Fertility Dashboard Analytics Reference Guide

Biofertility

Soybean Nitrogen Fixers

Certain archaea and bacteria carry the genes (described above) that fix atmospheric nitrogen into plant usable ammonium in exchange for carbon and phosphate. These bacteria form symbiotic relationships with plants, colonizing the roots of host plants. Of particular interest for soybeans are Rhizobia, particularly Bradyrhizobium japonicum. This species is responsible for the nodule formation on soybean roots, which will produce between 50 and 75% of the nitrogen required for a soybean crop. This metric is a more targeted version of our N-fixation potential metric, specific to soybeans. At low levels we recommend applying rhizobia products (inoculant) to your field if planting into soybeans.

Denitrification Potential

Denitrification is the process that converts nitrate to nitrogen gas, which removes plant-usable N from soils. The rate of this loss can range from 0 to 20% of the applied nitrogen in the soil. This is a facultative anaerobic process, meaning that it is most likely to occur during large rainfall events, in compacted soils, or during saturated soil conditions. Many organisms in the soil carry genes to perform denitrification, coding for nitrous-oxide reductase and NO-forming nitrite reductase. These organisms will cause denitrification when the right environmental conditions are met (primarily, low oxygen in the soil), and are naturally more abundant in some soils. If your Pattern Ag soil profile comes back with high denitrification potential, we recommend applying nitrogen stabilizers to maximize nitrogen use efficiency. Examples include: N-serve, Instinct, Agrotain, Guardian, and Super U. We also recommend avoiding applying fertilizers and manure during wet conditions, especially nitrate-containing fertilizers when these denitrification genes are abundant in your soil.

Phosphorus Solubilization Potential

Phosphorus is an essential element for energy transfer, nucleic acid formation, and sugar metabolism. Reduced availability of P limits water use efficiency, delayed crop maturity, and poor grain quality. Phosphorus readily bonds to calcium, aluminum, and iron in soil and becomes immobilized. Phosphate solubilizing microorganisms dissolve phosphorus from rocks and minerals into soil solution by secreting organic acids or producing specific enzymes. Pattern Ag provides insights into the abundance of genes associated with glucose dehydrogenase production; important in the regulation of the rate of phosphorus solubilization. If the abundance of these genes is low in your soil we recommend applying products that promote phosphorus mineralization. Examples include: Source from Sound Ag (P solubilization), Environoc 401 (P solubilization), Acceleron QuickRoots (P mineralization).

Plant Growth Promoters

Plant growth promoting fungi such as specific Trichoderma species are prolific producers of metabolites and enzymes that have beneficial impacts. These benefits include pathogen biocontrol, inducing pathogen resistance in plants, and enhancing plant growth and development. Pattern Ag targets a number of these Trichoderma

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species that have proven to promote these beneficial impacts and provides them to you as a benchmarked abundance against relevant agronomic fields. Many Trichoderma species we target are found in biological products, so if your test shows a low abundance of these beneficial fungi we recommend applying products that promote plant growth - examples include: Acceleron QuickRoots and T22 HC.

Anaerobic Potential

Tests, such as the PLFA, provide a ratio of Gram+ to Gram- bacteria. Pattern Ag provides a similar test based on the abundance of DNA in your soil profile linked to each group. The difference between the two groups is a classification according to their cell wall, which has important ecological implications. Gram+ bacteria are prominent members of plant-associated microbial communities, and while many are beneficial, a number are also pathogen causing. Gram+ bacteria grow quickly under ideal conditions, and a high proportion of these indicate the community is coming out of dormancy or highly stressed conditions (such as high temperatures or drought). Gram- bacteria, in contrast, can withstand intense environmental stress and are indicators of high use of pesticides, intense tillage, metal toxicity, or anaerobic conditions. The ratio of these is informative of what kinds of stressors your soil community is responding to. Your Pattern Ag test will tell you how your field looks relative to hundreds of similar fields throughout the Midwest.

Diversity

Soil microbial diversity is an excellent indicator of overall soil health. Variation in the communities can be seen as early indicators of soil health decline or improvement. Many rare or low abundance bacteria play important roles in key biogeochemical processes (i.e., soil fertility), processes that are lost as bacterial richness/diversity is reduced. A number of studies have demonstrated that increased diversity is linked to beneficial plant outcomes, including increased yield. The soil microbial diversity is often increased by diversifying crop rotations. Pattern Ag provides a bacterial diversity metric (Shannon's index) benchmarked against agronomic soil diversity across the Midwestern US.

AMF Mycorrhizal Fungi

AMF (arbuscular mycorrhizal fungi) natural root symbionts and are known to alleviate a number of plant stressors, including drought, high temperatures, heavy metals, salinity, and pathogens. AMF can act directly on plants by up-regulating plant tolerance mechanisms and preventing the down-regulation of important metabolic pathways. AMF also provides essential plant nutrients to their host plants, improving growth and development. In return, the host plant roots provide the fungi with sugars. The role of AMF as a bio-fertilizer can strengthen a plants' adaptability to a changing environment. Some agricultural management practices, such as tillage and excessive use of chemicals, can contribute to the degradation of soil fertility and the loss of AMF. Pattern Ag targets a number of these AMF species that have proven to promote beneficial impacts and provides them to you as a benchmarked abundance against relevant agronomic fields. Many AMF species we target are found in biological products, so if your test shows a low abundance of these beneficial fungi we recommend applying products that promote AMF abundance and colonization.

Nutrients

How are soil attribute values calculated?

We use the biological data from your soil samples to estimate key soil attributes (like pH, CEC, and Calcium). We refer to these as 'bio-based soil measurements'. Each sample we analyze generates ~10M biological data points, and by measuring the abundance of certain microbial groups, we can predict these attributes in your soil environment. The microbes that survive and thrive in your field are telling a story about your soil, and for the first time we're able to listen to what they're saying.

How do bio-based soil measurements compare to chemistry-based analysis?

Our bio-based measurements are calibrated using traditional chemistry-based soil measurements, and exhibit similar levels of accuracy to what you might expect from a soil chemistry lab. That said, our measures are driven by biological markers in the soil as opposed to traditional chemistry-based measurement techniques. This means in certain situations our results may be higher or lower than a chemistry-based analysis. In cases with significant variance, we suggest a deeper investigation to understand why the two readings might vary, before taking concrete action either way.

Ca: Calcium

Calcium is an essential plant nutrient required to develop strong cellular walls and membranes. Ca deficiency leads plants to be susceptible to diseases and have a reduced rate of growth. Calcium deficiency symptoms show up as browning in new leaves and an eventual die-back of growing leaf tips and roots. There is a strong link in many soils between pH and Ca, where alkaline soils contain more Ca than acidic soils. Some soils are naturally very high in calcium, such as soils with gypsum (calcium sulfate) or limestone (calcium carbonate). Ca deficiencies are favored by very low soil pH, highly weathered acid soils, and very high amounts of Mg and K on the cation exchange complex. Pattern Ag provides you a biological estimate of the soil Ca in ppm. Much of the Ca management in soils is linked to pH management, where soils with a pH above 5.5 will rarely have a Ca supply challenge. Lime applications increase the soil pH while also providing additional Ca to the soil. In contrast, gypsum applications will reduce pH in alkaline soils in the short-term.

Mg: Magnesium

Magnesium is an essential mineral for plant growth but can be maintained in most neutral pH soils with proper management. Intensive cropping of corn or potato can see a rapid depletion of Mg in an otherwise well balanced soil. Like many other nutrients, deficiency may be observed in acidic sandy soils. Deficiency symptoms will first occur in the older leaves on a plant, where leaves become yellow while the leaf venation remains green. During peak summer hours you may also witness increased crop stress symptoms in Mg deficient plants. Deficiency also can result in reduced root and shoot growth as well as lowered seed weight in some crops. In places where Mg is limited, Mg fertilizers can increase yield up to 10% regardless of the crop grown. We recommend considering the solubility of your Mg fertilizer source, because this nutrient can leach in highly acidic or coarsely textured soils.

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B: Boron

Boron is a highly mobile micronutrient that is second only to Zn as the most widespread micronutrient deficiency in crops. Boron is used by the plant in many ways, and deficiency symptoms range from low pollen count to reduced flowering per plant to general plant stunting. Optimal B availability has a lot of add-on benefits, improving the uptake of other nutrients (particularly K and P), and improving mycorrhizal fungi colonization in roots. Boron limitation is common in soils that have a great deal of leaching– namely low OM, sandy, acidic soils. Boron deficiency can also occur in soils that bind mobile nutrients tightly– these soils are often clay-dominated and characterized by high pH and iron or aluminum oxides. You may also see signs of boron deficiency in conjunction with environmental stressors, such as extended drought, and B deficiency further increases plant damage at the peak of summer. We recommend applying B if your levels are low as a part of maintaining overall crop health and nutrient efficiency.

Fe: Iron

Iron deficiency is a major issue for crops growing in more calcareous soils (high in Ca), but the problem is rarely insufficient Fe in the soil. As pH reaches 7.5 iron is no longer soluble, so Fe deficiency can be observed in plants even when soil Fe is high. Another challenge for Fe availability is soil saturation. When soils are very wet Fe becomes very soluble, as does P. The Fe and P then bind together, making both less available to microbes and plants. This can result in sub-field losses of both nutrients, where depressions in the field may hold water for prolonged periods. Like many other nutrient deficiencies, symptoms can be observed in the youngest leaves, where the leaf veins appear yellow or white. In severe cases the leaves will appear stunted. This effect is referred to as iron deficiency chlorosis (IDC). However, you may notice this fade if soils have the opportunity to dry out. Your Pattern Ag test gives you an extractable Fe measurement. Your options for managing Fe limitation include planting an IDC resistant soybean variety, minimizing nitrate carry-over from the previous year, applying iron chelate fertilizer at the same time as seeding the field, and researchers at U of M recommend planting oats as a competition crop.

Mn: Manganese

Manganese is very important to plant growth, especially in photosynthesis. Deficiency in this nutrient is widespread and often misdiagnosed. Low Mn can result in low yield, higher pathogen infection rates, and reduced ability to handle drought and heat stress. Deficiency is most common in sandy soils, very weathered soils, or organic soils with a pH above 6, and occurs in many crops including cereals and legumes. Deficiency can be observed in younger leaves that are pale and mottled. If your results return with low Mn in your fields then a foliar application of chelated manganese is a common way to manage symptoms directly. Many agronomists will recommend scouting and a foliar test to verify deficiency prior to a foliar fertilizer application.

pH: Acidity

Soil pH is the measure of the acidity or alkalinity of a soil, measured on a logarithmic scale. A change in 1 unit of pH changes the acidity by a factor of 10. Annually harvested crops can remove bases from the soil leading to increased acidity over time, and N fertilizers can leave an acidic residue in the soil. A pH range of roughly 6-6.5 units is optimal for corn/soybean rotations. Low pH can lead to toxic concentrations of soluble metals, Ca and Mo deficiency, and extremely low populations of microbes that transform N, S, and P to plant-available forms. For more information on pH impacts on nutrients please follow this link (for printed versions of this piece, see URL below). There are strong links between pH and Ca management, see the sections below for more details on how the two are managed in tandem.

URL: https://ucanr.edu/sites/Salinity/Salinity_Management/Effect_of_salinity_on_soil_properties/Effect_of_pH_sodicity_and_salinity_on_soil_fertility_/

Buffer pH

Buffer pH is used to determine liming requirements when soil pH is below an optimal range for a given crop. Buffer pH is a measure of the soil's ability to counteract a pH change from a lime application. No lime is recommended if the soil pH is above or within the optimal range for a crop. Liming rate tables will tell you what the recommended liming rate is based on your desired pH and the measured buffer pH. Those tables assume 100% effective neutralizing value (ENV), so we recommend checking the ENV reported for your lime source to adjust your rate in order to achieve your desired pH.

CEC: Cation Exchange Capacity

Cation Exchange Capacity, CEC, is the measurement of the soil's ability to store cations, which includes calcium (Ca), magnesium (Mg), potassium (K), sodium (Na) and aluminum (Al), among others. This measure is helpful for understanding the overall fertility of the soil, and for understanding the risk of leaching nutrients. For example, a low-CEC soil will benefit more from spring applied N and K rather than fall applied due to the leaching potential of cations. Pattern Ag provides a biological estimate of the soil CEC in units of meq/100g. The soil CEC is challenging to change, as it is an intrinsic property of the soil. Sand, for example, has no capacity to exchange cations, and most clay soils have a fairly large capacity to attract and hold cations. The best management strategy for a low CEC soil is to increase the humus in the soil.

OM: Organic Matter

Soil organic matter is the portion of the soil that is made up of plants and animals, both living and decomposing. The soil OM is a reservoir of nutrients for crops, increases nutrient exchange, retains moisture, and is an important factor in the texture of soils. OM improves soil texture by creating aggregates and reducing compaction. A healthy soil will have 2-4% OM or more, and can be maintained by reducing tillage, using cover crops, and reducing runoff.