NEW CONCEPTS IN TURF FERTILIZATION

Nitrogen is the most important element in a successful fertilization program. New concepts demonstrate when it is the best time to apply nitrogen, and how much is needed.

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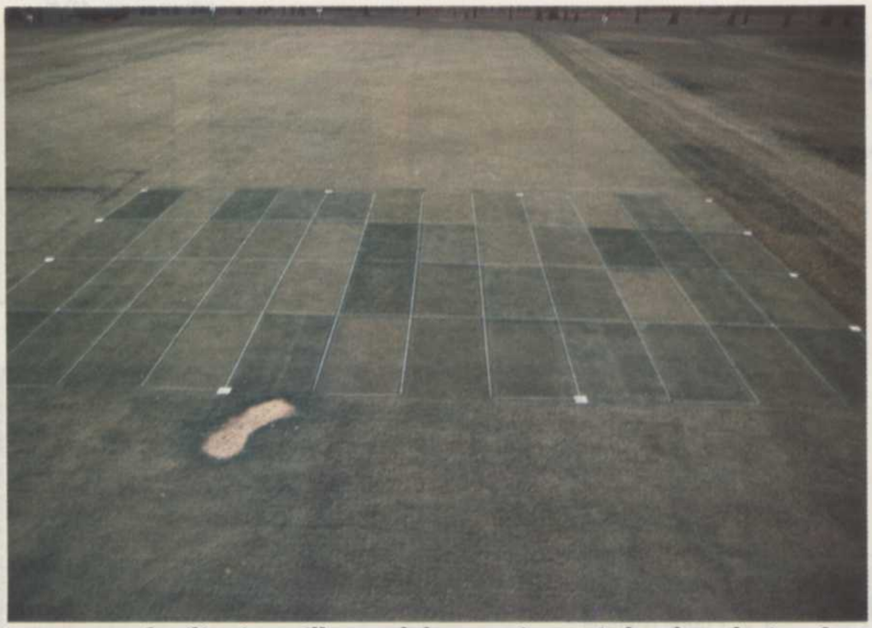

Late-season fertilization will extend the greening period and aesthetics of turf in fall and spring.

Turfgrass growth depends on an adequate supply of all essential plant nutrients, plus many other cultural and edaphic (soil-related) factors. Research in plant nutrition has shown that at least 16 elements are essential for plant growth and development (Table 1).

Those essential elements used in greatest quantities by the plant are referred to as macronutrients: nitrogen, phosphorus and potassium. Micronutrients, seldom deficient in most soils, are needed in relatively small quantities by the plant.

Nitrogen fertilization

Nitrogen receives the most attention in turfgrass fertilization programs for several reasons.

First, nitrogen is the essential element to which turfgrass is most responsive (Table 2). A key concept in turfgrass fertilization is that nitrogen is the "growth-control element." Supplies of other elements are maintained at adequate levels (maintenance fertilization). The turfgrass manager regulates growth and color by adding or withholding nitrogen.

Second, nitrogen plays a major role in turfgrass heat, drought and cold stress tolerances by its effect on rooting, plant carbohydrate levels and plant hydration.

Third, the turfgrass plant contains more nitrogen than any other element.

Fourth, nitrogen is a very dynamic element in the soil system. Its concentration is constantly changing, usually decreasing. The other essential elements are significantly more stable in soils. Nitrogen, therefore, must be routinely added to turfgrass to maintain a soil level sufficient for turfgrass growth.

An ideal nitrogen fertilization maintenance program on established turfgrass should provide for very slow to moderate uniform topgrowth throughout the growing season (Figure 1). The ideal program should supply enough nitrogen to stimulate some growth and green color to maintain turf quality and recuperative potential, where necessary. Rapid changes or surges in topgrowth, sometimes referred to as peak and valley growth or feeding, are undesirable from both an agronomic and maintenance standpoint.

Turfgrass shoot growth can be largely managed by the (1) amount of nitrogen applied; (2) type of nitrogen applied and (3) timing of the nitrogen application. Fast-release sources (e.g. urea) are readily available for the plant's use. They stimulate a relatively rapid plant/growth response.

Slow-release sources (e.g. methylene urea, sulfur-coated urea, IBDU) provide a time release of nitrogen to the plant. This results in a more uniform or controlled growth.

Fast-release/slow-release nitrogen combinations are typically used to control turfgrass growth and provide safety. Higher nitrogen rates generally stimulate greater turfgrass shoot growth.

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Nitrogen rates are usually limited to ½ to 1 pound per 1,000 sq. ft., especially with fast-release nitrogen sources. This avoids undesirable shoot growth surges during periods favorable for shoot growth (i.e. spring on cool-season grasses).

Recent nitrogen fertilization philosophy has been to limit nitrogen levels. This helps to avoid excessive topgrowth and adhere to a slow-to-moderate shoot growth concept.

This philosophy stems in part from the impact that nitrogen has on rooting and plant carbohydrate levels. Carbohydrates (sugars) support growth of plant parts (e.g. shoots and roots) and assist in recovery from injury. Carbohydrates are also the key source or energy for maintaining all the plant's growth and physiological processes.

Nitrogen applications favor turfgrass growth. As nitrogen rates are increased, more topgrowth is usually produced. More topgrowth results in more carbohydrate use to support this growth. *A key physiological principle is that under rapid growth, shoots take priority over roots, rhizomes and stolons for available carbohydrate.* Shoot growth will continue to respond to higher nitrogen levels, distinctly suppressing root growth and other growth processes.

These effects are well illustrated in a fertilization study evaluating the response of a Merion Kentucky bluegrass sod to incremental rates of nitrogen (topgrowth) and nitrogen content of clippings.

In contrast, sod strength, a reflection of root and rhizome growth, and rhizome weight decreased at higher nitrogen levels. Thus, when most of the plant's carbohydrate was directed toward shoot growth, root and rhizome growth suffered accordingly. Agronomists well recognize that a plant's stress tolerance is directly related to the depth and mass of the plant's root system.

Table 1:

Essential Plant Nutrients Required for Turfgrass Growth and Development

Macronutrients	Typical Percentage in Turfgrass Tissue[a]	Remarks
Nitrogen Phosphorus Potassium	3-6 0.2-0.5 2-3	Commonly used in maintenance fertilization at ratios of 3-1-2 to 5-1-2. Additional P and K (corrective) may be necessary where inherent soil levels are low.
Sulfur	0.2-0.3	Usually only applied where a specific deficiency has been diagnosed. Used in ratios similar to P.
Calcium Magnesium	0.4-0.6 0.2-0.4	Usually only applied where a soil pH adjustment is required or on alkali soils.
Micronutrients	Typical Parts per million (ppm) in Turfgrass Tissue	Remarks
Iron Zinc Molyldenum Manganese Copper Boron Chlorine	40-200 40-120 0.1-0.2 20-150 15-20 5-20 —	Iron is usually used to provide short term green color enhancement. Micronutrients primarily deficient on alkaline soils and/or soils with high phosphorus and/or high micronutrient levels (Mn, Zn, and Cu). Seldom deficient on fine-textured soils.

[a] Elemental percentages will vary to some extent depending on turfgrass species and cultivars, environmental conditions and other variables.

Research at Ohio State University has shown that root initiation and root growth of cool-season grasses occurs in the spring and again in the fall (Figure 2). Liberal nitrogen fertilization in the spring will have a tendency to restrict root growth in favor of shoot growth. The turfgrass plant will go into the summer with a shorter root system than when low-to-moderate rates of nitrogen fertilizer are used.

Furthermore, high rates of nitrogen will increase topgrowth and increase the need for spring mowing. Rapid topgrowth may result in the removal of large amounts of clippings at each mowing. The removal of more than a third of the foliage at any one mowing retards both root and tiller development.

A reduction in root growth at this time is extremely critical since spring is an optimum time for root growth. A lot of "good root growth growing time" can be lost in the spring by heavy nitrogen applications.

Thus, mismanagement of nitrogen during the spring can have a dramatic effect on the root system under the turfgrass going into the summer. This, in turn, means a significant influence on stress tolerance.

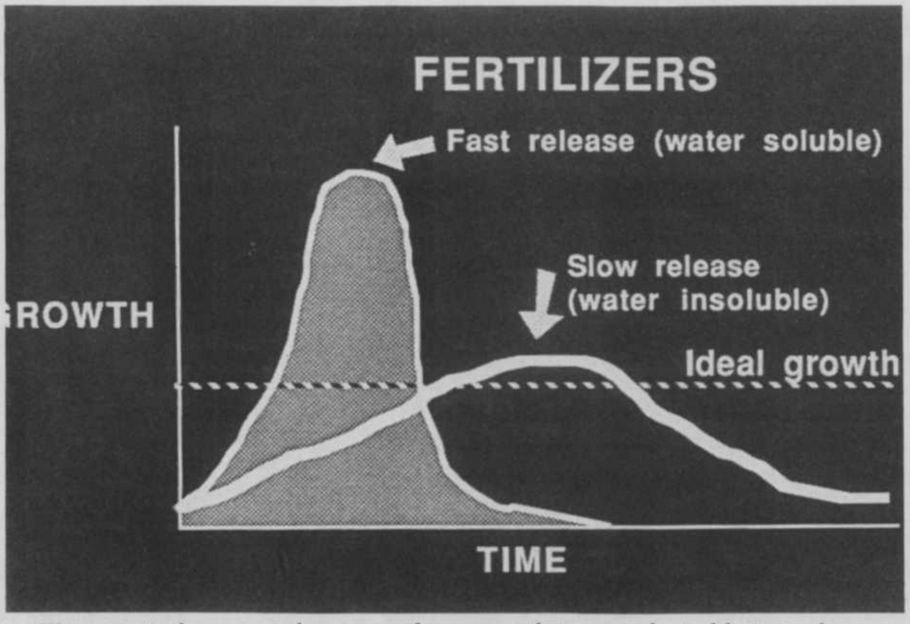

Figure 1. A slow to moderate, uniform growth is most desirable in turfgrass fertilization programs. Nitrogen is the "growth control" element.

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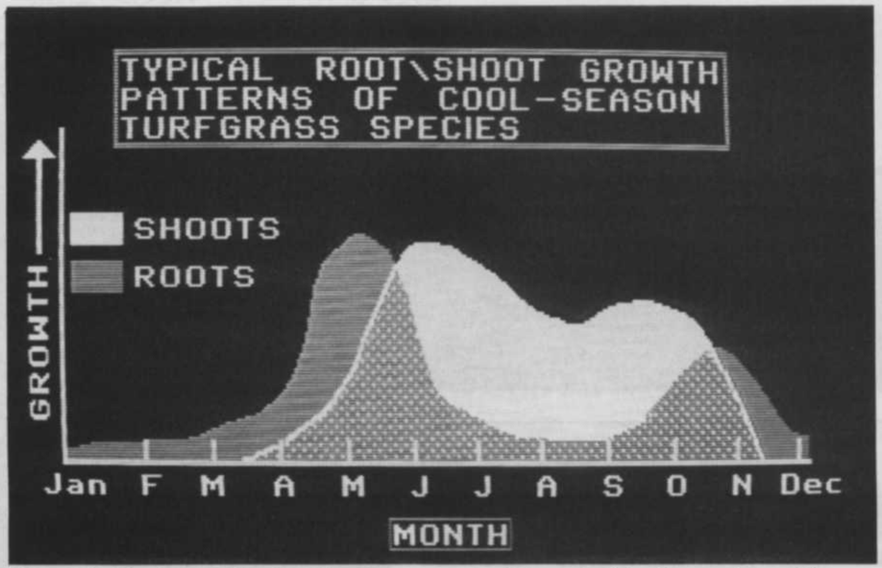


Figure 2. Root growth of cool-season grasses is greatest in the spring with a significant root growth surge again in the fall.

Timing of nitrogen applications is critical to a healthy turf with maximum stress tolerance. Heavy nitrogen fertilization during the spring and early summer is undesirable for cool-season turfgrasses. Environmental conditions are favorable for a rapid topgrowth surge at the expense of root growth. Lush, succulent growth is also produced from heavy nitrogen in the spring. This takes the turfgrass into the summer in a soft growth condition and more vulnerable to disease, heat and drought.

To avoid these latter disadvantages, late-season fertilization has been adopted for cool-season grasses. Late-season fertilization means application of nitrogen during that period of the year (late fall) that will favor root growth over shoot growth, and favor a positive carbohydrate balance in the turfgrass plant.

Cool-season turf shoot and root growth occur most readily in temperatures of 60 to 75 and 50 to 65 degrees Fahrenheit, respectively. Research at Ohio State University has shown that root growth of cool-season grasses will continue at soil temperatures close to freezing. Shoot growth will slow and eventually cease long before soil temperatures drop low enough to stop root growth. Roots can be actively growing while shoots above are brown and dormant. Late-season fertilization capitalizes on this differential in optimum temperatures and minimum temperatures for growth of shoots versus roots.

For the "late-season" concept to work successfully, turf must be green when the late-season nitrogen application is made.

On cool-season grasses, a late summer/early fall nitrogen application will ensure that the turf remains green before the late-season application.

Ideally, the late-season nitrogen application should be made when vertical shoot growth has stopped, but the turf is still green to produce carbohydrates via photosynthesis.

Air temperatures of 45 to 50 degrees Fahrenheit are usually necessary to ensure vertical shoot growth stoppage of cool-season grasses. Since temperatures will be at a point that stops roots, cool-season grass rhizomes and stolons will capitalize on any applied nitrogen and carbohydrate produced. The carbohydrate produced by the green turf will be more efficiently used for root, rhizome and stolon growth during the late fall, winter and spring.

Research at Ohio State University has shown a significant increase in both root growth rates and root numbers (Figures 3 and 4) from late-season nitrogen fertilization. A more positive carbohydrate balance also was provided from late-season fertilization compared to a spring/summer fertilization.

Nitrogen applications during the late season, if timed properly, will extend greening later into the fall and winter. Spring green-up will usually occur earlier.

In general, the turf's "greening period" from late-season fertilization can be extended four to eight weeks during late fall and early spring. This is a sound practice both agronomically and aesthetically.

Typically, spring color of late-season fertilized turf remains quite good until late May or early June. Then the effects of nitrogen applied the previous fall begin to wear off. Spring appli-

Poor fertilizer performance? It might be ammonia volitilization

Nitrogen loss from ammonia volatilization can result in poor fertilizer performance, according to David Kissel, researcher at Kansas State University.

Kissel says that as in leaching, losses of nitrogen by ammonia volatilization can make it necessary to re-apply fertilizer to restore the lawn to its original green color and vigorous growth.

Ammonia volatilization occurs when nitrogen is converted to a gas and released into the air. This nitrogen removal bypasses the turf and deprives a lawn of needed nutrition. Of the 16 elements needed for healthy turf development, nitrogen is by far the most important.

"Ammonia volatilization can take place when urea and urea-containing fertilizers are present on turfgrass surfaces, in the thatch layer, or very near the soil surface," he says. Non-urea fertilizers are also susceptible to nitrogen losses from ammonia volatilization, but only when applied to the surface of alkaline soils.

Along with heavy thatch, a lack of rainfall or irrigation will increase the chances for nitrogen loss from ammonia volatilization because movement of applied fertilizer into the soil will be reduced. Kissel says that substantial losses can be avoided if irrigation or rainfall occurs within a few hours after fertilizer application.

If irrigation is not possible, and conditions are favorable for loss, he recommended using non-urea nitrogen or slow-release fertilizer, such as sulfur-coated urea or some of the new products, like N-Sure nitrogen solution, in combination with the regular nitrogen source.

Kissel addressed the ammonia volatilization problem at the Kansas Turfgrass Foundation meeting in Wichita, Kan. □

Table 2:
Comparative Turfgrass Responses of Commonly Used Maintenance Nutrients — Nitrogen, Phosphorus and Potassium.

	Nutrient		
Turfgrass Response	Nitrogen	Phosphorus	Potassium
Shoot Growth	•		
Shoot Density	•		
Grass Color (Green)	•		
Root Growth	•	•	•
Establishment Rate	•	•	
Recuperative Rate	•		
Wear Tolerance	•		
Heat Stress	•		•
Drought Stress	•		•
Cold Stress	•		•
Disease Incidence	•		•

* Fairly strong relationship based on available research.

Table 3:
Nitrogen treatment effects on a Merion Kentucky bluegrass sod.

Nitrogen Rate	Annual Clipping Yield (dry wt.)	Nitrogen Content in Clippings	Sod Strength	Rhizomes
lb/A/month	lb/A	%	lb to tear	grams
0	463	3.0	146	99
15	1807	3.3	188	89
30	2555	3.6	130	120
60	5676	4.5	97	43
120	8447	5.4	67	14

Rieke, P. E. 1975. Turfgrass Fertilization - Nitrogen. 16th Illinois Turfgrass Conference Proceedings. 81-85.

Table 4:
A Comparison of Known Late-Season Fertilization Advantages on Cool- Versus Warm-Season Grasses.

Late-Season Effect	Cool-Season Grass Response	Warm-Season Grass Response
Winter hardiness	+−	−
Rooting	+	
Carbohydrate balance	+	
Fall color retention	+	+
Spring greenup	+	+
Spring mowing reduction	+	+
Turf density	+	+
Weed reduction	+	
Disease reduction	+	
Thatch accumulation	+	

Plus (+) denotes a positive response, negative (−) denotes a negative response, (+ −) denotes a limited response and a blank indicates research information limited.

cations of nitrogen should be delayed until the late-season fertility response dissipates.

The most efficient nitrogen sources for late-season fertilization programs are independent of temperature for nitrogen release. Soil temperatures and microbial activity are low at this time of the year, resulting in poor efficiency from temperature-dependent fertilizers like ureaformaldehyde.

Urea, IBDU, sulfur-coated urea and short chain methylene ureas will work effectively in this program. Recommended nitrogen rates are 1½ lbs. per 1,000 sq. ft.

In Ohio State University research, thatch has been found to be greater under late-season fertilization than under spring/summer fertilization. This has been the only disadvantage reported for late-season fertilization in cool-season grasses. The greater root growth occurring with late-season fertilization is considered the likely reason for more thatch. Thatch has been reported to consist of as much as 60 to 70 percent roots.

Management practices like late-season fertilization or high mowing that increase root depth and number will, more than likely, over time, increase thatch accumulation.

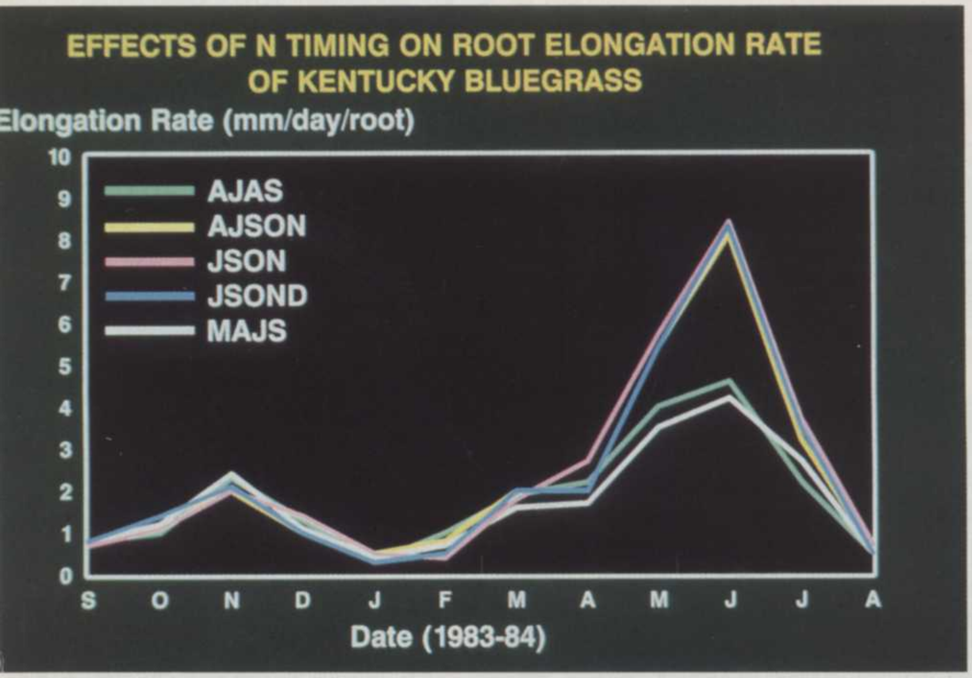
This implies that, in long-term management strategies where cultural practices maximize root growth, accompanying strategies like core cultivation must be used to control thatch.

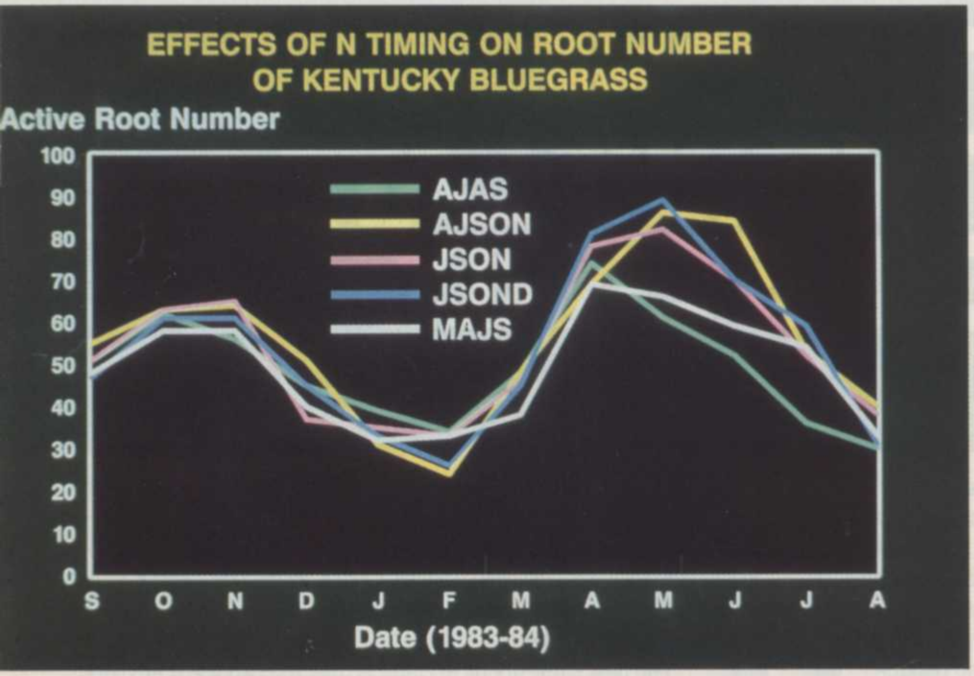
Limited information is available on the adaption of warm-season grasses to late-season fertilization. Some of the advantages claimed on cool-season grasses will provide similar benefits on warm-season grasses (Table 4), such as extended greening and earlier spring green up. Winter injury and winter hardiness are major concerns, however. In general, late-season fertilization will lower the winter hardiness of warm-season grasses by delaying or interfering with the hardening process.

This will result in a greater risk of injury, especially as in the northern limits of the transition zone. Turf managers must weigh the benefits against the risks.

Potassium fertilization

Turfgrasses need potassium in relatively large amounts, second only to nitrogen. The potassium content of properly fertilized turfgrasses normally ranges from two to three percent. Potassium in maintenance fertilization programs has generally been applied in a ratio of 3:1:2 to 5:1:2, nitrogen-to-phosphorus-to-





Figures 3 & 4. Late-season fertilization (O, N and/or D) significantly increased root elongation rates and root number during the following spring and early summer. Nitrogen was applied at one pound rates during the months indicated.

potassium. On low potassium soils, additional potassium may be necessary.

Recent research has demonstrated that increasing potassium levels result in improved root growth; an enhancement of heat, cold and drought tolerance; better wear tolerance and less chance of disease.

This research suggests a nitrogen-to-potassium ratio approaching 1:1. Higher analysis potassium fertilizers will be most beneficial before and during stress periods. Higher potassium levels prior to winter have been found to be extremely beneficial to warm-season grasses. They enhance winter hardiness and would certainly seem warranted in late-season fertilization of warm-season grasses.

Phosphorus fertilization

Phosporus usually enhances turfgrass establishment rate from seed or vegetative plantings and enhances root growth. In maintenance fertilization programs, phosphorus has generally been applied in ratios of 3:1:2 to 5:1:2 nitrogen-to-phosphorus-to-potassium.

Nitrogen-to-phosphorus ratios of 1:1 to 1:2 are recommended in establishing new turfgrass areas. Phosphorus deficiencies are, however, rarely observed in established turf areas unless their level in the soil is extremely low or an unfavorable pH exists.

Micronutrients

Micronutrient levels are usually adequate in most soils. In addition, these nutrients are needed in very small quantities. They are often supplied as impurities in commonly-used fertilizers, liming materials, top dressing, certain pesticides and irrigation water.

Sandiness increases the possibility for micronutrient deficiencies. However, most sands used for soil modification are not pure and are usually modified to some extent with soil or organic matter.

Thatch has been found to be greater under late-season fertilization than under spring/summer fertilization.

In general, micronutrient deficiencies are most likely to occur in alkaline soils (high pH). They are further aggravated by high soil phosphorus and high soil levels of other micronutrients. It is adviseable to use both soil and tissue testing to define a micronutrient deficiency.

Iron is the micronutrient most frequently supplemented in turfgrass fertilization programs. Its more frequent use among micronutrients is primarily due to its capability to enhance turfgrass color.

Iron application of 1 to 2 oz. of iron carrier per 1,000 sq. ft. produces a relatively rapid dark greening response with a short residual of one to three weeks. Iron has been known to have positive influence on plant carbohydrate reserves. It more recently has shown to have a positive effect on drought hardiness. **LM**