University of Kentucky
College of Agriculture, Food and Environment
Cooperative Extension Service

Iron for Kentucky Turfgrasses

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Iron (Fe) is commonly applied using granular or foliar sources to enhance turfgrass color. Iron applications can result in darker green turfgrass as a result of increased Fe uptake or Fe oxidation on the leaf surface. In many cases, Fe results in no turfgrass response at all. Understanding the dynamics of Fe in the plant and in the soil and conditions under which an Fe response would be expected can enhance your nutrient management programs. The objective of this publication is to explain the function of Fe within the plant, describe the Fe sources available for turfgrasses, and identify which Fe fertilizers are most effective.

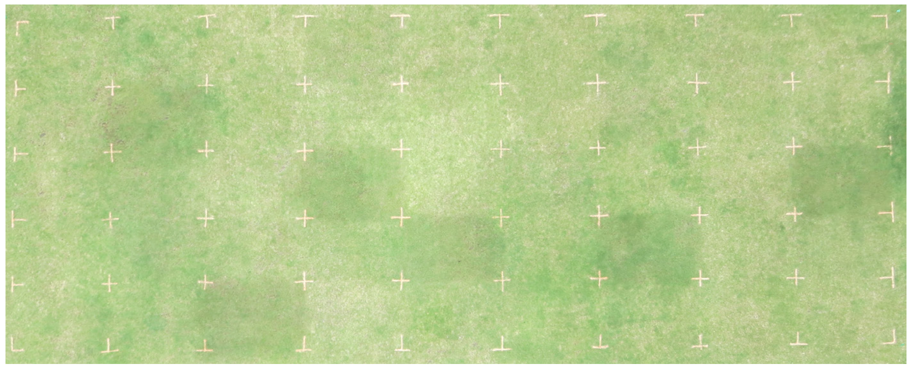

Figure 1. Bermudagrass showing response to foliar iron (each dark green rectangle) compared to granular Fe or no Fe (all remaining rectangles)

Function of Iron

Turfgrass can appear darker green after an Fe application because the supply of Fe from the soil is often less than the plant's demand. Iron is needed in numerous photosynthetic functions, including activation of enzymes that catalyze chlorophyll synthesis, maintenance of thylakoid membrane (the site of the light-dependent photosynthesis reactions) structural integrity, and the transfer of electrons during photosynthesis. Although several nutritional elements may result in darker green turfgrass, the roles of most elements within the plant are not interchangeable with one another. For example, the application of Fe will not cure chlorosis caused by a nitrogen (N) deficiency.

Iron is immobile in the plant, thus deficiency appears on younger leaves first. Iron deficiency may be observed in turfgrasses in the spring following N fertilizer applications. This can be frustrating because the N application should have resulted in greener turfgrass but in fact, the lawn may appear chlorotic in places. The most likely explanation for this observation is that N applied during the spring encourages turfgrass growth and, in turn, increases the demand for Fe. However, this demand for Fe cannot be met because turfgrass root growth is still limited in the spring and, thus, the ability to take up Fe is low resulting in chlorotic leaf blades. Cool, wet soils tend to exacerbate this chlorosis. As soil temperatures increase, the quantity of turfgrass roots increases resulting in greater uptake of Fe and a decrease in Fe deficiency symptoms. Springtime occurrences of Fe deficiency normally dissipate within a few weeks. Otherwise, turfgrass Fe chlorosis can be minimized by applying foliar Fe (Figure 1).

Soil Iron

Iron makes up about 5% of the earth's crust but most of this Fe is unavailable for plant uptake because it is bound in primary or secondary minerals. Compared with other cations in the soil solution, soluble Fe is usually very low and is commonly lower than necessary to meet plant requirements. So how does turfgrass acquire Fe if the soluble Fe is insufficient? Turfgrasses exude hydrogen ions to lower the pH near the root surface and/or they exude natural chelating compounds known as phytosiderophores that complex Fe and renders the Fe available for plant uptake. Even with the ability to chelate soil Fe, turfgrasses may not receive sufficient Fe to achieve the desired green color expected by many turf managers or homeowners. In these cases, Fe fertilizers can be used to enhance turfgrass greening.

The availability of Fe in soils is dependent upon soil moisture, soil pH, soil temperature, and organic matter content. As soil moisture increases, the quantity of Fe available for plant uptake also increases because the rate of Fe oxidation is much lower when oxygen is limited. This may seem advantageous but limited oxygen also negatively influences turfgrass root growth. Thus, a moist soil that is not too dry or too wet is ideal. Iron remains soluble for no more than a few minutes in aerated solutions of pH 7.0 or higher. This does not imply that Fe is always soluble when soil pH is below 7.0. The dominant plant-available form of Fe in soils is ferrous Fe (Fe^{2+}) and because Fe^{2+} reacts directly with oxygen (O_2) in an aerated soil solution, little, if any, soluble Fe will be available for turfgrass uptake until the soil pH falls below 4.0. Low soil temperatures may limit Fe uptake by reducing phytosiderophore production or by increasing bicarbonate accumulation, which precipitates soluble Fe as $FeCO_3$. Humic and fulvic acids found in soil organic matter may increase Fe solubility. In short, Fe acts as a catalyst for the oxidation of organic matter by O_2, which increases the amount of Fe^{2+} in soil solution. This reaction occurs despite the presence of O_2 in soil solution, thus soils with appreciable organic matter should be less prone to producing Fe deficient turfgrass.

Soil Testing

Iron applications should not be based upon soil test Fe levels. The University of Kentucky soil testing lab will test soils for Fe upon request, but the lab does not provide Fe recommendations. This is because the concentration of Fe changes rapidly in most aerated soils and thus, by the time the applicator receives the recommendation, the soil Fe levels would likely be different from the initial soil concentration. In addition, soil test calibrations used to predict a response to the application of Fe have not been established on Kentucky soils.

Tissue Testing

Tissue testing provides a measure of the Fe content of the turfgrass at the time the tissue sample was taken. However, similar to soil testing, tissue testing is not a reliable method to manage Fe applications to turfgrass. Iron concentrations in turfgrass leaves fluctuate based upon species, season, and soil as well as many other variables.

Can tissue testing be useful in managing Fe applications to turfgrass? In general, no. Even under very controlled conditions from the same turfgrass stand, tissue test results for Fe can fluctuate greatly. For this reason, it is difficult to determine what "normal" Fe levels should be in turfgrass tissue. Without knowing 'normal' Fe levels, we cannot determine if our levels are too low, too high, or just right.

Is Iron Needed?

Since soil and tissue Fe test results are unreliable, the best way to determine if Fe is needed is through an on-site visual assessment. Test and area with a small amount of Fe fertilizer to see if you see a response. Start by using foliar Fe sulfate applied at 1 lb. of Fe per acre. If a response is observed, then additional Fe applications may be made to the remainder of the turfgrass using the same Fe source and application method. If no response is observed, try a different Fe source or increase the application rate. On-site tests of granular Fe sources may be conducted in the same manner. However, granular Fe sources require a higher application rate beginning at 20 lbs. of Fe per acre. Please keep in mind that a turfgrass response to soil-applied Fe has not be documented except from ethylenediaminetetraacetic acid (EDTA), diethylenetriaminepentaacetic acid (DTPA), or ethylenediaminedi-*o*-hydroxyphenylacetic acid (EDDHA).

Applying Iron

Granular Applications

Most granular, non-chelated forms of Fe will rapidly become unavailable to the plant and the money spent on these Fe fertilizers will have been wasted. Instead of using non-chelated Fe sources, granular applications of Fe should be limited to the chelates EDTA, DTPA, or EDDHA. In order to induce a turfgrass response, granular Fe chelates should be applied at 20 lbs. of Fe per acre and monthly applications may be necessary before a response is observed. Because achieving these high rates may not be feasible, applying foliar Fe may be a more cost-effective option.

Foliar Applications

Iron applied directly to the turfgrass leaves is often the most efficient and reliable method of applying Fe. When applied to the foliage, the Fe bypasses the soil where oxidation may render the Fe unavailable. Generally, all sources of liquid Fe will result in a greening response so long as the source contains soluble Fe. Spray-grade Fe sulfate is normally the least expensive foliar Fe source and often results in a similar response as the more expensive but easier to apply Fe chelates. Properly applied foliar Fe does not normally require chelation because the Fe should not enter the soil. Foliar applications of Fe should not exceed 5 lbs. of Fe per acre because exceeding this limit increases the risk of foliar burn and may result in 'blackening' of the turf. Blackening is a result of the Fe

Applied ↓

$$Fe^{3+} + 3H_2O = Fe(OH)_3 + 3H^+$$

↓ Precipitate

Figure 2. Iron applied to soil rapidly oxidizes and becomes unavailable for plant uptake.

Figure 3. Granular iron sulfate fertilizer particles will rapidly dissolve and stain wet surfaces such as this sidewalk.

Figure 4. Granular iron sulfate particles that reach the soil surface will rapidly oxidize and form a red/brown stain.

oxidizing on the leaf surface rather than entering the leaf. Normally, burns from Fe application dissipate within one to two weeks, assuming the turfgrass is healthy and actively growing. Lower rates closer to 0.5 lbs. of Fe per acre have less risk of burn and are common on putting greens and highly manicured turfgrass. Iron applied at low rates may require more frequent applications to maintain the desired color. Regardless of whether low or high Fe rates are used, the Fe should be applied in approximately 40 gallons of water per acre (1 gallon per 1,000 ft^2). This application volume allows the Fe to remain on the leaves rather than be rinsed off into the soil.

Iron Sources

Iron Sulfate

Iron sulfate is perhaps the most common soluble granular Fe source for turfgrasses. Iron sulfate typically has an analysis of 20% Fe and appears as a white to light greenish blue, angular particle or prill, and it is 100% water soluble. Both granular and foliar forms of Fe sulfate are used in turfgrass management, but only foliar Fe sulfate has resulted in a beneficial turfgrass response in University studies. Granular Fe sulfate must dissolve into the soil solution and be taken up by the roots. During this process Fe sulfate reacts with water to form an Fe hydroxide (Figure 2). This oxidation process is extremely rapid resulting in as much as 95% of the applied Fe becoming unavailable within one hour of soil contact. In addition, if the oxidation process occurs on surfaces such as cart paths, sidewalks, driveways, patios, etc., a reddish brown stain will occur (Figure 3). Staining can also occur on the soil surface (Figure 4) and even on the turfgrass canopy (Figure 5). Because these stains are formed chemically, they are difficult to remove. Therefore, Fe sulfate should be applied as a liquid to the turfgrass foliage rather than applied to the soil.

Iron Humate

Iron humate is the bi-product of water treatment facilities that produce potable water from humate-rich river water. The material is normally a dark brown to black granule and has a guaranteed Fe analysis of 14%. Iron humate is approximately 30% water soluble with the remaining Fe being in a slowly available form. Fe humate has been tested on turfgrass using 20 pounds of Fe per acre and resulted in no improvement in turfgrass color or quality. Although a portion of the Fe is slowly available, the Fe must still solubilize into the soil solution before plant uptake can occur. Because the Fe is not chelated, the Fe entering the soil solution will oxidize similar to Fe sulfate. The solubility of Fe sources is shown in Figure 6.

Iron Oxide

Iron oxide is the end-product of Fe weathering and more than 99.5% of Fe within Fe oxide is water insoluble. The product is normally a black, angular, very hard granule and guarantees 50% or more Fe. No turfgrass response to Fe oxide has been documented in University studies. Iron oxide and all forms of Fe oxide should not be used as a turfgrass fertilizer.

Iron Sucrate

Iron sucrate is manufactured by pelletizing powdered Fe oxide using a sugar, usually molasses. The product is normally a spherical, black prill and guarantees 50% or more Fe. Although the prills readily disperse in water, Fe sucrate is not water soluble. The dispersion forms a suspension in water, but the fine particles remain insoluble. Turfgrass research using Fe sucrate has not resulted in improved turf quality, growth, or color.

Iron Chelates

Chelation is the process of binding a metal to an organic complex, which results in the metal becoming more soluble. Many Fe chelates exist for use on turfgrasses but only EDTA, DTPA, and EDDHA are documented to result in turfgrass responses when applied to the soil. EDTA, DTPA, and EDDHA may also be applied as a foliar spray and

Figure 5. The black dots on this bermudagrass occurred when granular iron sulfate was applied and not watered in. The oxidation that would normally occur on the soil surface occurred on the leaves instead.

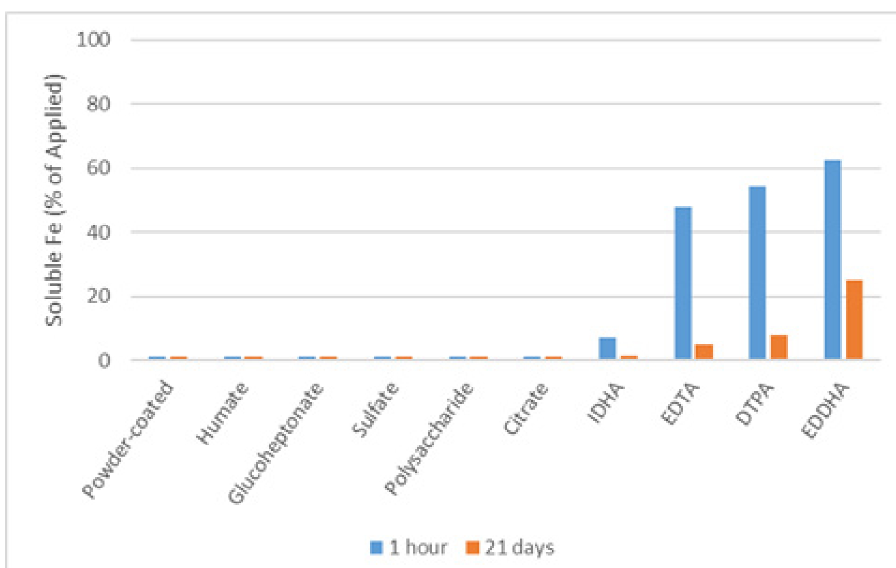

Figure 6. Non-chelated iron fertilizers applied to soils become insoluble in less than 1 hour. Chelation as EDTA, DTPA, or EDDHA is necessary if soil application is desired.

the common guaranteed analyses range between 5% and 10% Fe. Other Fe chelates such as gluconate, glucoheptonate, polysaccharide, and citrate may be included to improve shelf-life and, when applied as foliar sprays, they commonly improve turf color, but they do not increase the availability of Fe in the soil. Keep in mind that high application rates of Fe chelates, especially Fe EDTA, can be phytotoxic to some landscape plants.

Powder-coated Iron

Some fertilizers may be blended with a component of very fine Fe powder added when the fertilizer is being blended. This powder attaches to each fertilizer particle, which greatly increases the uniformity of Fe distributed across the turfgrass. The Fe powder may be derived from Fe sulfate, Fe oxide, or Fe chelate. Each of these powder-coated Fe sources have been tested on turfgrass and none have increased turfgrass color or quality compared with untreated turfgrass. In the case of Fe sulfate and Fe oxide, the lack of response is due to the same soil chemical reactions that limit Fe solubility from conventional Fe fertilizers. In the case of powder-coated Fe chelates, the reason no response has been observed is unknown. However, it is likely that the amount of Fe chelate required to induce a response is greater than the amount of Fe chelate that can be applied via this coating method. Until a turfgrass response to powder-coated Fe is confirmed in Kentucky, the use of powder-coated Fe is not recommended.

Organic Iron

The value of organic Fe in fertilizers such as municipal biosolids is difficult to evaluate because most organic Fe sources also contain N and/or phosphorus. Separating the influence of Fe from the influence of N and phosphorus can be difficult and, thus, a response to organic Fe has not yet been documented on Kentucky turfgrasses.

Summary

Iron is an important component of any turfgrass fertility program and can enhance turfgrass quality and color. If your initial pilot test results in a turfgrass response, then further Fe applications may be warranted. Otherwise, Fe applications should be omitted. Granular Fe sources should be limited to EDTA, DTPA, or EDDHA, whereas foliar applications can include any soluble Fe source.

References

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Issued 12-2019