary**

Getting a crop to market requires a large effort to prepare soil, transplant or seed, irrigate, weed, harvest, and market. To maximize the yield from this effort, it is necessary to provide adequate nitrogen fertility for the growing crop. Organic farmers depend on nitrogen mineralization from soil organic matter, composts, manures, organic fertilizers, and cover crops for plant-available nitrogen. Mineralization is the biologically-mediated process that converts nitrogen bound to carbon (organic nitrogen) to plant available forms of nitrogen (mineral nitrogen). Planning for adequate fertility from organic sources is difficult because mineralization is highly dependent on temperature and moisture. Also, the rate at which crops take up nitrogen from the soil varies throughout the season. When plants are small they do not take up nitrogen in the same amount as larger crops.

Well-managed plant-soil systems are tightly coupled, in other words they are balanced in terms of nitrogen availability and nitrogen uptake. Uncertainty about nitrogen fertility can lead to nitrogen deficient or nitrogen saturated systems caused by insufficient or excessive fertilizer applications. Too little fertilizer compromises yield and profit while over-application leaves nitrate in the soil that is prone to leaching during the winter and poses a threat to water quality. A 2010 survey of 4 western Washington organic farms indicated that 41% of the fields tested had high or excessive fall soil nitrate values (Collins et al., 2013a). A high fall soil nitrate value is an indication that more fertilizer was applied than the crop was able to take up.

In organic farming systems, fertility is provided from sources of nutrients that are naturally-derived, since most synthetic fertilizers are not allowed. The WSU Extension publication, "Soil Fertility in Organic Systems: A Guide for Gardeners and Small Acreage Farmers," discusses the many fertilizers and soil amendments that are available for organic production and how to estimate an application rate to meet crop demand. Cover crops, composts, manures, and organic fertilizers are all viable sources of fertility for organic farmers. Choosing which fertilizer or amendment to use will depend on the farmer's specific goal.

The soil organic matter is another source of mineral nitrogen. When cover crops or amendments are incorporated into the soil they provide only a portion of their total nitrogen content to the soil during the year of incorporation. Legumes may mineralize 50% in the first year, but grain cover crops will mineralize less

(Sullivan and Andrews, 2012). In both cases, the remaining nitrogen becomes part of the soil organic matter, representing a bank of slow-release fertilizer. To optimize yield and minimize costs, farmers need to understand the timing and potential magnitude of N mineralization from the soil bank.

In 2012, Collins, Cogger, and Bary (unpublished data) examined rates of nitrogen mineralization from soil and uptake by broccoli in plots that did not receive any additional nitrogen fertilizer. Figure 1 shows both nitrogen uptake by broccoli and nitrogen mineralization from soil at the WSU Puyallup Research and Extension Center. Nitrogen uptake changed during the growing season and followed an "S-shaped" curve. Nitrogen mineralization from soil was more consistent and it is evident that the nitrogen mineralization rate exceeds plant N uptake early in the season. Transplanting in mid-May was well timed to take advantage of early season N mineralization, assuming the pool of accumulated nitrogen was not lost to leaching.

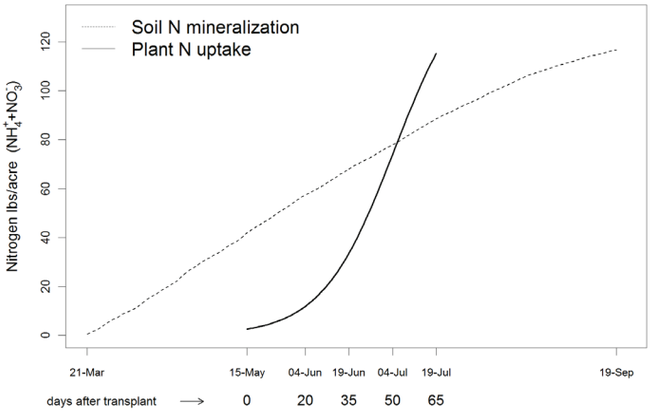


**Figure 1. Nitrogen uptake by broccoli and nitrogen mineralization from soil at WSU Puyallup Research and Extension Center in 2012. Mature broccoli heads were harvested 65 days after transplant.**

Following the first period of about 20 days after transplanting, the rate of plant uptake increased to a rate surpassing the mineralization rate. Without additional fertilizer, broccoli transplanted earlier in the spring might have experienced nitrogen stress during the period of maximum uptake and yielded less or required more time to mature. Fertilizer products that are rich in readily available nitrogen are good choices for early season applications when relatively little nitrogen has been mineralized from the soil organic matter.

Building soil fertility with cover crops and organic amendments can decrease the need for organic fertilizers. When fertilizers are used, there are several strategies that can increase nitrogen use efficiency, including: slow-release fertilizers, split applications, fertigation, soil and tissue testing, and careful attention to irrigation (Sanchez and Doerge, 1999).

Many organic fertilizers are slow-release fertilizers because when they are applied not all of the nitrogen is in a plant available form. This can be advantageous in terms of providing a consistent supply of available nitrogen to match plant demand throughout the growing season from one pre-plant application. However, the percentage of nitrogen that is made available during one season varies widely among organic fertilizers (see Collins et al. 2013b and Andrews et al., 2010). One should take into account the estimated plant available nitrogen over a season when calculating how much organic fertilizer to apply pre-plant.

Another strategy to meet changing plant nitrogen demand is to split fertilizer applications. Fertilizer can be applied during the growing season by side-dressing in a band next to actively growing plants or through fertigation (applying soluble fertilizer through irrigation water). Farm implements used to side-dress conventional fertilizers are suitable for placing most pellet or granulated organic fertilizers in a band. Depending on a farm's available infrastructure, fertigation can be an efficient application method since nutrients can be metered out over the growing season and rates adjusted according to plant growth. Split applications are more beneficial compared to one pre-plant application in sandier soils than in more clay-rich soils (Sanchez and Doerge, 1999). Fertilizer rates can be adjusted by monitoring crops visually and with mid-season soil and tissue testing. A fall soil nitrate test is a good tool to evaluate how effective the fertilizer program was and to guide the next season's fertilization (Collins, 2012).

Finally, soluble nitrogen can move down the soil profile and out of reach of plant roots if soils are over-irrigated. Water plants efficiently by monitoring the soil moisture or by using irrigation scheduling tools (Peters, 2013; McMoran, 2012)

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