MICRO-MANAGING

Do not underestimate the importance of micronutrients in intensively managed turfgrass.

BY JIM SKORULSKI

Micronutrient nutrition is probably the least understood facet in turfgrass fertilizer management programs. This is understandable, considering acute deficiency and toxicity symptoms are rare and only recently have scientists begun to understand the complex functions micronutrients play in turfgrass plants and the field situations that enhance deficiencies or excesses. Analytical tests for micronutrients in soils and plant tissues are also becoming more refined for turfgrass systems. The knowledge base is not complete by any means, but the mysteries of micronutrients are slowly disappearing.

So who should be concerned with micronutrient nutrition? Every turf manager should at least be able to identify the plant essential micronutrients and understand the situations or conditions where deficiencies or excesses may exist and the potential impacts they can have on a turfgrass system. Golf course superintendents irrigating with effluent or salt-affected water, growing-in a new golf course, working with low-CEC and heavily leached soils, or managing highly acidic, calcareous or organic soils are more apt to deal with deficiency or micronutrient imbalances and should have a greater knowledge of the role of micronutrient availability and nutrition.

THE ROLE OF MICRONUTRIENTS

The essential macronutrients — nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S) — are used in large quantities by plants as building blocks for amino acids, proteins, sugars, and starches. Iron (Fe), manganese (Mn), zinc (Z), copper (Cu), molybdenum (Mo), boron (B), chlorine (Cl), and nickel (Ni) are also considered essential nutrients for plant growth but are found in much lower concentrations in the plant and thus are termed micronutrients. Their role is equally important, serving as catalysts in a wide array of metabolic functions. Table 1 provides a list of functions for various micronutrients.

Manganese-deficient bentgrass plants are more susceptible to take-all patch disease. The manganese (Mn) is critical in the production of the lignin found in cell walls and makes the plant more resistant to disease. Soil acidification programs or supplemental applications of Mn can be used to maintain adequate levels of Mn in the rootzone.

SOIL AND TISSUE TESTING

Micronutrients are monitored with soil and tissue nutrient tests. Laboratories most often utilize weak acids or chelating agents such as DTPA (diethylene triaminepentaacetic acid) or the universal extracting agent Mehlich-III combined with the chelating agent EDTA (ethylene diamine tetraacetic acid) to extract plant-available

Table 1

Micronutrient functions and soil, management, and climatic conditions associated with deficiencies and excesses/toxicity.

	Functions	Deficiencies	Excesses/Toxicity
Fe	• Chlorophyll synthesis • Electron transfer in Pn • Activator for enzyme in respiration • Constituent of antioxidant enzymes • Lignin synthesis	• Soil pH > 7 • Weak root system • Excess thatch • Cold soil temperatures • High [Cu], [Mn], [Zn] • Calcareous, arid soils	• Can induce Mn deficiency • Leaf blackening • Centipedegrass sensitive • Acidic, poorly drained soils can produce toxic levels of soluble Fe
Mn	• Oxygen evolution in Pn • Chlorophyll synthesis • N utilization and assimilation • Lignin synthesis • P and Mg uptake • Enzyme activation	• High pH soils • Highly leached, low pH or calcareous sands • Peat, muck soils pH > 7 • High [Cu], [Zn], [Fe], [Na] in low CEC soils • Dry, warm weather	• Soil pH < 4.8 • Anaerobic soils with low pH • Induce Fe, Ca, or Mg deficiencies
Cu	• Electron transfer in Pn and respiration • Synthesize antioxidant enzyme • Lignin synthesis	• High pH soils • Peat and muck soils • Highly leached calcareous soils • Rarely deficient in turfgrasses	• Acidic soils • Heavy applications of copper-based fungicides • Reduced shoot and root production • Suppress uptake of Fe, Mn, Zn, and Mo
Zn	• Structural component of many enzymes • Constituent of antioxidant enzyme • Carbohydrate metabolism • Protein synthesis	• Rarely deficient in turfgrasses • High soil pH • Peat and muck soils • High [Fe], [Cu], [Mn], [Na] • Cool, wet weather • High soil moisture	• Toxic levels may inhibit root and rhizome development • High levels may induce Fe and Mg deficiencies • Some mine spoils and municipal wastes may contain high levels of zinc
B	• Cell wall, plasma membrane structure • Synthesize antioxidant enzyme • Root cell elongation	• Most grasses insensitive to B deficiency • pH > 6.5 • High [Ca] • Dry soils • High [K] in B deficient soils • Peat or muck soils	• Irrigation water with high [B] • Soils naturally high in B (arid and semi-arid soils) • Some composts • Overapplication of B fertilizer • Toxic levels in tissue range 100 - 1,000 ppm

Fe, Cu, Mn, and Zn from soils. Hot water or a water-saturated paste extract is used for B. Micronutrient concentrations are reported in parts per million in the soil test report. Sufficiency ranges for micronutrients in soils are listed in Table 2. The sufficiency ranges are *guidelines* used to help interpret a test and make recommendations.

Soil test recommendations for micronutrients involve a ranking system that is based on expected plant response. The rankings are often titled deficient, low, optimum, excessive, etc. A deficient or low ranking indicates that a positive plant response is likely to occur as a result of an application of that nutrient. A low ranking does not necessarily mean that a deficiency symptom will be evident in the field. This is especially true with Zn and Cu. Rankings for Fe and Mn are generally more consistent. A low ranking should be used as a red flag, indicating the need to investigate fertility and management programs more closely. Similarly, a high or excessive ranking for a particular nutrient does not mean that symptoms of toxicity will appear, but that a closer look should be taken at fertility practices.

Micronutrient analysis is not always a standard part of a soil nutrient test, and it may have to be requested. Ask the laboratory to include the ranking scale and to list the extractant used for the test. The frequency of testing will depend upon your site conditions. A micronutrient test should always be included as part of the general soil nutrient test for any new golf course site, during grow-in programs, or where micronutrient problems are expected. Periodic testing is recommended even where there are no problems to monitor changes and evaluate ongoing fertility practices.

A soil analysis is an important tool to help predict potential micronutrient deficiencies and imbalances. A tissue test may be more helpful to confirm suspected deficiencies and toxicity problems. The tissue test is only as good as the sample collected, so care should be taken to keep samples clean and free of soil and limited to the site you wish to be tested. Clipping samples can be collected from both problem and non-problem areas for comparison purposes. A more representative sample should be used if the test is for monitoring purposes. The clippings can be collected from mowing baskets on greens or clipped manually from other golf course areas. Root tissue samples can be obtained using a soil probe. Avoid sampling soon after a fertilizer application has been made. The laboratory you will use to complete the test can also provide more information on specific sampling techniques and packaging of the tissue samples.

Commercial and university laboratories are equipped to complete an analytical tissue test. The clipping or root samples received in the laboratory are first washed and then dried or ashed and treated with strong acids to dissolve the nutrients. The concentrations are calculated and the results provided along with a ranking that compares the values with normal ranges. Table 3 provides sufficiency ranges for micronutrients in turfgrass tissues.

Table 2

DTPA and Mehlich III extractable Fe, Zn, Cu, and Mn levels used by many laboratories for micronutrient availability.[a]

Micronutrient	Low (Deficient)	Medium	High (Sufficient)[b]
DTPA[c]		ppm	
Fe	< 2.5	2.6 - 5.0	> 5.0
Mn	< 1.0	1.0 - 2.0	> 2.0
Zn	< 0.5	0.6 - 1.0	> 1.0
Cu	< 0.2	0.2 - 0.4	> 0.4
Mehlich III[c]			
Fe	<50.0	50 - 100	>100.0
Mn	< 4.0	4.0 - 6.0	> 6.0 (pH 6.0)
	< 8.0	8.0 - 12.0	> 12.0 (pH 7.0)
Zn	< 1.0	1.1 - 2.0	> 2.0
Cu	< 0.3	0.3 - 2.5	> 2.5

[a]After Tisdale et al. and Mortvedt.

[b]Extractable micronutrient levels are preferred to be within the High range for high-maintenance, recreational turfgrass sites but within the Medium range for non-recreational grasses.

[c]Rankings for micronutrients are more accurate for plants sensitive to a particular micronutrient, such as vegetable crops, than for turfgrasses, which are not sensitive to micronutrients.

Reference: R. N. Carrow et al. 2001. p. 251.

SITE ANALYSIS

The following considerations are helpful when evaluating the status of micronutrients at your site:

- Are site conditions conducive to a particular deficiency?
- Are there visual symptoms present on individual plants that may indicate a deficiency?
- Are there any "red flags" indicated in the soil nutrient tests?
- Is there anything in the water quality tests that may influence micronutrient status?
- Have tissue tests been completed for affected and non-affected areas?
- Are you managing grass species or cultivars that have special requirements?
- Have smaller-scale test applications of micronutrients been completed to confirm a suspected deficiency?

Micronutrient deficiencies may occur because of certain weather conditions or interactions with other micronutrients. Examples of deficiencies can sometimes be seen with iron, when soil temperatures remain cool, wet, or when roots become dysfunctional because of high soil temperatures or disease. Excessive concentrations of one micronutrient may induce a deficiency of another. The heavy leaching requirements of salt-affected soils can also cause deficiencies of Fe, Mn, Cu, and Zn.

Soil pH probably has the largest impact on micronutrient availability. Micronutrient deficiencies occur more commonly in calcareous sands or soils, or where water pH is high. Excessive liming can have the same impact. Fe, Mn, Zn, and Cu are more soluble in acidic soils, and deficiencies are not anticipated unless the soils are heavily leached. Excessive levels of Fe,

Table 3

Sufficiency ranges for nutrient concentrations in clippings from turfgrass.

	Sufficiency Ranges for				
Nutrient	Bermudagrass[a]	Creeping Bentgrass[a]	Perennial Ryegrass[a]	St. Augustinegrass[a]	General[b]
N, %	4.00 - 6.00	4.50 - 6.00	3.34 - 5.10	1.90 - 3.00	2.75 - 3.50
P, %	0.25 - 0.60	0.30 - 0.60	0.35 - 0.55	0.20 - 0.50	0.30 - 0.55
K, %	1.50 - 4.00	2.20 - 2.60	2.00 - 3.42	2.50 - 4.00	1.00 - 2.50
Ca, %	0.50 - 1.00	0.50 - 0.75	0.25 - 0.51	0.30 - 0.50	0.50 - 1.25
Mg, %	0.13 - 0.40	0.25 - 0.30	0.16 - 0.32	0.15 - 0.25	0.20 - 0.60
S, %	0.20 - 0.50	no data	0.27 - 0.56	no data	0.20 - 0.45
Fe, ppm	50 - 500	100 - 300	97 - 934	50 - 300	35 - 100
Mn, ppm	25 - 300	50 - 100	30 - 73	40 - 250	25 - 150
Cu, ppm	5 - 50	8 - 30	6 - 38	10 - 20	5 - 20
Zn, ppm	20 - 250	25 - 75	14 - 64	20 - 100	20 - 55
B, ppm	6 - 30	8 - 20	5 - 17	5 - 10	10 - 60
Mo, ppm	0.10 - 1.20	no data	0.5 - 1.00	no data	no data

[a]Mills and Jones, 1996.
[b]Jones, 1980.
Reference: R. N. Carrow et al. 2001. p. 172.

Mn, Cu, and Zn are more likely to be available to plants in highly acidic soils (pH<5). Boron toxicity is also more prevalent in low-pH soils where B levels in the native soils or irrigation water are high. High levels of a micronutrient may also accumulate in soils and plant tissue following repeated use of certain composts, sludge-based fertilizers, and plant fugicides.

FERTILIZER STRATEGIES

Micronutrients can often be managed proactively with an application or two of a fertilizer containing a complete micronutrient package and by managing soil pH. Seldom will applications of Cu, Zn, or B alone be necessary, and adequate concentrations of those nutrients can be maintained by using one of the fertilizer packages. Fe deficiencies are the most common among the micronutrients. Foliar applications of Fe are common to correct the deficiencies and to maintain desirable color. Mn deficiencies are less common, but supplemental applications may be required in high-pH soils, heavily leached low-pH sands, or where patch diseases are a concern. Calcareous soils, salt-affected sites, or heavily leached sandy soils (CEC<2-3 meq per 100 gm soil) may require more frequent and light applications of micronutrient-based fertilizer packages or supplemental applications of Fe or Mn.

Micronutrient fertilizers are available in soluble formulations for foliar or soil applications. Foliar applications of micronutrients may be desirable where a rapid response is required or if there are concerns about soil availability (see Table 1).

Chelated formulations of micronutrients are available for foliar and soil applications as well. The chelates are more expensive but will remain available to plants longer in high-pH soils or other instances where availability is a concern.

Foliar application of any fertilizer requires time for absorption into the plant, so delaying mowing practices will ensure that higher concentrations of nutrients are absorbed. Foliar applications of both Fe and Mn must be made frequently, as the nutrients are not

Table 4

Application rates of various micronutrients for test plots to determine the need for wider-scale applications.

Micronutrient	Lbs. per 1,000 sq. ft.	Fluid oz. per 1,000 sq. ft.*	Fertilizer Sources
Iron	.0250	2.000	Ferrous sulfate (20% Fe)
Manganese	.0125	.800	Manganese sulfate (26-28% Mn)
Zinc	.0100	.460	Zinc sulfate (35% Zn)
Copper	.0030	.140	Copper sulfate (25% Cu)
Boron	.0020	.190	Boric acid (17% B)
Molybdenum	.0010	.036	Sodium molybdate (47% Mo)

*Fluid oz. of product applied in 1-3 gallons of water per 1,000 sq. ft.

mobile inside the plant. Zn, Cu, B, and Mo are more mobile, and deficiencies can be corrected more easily with foliar applications. Soil applications of Mn are most effective to increase Mn concentrations in the roots.

Soil and tissue tests help chart micronutrient status in soils and the plant. However, a suspected deficiency of a micronutrient can also be confirmed by completing a field application of that nutrient over a small test plot. A plant response following the application confirms the deficiency and perhaps the need for wider-scale applications. Table 4 provides application rates of the various micronutrients for such tests.

Managing micronutrients is not an exact science. Those managing sandy or high-pH soils, salt-affected sites, or who are growing-in a golf course should be familiar with the interactions among micronutrients, the factors that can cause imbalances, and what fertilizer strategies can be used successfully. So take the time to learn more about the role of micronutrients in turfgrass systems and how site conditions, management practices, and weather conditions can impact their availability. This is one time when micromanaging is not just acceptable, but is downright necessary.

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JIM SKORULSKI *is the Green Section agronomist who visits golf courses throughout New England and eastern Canada.*

Cold soil temperatures and an already weak root system can impact nutrient absorption and result in nutrient deficiencies in the plant.