

# **GUIDE TO TURFGRASS NUTRIENT STATUS & HEALTH**

**BY JIM CONNOLLY, PRESIDENT PLANET TURF**

---

## **DIAGNOSING NUTRIENT DEFICIENCY**

Golf putting green turfgrass mown at about 1/8-inch (3 mm) does not display deficiency symptoms like other crops such as corn, rice and wheat. Observations are important, but the best we can do is judge the nutrient status by overall color, density, and growth rate. However, with the advent of plant growth regulators, rolling, ultra-low cutting, and other forms of intense maintenance, nutrient status and deficiencies are very hard to recognize by visual observation. For this reason, tissue testing can be an excellent way to accurately determine the nutrient status of your turf.

Soil, water, and tissue testing provides clues to the nutrient potential in turfgrass. Soil test results give a picture of soil nutrient levels, but only estimates the availability of those nutrients. Irrigation water tests are used to calculate the input of carbonates, salts, bicarbonates and nutrients. Tissue testing shows what is actually in the plant at the time of the test and helps to determine plant nutrient levels and balances when observed on a regular basis. Tissue testing must be done several times during each season. Combining with a soil and irrigation water test, tissue testing can answer many questions about the fluctuations in plant health and nutrient uptake.

The two types of soil test methods are traditional exchangeable methods and water-paste methods. Water paste is not an acceptable method, unless the turfgrass manager takes many tests, uses irrigations water, and develops his own optimum levels. Exchangeable test methods have been used for decades and is the only test that can estimate soil nutrient availability.

The first step in understanding nutrient management for putting greens is to understand what the sufficiency range of nutrients should be. This is done by evaluating several test results and monitoring trends and movements in nutrient content in the leaf. One or two tests is not enough. Visual observations, combined with test result records will help you determine your own optimum levels.

You must also consider the mobility of nutrients in plants. Mobile nutrients can be translocated from old tissue (bottom of the plant) to new tissue (top of the plant). Mobile nutrient deficiency symptoms occur on lower, older leaves as the new emerging leaves demand the nutrient. The mobile nutrients are Nitrogen (N), Phosphorus (P), Potassium (K) and Magnesium (Mg). Low levels of these nutrients from tissue tests on actively growing greens may indicate low plant metabolism, low soil levels, low free water soil content, plant stress, or low root health.

Immobile nutrients are not easily translocated in plants. Deficiency symptoms occur on upper, new leaves. Nutrients that are immobile in plants are boron (B), calcium (Ca), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), sulfur (S), and zinc (Zn). Low levels of these nutrients in plant tissue usually mean the root system is not absorbing

these nutrients for some reason. Immediate foliar application will address the problem within hours, and soil applications of highly soluble nutrients may correct the problem in several days.

When tissue tests show deficient levels of any nutrient, the following causes may be possible.

1. Insufficient amount of available nutrient in soil. The chemical characteristics of soil may reduce availability of nutrients.
2. The nutrient is positionally unavailable. It is not near the root.
3. Underdeveloped or damaged root system which may be due to cool, wet, dry, or compacted soil.
4. Plant stress conditions that limit the metabolism and flow of fluids in the plant.

## **ROLE AND CONTENT OF NUTRIENTS**

**NITROGEN (N)** - Nitrogen concentration in dry, green, plant tissue will generally exceed 3% (by mass), and can be as high as 6% in leaf clippings. N is necessary for protein formation and the generation of new cells. Nitrogen is the most commonly deficient essential plant nutrient in turfgrass systems. But all nitrogen forms are not the same! A balance of nitrate ( $\text{NO}_3$ ) and ammonium ( $\text{NH}_4$ ) should be 3:1 in the soil to avoid nitrogen imbalance. During stress times, or anthracnose season, it is good to keep nitrogen close to 5%. N content can be manipulated at any time of the year. Urea is the most common form of foliar applied nitrogen.

**PHOSPHORUS (P)** - Concentration of P in dry plant tissue ranges from 0.1 to 0.8% by mass. As a component of ATP, phosphorus is needed for the conversion of light energy to chemical energy (ATP) during photosynthesis.

**POTASSIUM (K)** - The 2nd most abundant nutrient in plant tissue. Potassium concentration in dry plant tissue ranges from 1 to 3% by mass. K concentrations seldom go above 2.7 % and the plant does not appear to accumulate K, contrary to many claims. It must be continually applied to maintain adequate soil levels. Even then, the plant regulates the uptake of K and low K levels are often a sign of some other stress related situation. Remove the stress and K is absorbed by the plant root more easily. K is a very important component of water regulation in turfgrass plants and stomata opening.

**CALCIUM (Ca)** - Calcium is the 3rd most abundant element in tissue, generally having a dry tissue concentration of 0.5 to 1.3% by mass. Ca is critical for root growth, cell strength, and immune system. Ca is subject to many factors that limit availability in the soil. Applying calcium foliar fertilizer in the form of Calcium Polyamine is often the only way to ensure Ca in the plant. Its uptake is limited by ammonium excess in the soil.

**MAGNESIUM (Mg)** - It is an essential plant nutrient for chlorophyll synthesis. Mg usually comprises 0.1 to 0.5% dry leaf tissue by mass but most courses in our area contain less than 0.3% Mg. Mg uptake is subject to problems very similar to Ca.

SULFUR (S) – Sulfur is necessary for nitrogen metabolism and should be present in at least a 10:1 ratio of N:S.

## HOW NUTRIENTS ENTER THE PLANT

Plant roots are designed to acquire nutrients from soil, but at times, are very inefficient and foliar applications of nutrient are more efficient. Root uptake of nutrients is a complex science involving electrical charges, membrane dynamics, and issues too complex to discuss here. Root activity is happening every minute, every hour, and every day! If nutrients can make it to the roots, and the plant is *healthy*, the nutrients are transported up the xylem, and delivered to the cells of leaves and shoots.

Roots don't have teeth or arms to grab nutrients. In order for uptake to occur, plant nutrients must exist near the root in solution before they have a chance to be absorbed. There are four ways nutrients can enter the root.

1. **Root Interception:** As roots grow, they contact more soil and more soil solution (water+soil+nutrients). Root hairs grow from large roots and are important for nutrient absorption because they dramatically increase the surface area of the root system.
2. **Mass Flow:** Nutrients can remain soluble in soil and flow with water. Nutrients are absorbed only during the time when evapotranspiration (ET) is taking place, usually during the day. Soil water often contains nutrients and these nutrients will travel into the plant with water.
3. **Biological Transport:** Plants form mutually-beneficial (symbiotic) relationships with organisms and other plants. Fungi, bacteria, and other organisms consume carbon-rich exudates from the plant, and from other organisms. This process increases availability of nutrients, especially micronutrients. Humus, humic acid, and organic fertilizers can increase this activity.
4. **Diffusion:** This only occurs under very short distances (<1 mm). Roots absorb nutrients in solution, and that creates a "gradient" where more nutrients move from higher concentration areas to lower concentration areas. This process requires water and temperature. Diffusion rates double with every increase of 18F. So, expect twice the nutrient availability and uptake at 78F than 60F.

The key is making sure the nutrient levels are adequate in the soil, and then maximize conditions, mostly turfgrass health and low stress, that lead to nutrient uptake based on management, season, and an understanding of the 4 ways plant roots can get those nutrients.

## FOLIAR FEEDING OF TURFGRASS

Foliar fertilization is widely accepted as an effective way to supplement nutrients to low cut turfgrass. The root is effective at supplying nutrients, but that does not always happen for one reason or another. Foliar fertilization is a very useful management tool

when roots aren't getting the job done. It is particularly useful under the situations listed below.

1. Nutrients may be present in the soil but are insoluble due to pH levels and soil environment conditions. This is particularly true of micronutrients. Foliar applications of micronutrients that are chelated with amino acids are rapid, dependable, and cost effective. Soil chemistry can also affect availability of cations (Ca, K, Mg). P can be tied up when pH is slightly above or below neutral. P is also immobile in cold soils. Applying foliar products can correct many of these shortfalls but not all formulations of nutrients are foliar absorbed. They must be manufactured in a way to assure foliar uptake.
2. Bentgrass and Poa annua can easily consume and metabolize over 2 lb/nitrogen/1000 sq ft per month. Golf course managers do not apply this much nitrogen which leads some to say that greens are "always" nitrogen starved. One of the reasons for low levels of all nutrients in low cut greens is the limited supply of N needed for metabolism and the energy to move nutrients into the plant and from cell to cell. Applying more nitrogen will help increase the content of many nutrients, however, putting quality would be sacrificed and all sorts of other management problems are created. The most rapid method for supplying and maintaining sufficient nitrogen levels in the plant is by regular foliar fertilization. Foliar applied nitrogen is absorbed within hours, where root absorption may take over 1 day. Sufficient nutrient levels are difficult to maintain with infrequent foliar applications. Applications must be made at least every 7-10 days.

## **HOW THE LEAF ABSORBS NUTRIENTS**

The leaf is covered with a layer of waxes, called the cuticle. The major function of the cuticle is to protect the leaf from excessive water loss by transpiration. The leaf also has holes, called stomata, but stomata are not the main entry point for foliar nutrients. Research shows that nutrient uptake occurs even when stomata are closed.

Other openings, called hydrophilic pores, are the main avenue of entry for nutrients. These pores are less than 1-nanometer in size and there about 1000 pores per cm<sup>2</sup>. Even if the nutrients are small enough to enter the pore, the pores are lined with negative charges that repel other negative charged nutrients. This helps the penetration of cations (+) but repels anions (-). However, if the exchange surface becomes saturated with cations, penetration can slow and uptake stops. Therefore, size and charge make a difference.

Small (< 1 nanometer), neutrally charged nutrients are the most efficient form of nutrient for foliar applications. Planet Turf TRACK products are formulated to increase both the rate and quantity of micronutrient penetration by using neutral-charged chelates called Polyamines. Polyamines are less than 1 nanometer in size and carry a neutral charge and are derived from natural plant extracts consisting of nineteen L-amino acid molecules.

The advantage of Polyamines, when compared to EDTA, sulfates, citrates, and other synthetic chelates, is the plant can immediately use the organic acids to maintain charge balance, for an energy source, and for a source of carbon skeletons. Since all of the organic acids come from natural sources, the plant can metabolize the carbon-based Polyamines.

## **PUTTING A NUTRITION PROGRAM TOGETHER**

Foliar applications of immobile elements (Ca, Fe, Mn, S, Cu, Zn, B) will correct low or deficient levels for only a few days. They may be absorbed by the leaf, but they are not transported throughout the plant. Even so, benefits have occurred and may improve long term plant health. The most obvious example is an application of Iron Sulfate. The “greening” response lasts only a few days but overall benefits may be longer. Nevertheless, there may be no better way to supply the plant with immobile nutrients during periods of low soil moisture, environmental stress, and limited root systems.

Soil applications of the immobile nutrients may result in a sustained level of nutrients in the plant if the rootzone conditions are favorable. The rhizosphere is the area around the root (within a fraction of a millimeter) where chemical reactions take place that affect nutrient uptake. More is known about our galaxy than the rhizosphere! Factors that affect the uptake of any soil nutrient are pH, root architecture, free soil water, soil oxygen, competition from other nutrients, and soil temperature.

The turfgrass manager will utilize both foliar and root feeding methods to ensure maximum nutrient content in the plant.

The mobile Elements (N, Mg, K, P) are absorbed and moved within the plant from old to new cells, and from new to old cells. Nitrogen should be maintained at a soil level of 10 ppm N. Turf managers can use slow release nitrogen or apply more frequent reduced rates of soluble nitrogen to the soil. Soil balance of  $\text{NO}_3$  and  $\text{NH}_4$  is important and should be close to 1:1. Foliar applications can also be used to supply nitrogen where immediate absorption is required. If tissue tests indicate a need, apply 0.10- 0.20/N/1000 sq. ft in foliar form.

Maintaining adequate levels of magnesium ( $\text{Mg}^{++}$ ) and potassium ( $\text{K}^+$ ) is challenging. There are interactions between all cations (Ca, Na, Mg, K, H) and plant level manipulation is difficult. If soil tests indicate a need, various forms of these elements can be applied. The challenge is most putting greens have low CEC and high calcium levels. Plants actively absorb K along the length of their root systems, whereas Mg and Ca enter only at the root tips. Thus grass plants usually contain more K than Ca, even when the soil's base saturation is 5% K and 65% Ca. K and Mg are mobile moving from older leaves into growing points. But Ca is immobile so the plant must maintain a steady flow of Ca from the soil to newly forming tissue. This flow can be interrupted by dry soil conditions, sudden wet/dry fluctuations, rapid vegetative growth, excessive soluble nitrogen (N) levels, or high soil K, Na or ammonium ( $\text{NH}_4$ ), which inhibit Ca uptake. Ca

can be applied as a foliar Polyamine or applied to the soil as soluble calcium chloride or calcium nitrate.

Potassium fertilizer applications without regard for Mg and Ca can lead to low plant levels of the later. When K is needed, it can be applied as potassium sulfate to the soil. Frequent light applications at ½ lb potassium sulfate every month should maintain adequate soil-k levels in high sand greens. Foliar applications of K as potassium carbonate or potassium sulfate can be made at 0.1-0.2 lbs/actual K per 1000 square feet on a weekly basis.

If soil tests call for magnesium, it can be applied as magnesium sulfate at the rate of ¼ lb magnesium sulfate each growing-month. For more rapid availability, apply a chelated Polyamine Mg at 1 oz/1000 square feet.

### **SOIL TESTING: SOIL BALANCE & CHEMISTRY**

Nutrient management in 90%+ sand putting greens is not the same as managing soils that contain evenly dispersed organic matter, humus, and clay. Nutrients are only retained on charged soil colloids that contain organic matter, humus and clay. Putting greens are commonly very low in all of these. It is very similar to hydroponic farming. This is why regular tissue testing can reveal the current plant status. Frequent tissue testing will reveal trends and fertilizer application efficiency. When evaluated with soil tests, a tissue test will show if the soil matches predicted tissue levels. Sometimes it does, sometimes it does not. More investigation is needed to determine what may be happening.

There are two concepts of increasing availability of certain nutrients in the root zone.

1). the concept of “liberating” soil nutrients that are tied up in insoluble forms. This involves that application of humic acid, and other “charged” materials. 2). the other approach, more commonly accepted by agriculture, is to load the soil with sufficient levels of nutrients in the chance that the nutrients will become available when there is sufficient water to dissolve them. In sandy soils, this requires frequent applications of needed nutrients at correct amounts.

### **PUTTING TOGETHER A PROGRAM**

Consider that a farmer harvests one, or two times per year and golf course superintendent harvests every day! Since nutrients are removed in the clippings every day, they must be replaced frequently. Foliar feeding can only supply about 8 days worth of nutrients and is meant to supplement a soil fertilizer program. Furthermore, since some nutrients leach from the green within a few weeks, a regular soil feeding program is also necessary.

The typical nutrient content of a Bentgrass/Poa annua greens clipping is

<b>NUTRIENT</b>	<b>PPM in TISSUE</b>	<b>RATIO OF EACH NUTRIENT</b>
N	45000	10
P	4000	.8
K	25000	5.5
S	4500	1
Ca	6000	1.3
Mg	2500	.5
Micro Nutrients	Less than 100 ppm	various

Supplying nutrients as they are needed is a function of applying balance foliar and soil applications of nutrients. TRACK foliar products can be applied to achieve the correct ratios of nutrients. Regular tissue testing allows the turfgrass manager to design a custom program, as needed, and can save wasted applications of nutrients that are already sufficient. While every course is different, there are some common applications of foliar nutrients that meet many situations.

### **STRESS CONSIDERATIONS**

A nutritionally healthy plant is better able to withstand heat stress and disease attack. It is also better able to withstand traffic and other forms of physical stress. In addition, a well fed plant will be more water efficient, have a deeper root system, and quicker recovery from damage.

Anti-stress mechanisms can be enhanced in plants from applications of seaweed extract and chemicals that induce stress resistant.

### **INDUCED STRESS RESISTANCE PRODUCTS**

<b>PRODUCT</b>	<b>FUNCTION</b>	<b>RATE/1000 SQ FT</b>
SAR 20	Contains PO <sub>3</sub> , known to build immune resistance in plants	4 oz
Vitalus	Prolong cell life, increase rooting, pre-stress building	0.3 oz/1000
Micro Sea	Contains hormones, amino acid and micronutrients	3 oz/1000
Polyamine S-525	Contains amino acids, glycosides and lactobacillus	1 oz
Huma Health	Provides carbon for microbial activity	10 oz