



Dealing with summer-induced chlorosis of turf

Applying high rates of iron appears to alleviate summer-induced chlorosis in Kentucky bluegrass.

Chlorosis, a yellowing of the plant resulting from a decrease in chlorophyll content, can have a variety of causes, including nutritional, environmental and biological stresses. Chlorophyll is important to plants because of its role in photosynthesis. Through photosynthesis, plants produce carbohydrates (food) that are critical to every growth and development process. If there are not enough carbohydrates, leaf growth will slow and rooting will decrease. A chlorotic plant will be less tolerant of other environmental stresses, such as traffic and disease infestation.

Causes of chlorosis

The most common nutritional cause of chlorosis is a lack of nitrogen, which is part of the chlorophyll molecule and is involved in many of the processes by which chlorophyll is formed. Yellowing of the plant when nitrogen levels are low, followed by a rapid green-up response to nitrogen application, is well known to superintendents. Deficiencies of other elements, including iron, magnesium, manganese and sulfur, can also result in chlorosis (3). Deficiencies of these nutrients will depend on a variety of environmental and soil-related factors, especially pH. There can be sufficient amounts of these elements in the soil, but pH can affect their availability to the plant. This is particularly true of iron, which becomes unavailable to plants in soils with pH levels above 7 (1,2,5,6,7).

Summer-induced chlorosis

Chlorosis of turf is not a new occurrence. How-

ever, recently we have observed chlorotic turf with unusual characteristics. In northern regions of the U.S., summer-induced chlorosis occurs from the middle of July into September and is not usually seen in the spring and fall. Normal chlorosis caused by nutritional imbalances will occur throughout the year at any time the plant is actively growing, particularly in cold and wet conditions in spring and fall (4,8). This type of chlorosis generally does not go away by itself and requires nutrient applications, whereas summer-induced chlorosis generally occurs during high-temperature periods, regardless of nutritional levels, and then subsides when temperatures cool in the fall.

In the Midwestern U.S., summer-induced chlorosis occurs on both Kentucky bluegrass (*Poa pratensis*) and creeping bentgrass (*Agrostis stolonifera*) and tends to be most prevalent on sand-capped and sand-modified soils, but is also common on native soils. Over the past 10 years, Nick Christians and Dave Minner of Iowa State University have observed summer-induced chlorosis in many areas of the Midwest and have received phone calls from across the nation inquiring about turfgrass that is undergoing similar symptoms. Christians has also observed summer-induced chlorosis in Korea and China. After making observations and hearing others ask about these chlorosis symptoms, Christians and Minner both made nonreplicated applications of iron to test areas to determine whether iron applications would correct the symptoms.



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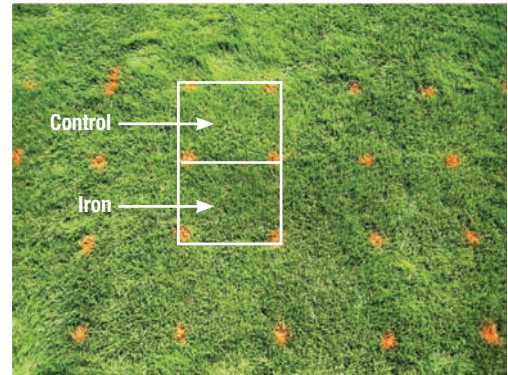


There was little response to the iron fertilization, leading both to believe that the chlorosis was due to some other factor.

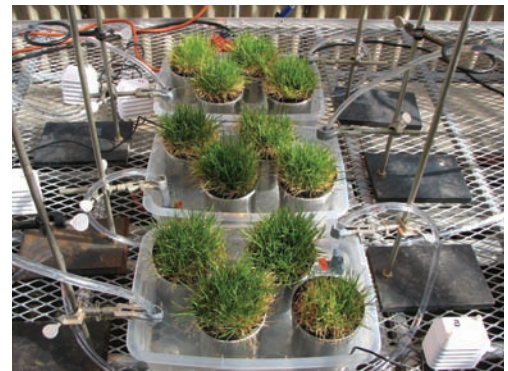
Preliminary studies

As a master's degree student at Iowa State University in Ames, David DeVetter began his work on summer-induced chlorosis in 2006. A preliminary screening study was conducted to investigate turf response to a variety of materials. Eighteen treatments including an untreated control, various rates of several nutrients, a plant growth regulator and an experimental organic soil conditioner were replicated three times (Table 1).

This study was conducted in August 2006 on an area of Unique Kentucky bluegrass at the Iowa State University horticulture research station in Ames. The test area had been sand-capped to a depth of 8 inches (20 centimeters) in 1999, using calcareous sand with a pH of 8.2. Turf on the sand-capped area was maintained at a 3-inch (8-centimeter) mowing height and was irrigated as needed to prevent moisture stress. The turf in this



The initial screening study was done on chlorotic turf at the Iowa State University horticulture station in Ames in summer 2006. Photos by D. DeVetter



Root zones of Kentucky bluegrass plugs were subjected to various temperatures in the greenhouse.

Treatments

Fertilizer (source)	Rate (of element or product)	
	pounds/acre	kilograms/hectare
Untreated control	0	0
Nitrogen (urea)	22	24.65
Nitrogen (urea)	44	49.31
Nitrogen (urea)	65	72.85
Iron (Fe EDDHA)	1	1.12
Iron (Fe EDDHA)	2	2.24
Iron (Fe EDDHA)	3	3.36
Sulfur (ammonium sulfate)	1	1.12
Sulfur (ammonium sulfate)	2	2.24
Sulfur (ammonium sulfate)	3	3.36
Magnesium (magnesium carbonate)	2	2.24
Magnesium (magnesium carbonate)	3	3.36
Manganese (manganese chloride)	0.5	0.56
Manganese (manganese chloride)	1	1.12
Calcium (calcium carbonate)	2	2.24
Molybdenum (ammonium molybdate)	0.01	0.01
Soil conditioner (Grain Processing Corp. experimental formulation)	1,746	1,957.0
Plant growth regulator (Primo MAXX)	26 ounces/acre	1.9 liters/hectare

Table 1. Nutrient study treatments and rates applied on Aug. 6, 2006, to chlorotic Unique Kentucky bluegrass at the Iowa State University horticulture research station.

area had developed summer-induced chlorosis to varying degrees since its construction.

Nutrients were applied at relatively high rates in this study to determine whether there would be any visible recovery. The turf that received various rates of iron fertilization had a greening response, and the turf receiving the other treatments was not distinguishable from the control, which remained chlorotic. This result was surprising because the turf did not show any greening response to iron in previous tests. However, the high rates of iron used in this study were not used in the previous studies. Therefore, the iron rates used previously may not have been sufficient to correct chlorosis symptoms. Once the cause of the chlorosis was understood, the next step was to determine the reason for its development.

Generating summer-induced chlorosis

Because of the timing of summer-induced chlorosis, we hypothesized that it was caused by high temperatures in the root zone. Two studies



with increased root-zone temperature were conducted to test this hypothesis.

Greenhouse study

From February to July 2007, a greenhouse study was conducted where water baths were used to control root-zone temperature of Kentucky bluegrass plugs that had been collected from the sand-capped area. After acclimation to greenhouse conditions, the plugs were subjected to root-zone temperatures of 65 F, 75 F or 85 F (18 C, 24 C or 30 C).

Chlorosis was not induced over the course of the experiment, and color ratings and overall turf quality ratings were the same for all treatments. Chlorophyll concentrations did differ among treatments, with lower chlorophyll concentrations from plugs grown with higher root-zone temperatures. This indicated that, although we could not see yellowing of the turf, chlorophyll was reduced at the higher temperatures.

Field study

In June 2007, a field study was conducted to see if summer-induced chlorosis could be simulated in field conditions. A Heatway snow-melting system that was previously installed at the Iowa State University horticulture research station in 1996 and established to Unique Kentucky bluegrass was used to increase root-zone soil temperatures from an ambient soil temperature of 74 F (23 C) to soil temperatures of 94 F and 103 F (34 C and 39 C).

Six plots 15 feet × 20 feet (4.6 meters × 6.1 meters) were used in this experiment. Plots were heated by heating a 50:50 mixture of polyethylene glycol and water and running it through tubes underneath the plots. Tubes were buried under 12 inches (30 centimeters) of calcareous sand with 8-inch (20-centimeter) spacing between tubes. Chlorosis was apparent three days after the start of temperature treatments in all plots with root-zone temperatures of 94 F (34 C) and above. The water baths used in the greenhouse study apparently had not been warm enough to cause symptoms to develop.

Preventing summer-induced chlorosis

A field study was conducted in June and July 2007 to determine whether summer-induced chlorosis could be prevented by applying iron treatments before the onset of symptoms. Treatments of 0.8 pound iron/acre (0.9 kilogram/hectare) were applied once to each of 27 3-foot × 3-foot (0.9-meter × 0.9-meter) plots before the onset



Chlorosis developing on the grass located on the Heatway system.

of chlorosis using iron chelated with EDDHA. Plots receiving the first treatment were fertilized on June 8 with each subsequent treatment applied to the next set of plots one week later. Eight weeks later, each plot had received one application of 0.8 pound iron/acre (0.9 kilogram/hectare) with the application date being the only difference. The preventive treatments were not successful at controlling chlorosis. The untreated control plots, which were highly chlorotic, were not distinguishable from any of the treated plots. Applying iron to turf before the onset of chlorosis did not prevent or even lessen the severity of the symptoms. Soil temperatures in this experiment were in the low to mid-80s (F) (27 C-29 C) at the 3-4-inch soil depth and were presumably higher closer to the surface.

Correcting summer-induced chlorosis

The level of iron applied in the original screening study had been relatively high. Another study was conducted in August 2006 and July 2007 to evaluate the response to iron EDDHA levels varying from 0 to 1.0 pound iron/acre (0 to 1.1 kilograms/hectare) to determine the impact of iron rate on controlling summer-induced chlorosis.

The results of the two years differed. In 2006, turfgrass color improved within two to three days



Color ratings

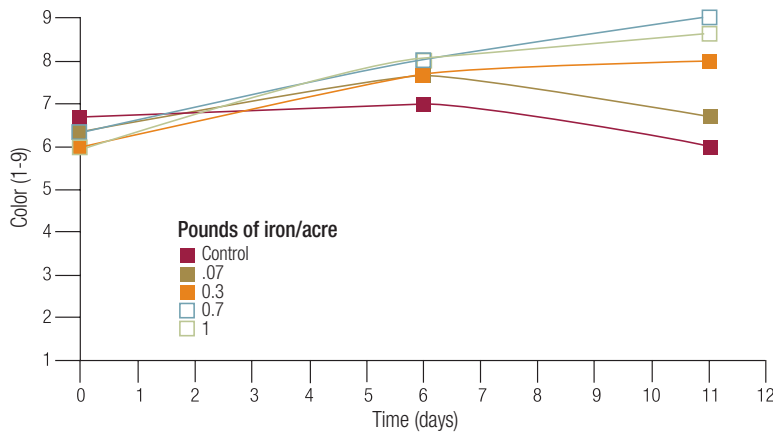


Figure 1. Mean color rating of Kentucky bluegrass plots during an iron-fertilizer-rate study in 2006. Data points are the mean of three experimental units. Color was assessed visually on a scale of 1 to 9, where 1 is the poorest color, 6 is acceptable and 9 is the best color. Standard error of difference (S.E.D.) for comparison among treatments = 0.32.



The research says

→ In a field study, chlorosis became apparent in Kentucky bluegrass three days after temperatures of 94 F and above were induced in the root zones of experimental plots.

→ In 2006, high rates of iron were applied to severely chlorotic turf several days after the onset of symptoms, and turfgrass color improved within two to three days and remained green for up to 12 days. Color improved with each increment up to 0.7 pound iron/acre.

→ Preventive treatments did not stop the onset of chlorosis. The best time to apply iron to alleviate summer-induced chlorosis symptoms was found to be when symptoms had fully developed.

after application, and the treated plots remained green for up to 12 days (Figure 1). The iron application rate played a large role in controlling summer-induced chlorosis. Color improved with each increment up to 0.7 pound iron/acre (0.8 kilogram/hectare). In 2007, results varied, and it was difficult to determine the response to the higher iron rates. One difference between the two studies that may have led to differing results was the timing of application. In 2006, treatments were applied to severely chlorotic turf several days after the onset of symptoms. In 2007, treatments were made to turf just at the point where symptoms were beginning to develop.

Conclusions

During this study we found that iron plays an important role in summer-induced chlorosis. Iron application led to an improvement in turfgrass color when applied to chlorotic turfgrass. Color was improved more by high rates of iron than lower rates, with a leveling off of improvement above 0.7 pound iron/acre (0.8 kilogram/hectare). Preventive treatments did not stop the onset of chlorosis. The best time to apply iron to alleviate summer-induced chlorosis symptoms was found to be when symptoms had fully developed.

Root-zone temperature was found to play a role in summer-induced chlorosis. We observed the development of symptoms in the field when root-zone temperatures were elevated to 94 F (34 C) and above, which are quite common in mid-summer when temperatures are high.

More work is needed to understand this phe-

nomenon. It is still unclear why the high root-zone temperatures are causing chlorosis. It is possible that high temperature is impairing root growth and function or that the high temperatures reduce the availability of iron, or a combination of these factors. Other interactions in the root zone that we do not clearly understand could also contribute to the problem.

Further work is needed to investigate summer-induced chlorosis. The work conducted so far has given us a good start, but it has led to many other questions that will be studied in future years.

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