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TURFGRASS TRENDS

IRON DEFICIENCY

Study Examines Iron Deficiency Stress in Kentucky Bluegrass

Information proves valuable for geneticists seeking development of new cultivars

By Emily A. Buxton, Bryan G. Hopkins, Von D. Jolley, and Bruce L. Webb

Iron (Fe) is essential to plants and is directly involved in chloroplast development and important reactions of photosynthesis (Sharma, 2006). Although it's the fourth most abundant element in the earth's crust (Tisdale et al., 1993), its availability to plants in alkaline soils is very low because it is rapidly oxidized and immobilized. The effect of soil pH on the solubility of Fe is so pronounced that the solubility of Fe minerals decreases exponentially with each pH unit increase in the soil (Hansen et al., 2006).

Despite the low availability of Fe in alkaline soils, many plants have been able to adapt and grow well in these soil environments (Hansen et al., 2006). The responses of some grasses to Fe-deficiency stress has been shown to involve the increased production and exudation of organic chelates (phytosiderophores) from roots (Hansen et al., 2006). These phytosiderophores chelate Fe^{3+} in the soil, thus increasing its solubility and availability for plant uptake.

In the past, many Kentucky bluegrass (KBG; *Poa pratensis L.*) cultivars have been susceptible to Fe-deficiency chlorosis when grown on alkaline soils and consequently were routinely treated with Fe (Christians, 1998). It is widely reported that Fe is applied when turf is chlorotic with the result being a greening response.

Shallow rooting depth is a common problem in shortly mowed golf course and sports turf management venues and, as such, Fe is often used as a pseudo substitute for high rates of nitrogen (N), with Fe application providing a bright green color even when N availability is kept minimal to favor root development over shoot growth (Yust et al., 1984). The eyesore of chlorosis and the expense to treat it could be avoided if cultivars resistant to Fe deficiency were identified.

Quantifying phytosiderophore production over time while under Fe-deficiency stress has been used to identify Fe-deficiency-resistant genotypes in other monocots such as corn, oat and wheat (Lytle et al., 1990; Hansen and Jolley, 1995; Hansen et al., 1996) and could potentially be used as a screening technique for KBG (Cesco et al., 2006).

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Study methods

A hydroponic study was conducted with the objective of comparing the phytosiderophore release of four cultivars (Award, Baron, Limousine, and Rugby II) known to differ in their susceptibility to Fe-deficiency chlorosis. Seeds were germinated on a layer of cheesecloth (for wicking of moisture) atop a layer of plastic mesh (support) assembled between the cap and base of ABS DWV fittings.

The fittings holding seeds were placed in plastic trays filled with a complete nutrient solution (Barben et al., 2009). After 36 days of germination and growth in an environmental chamber, the groups of KBG were put into deficient (1 micrometer or µM) or adequate (10 µM) treatments of Fe with a solution pH of 7.4.

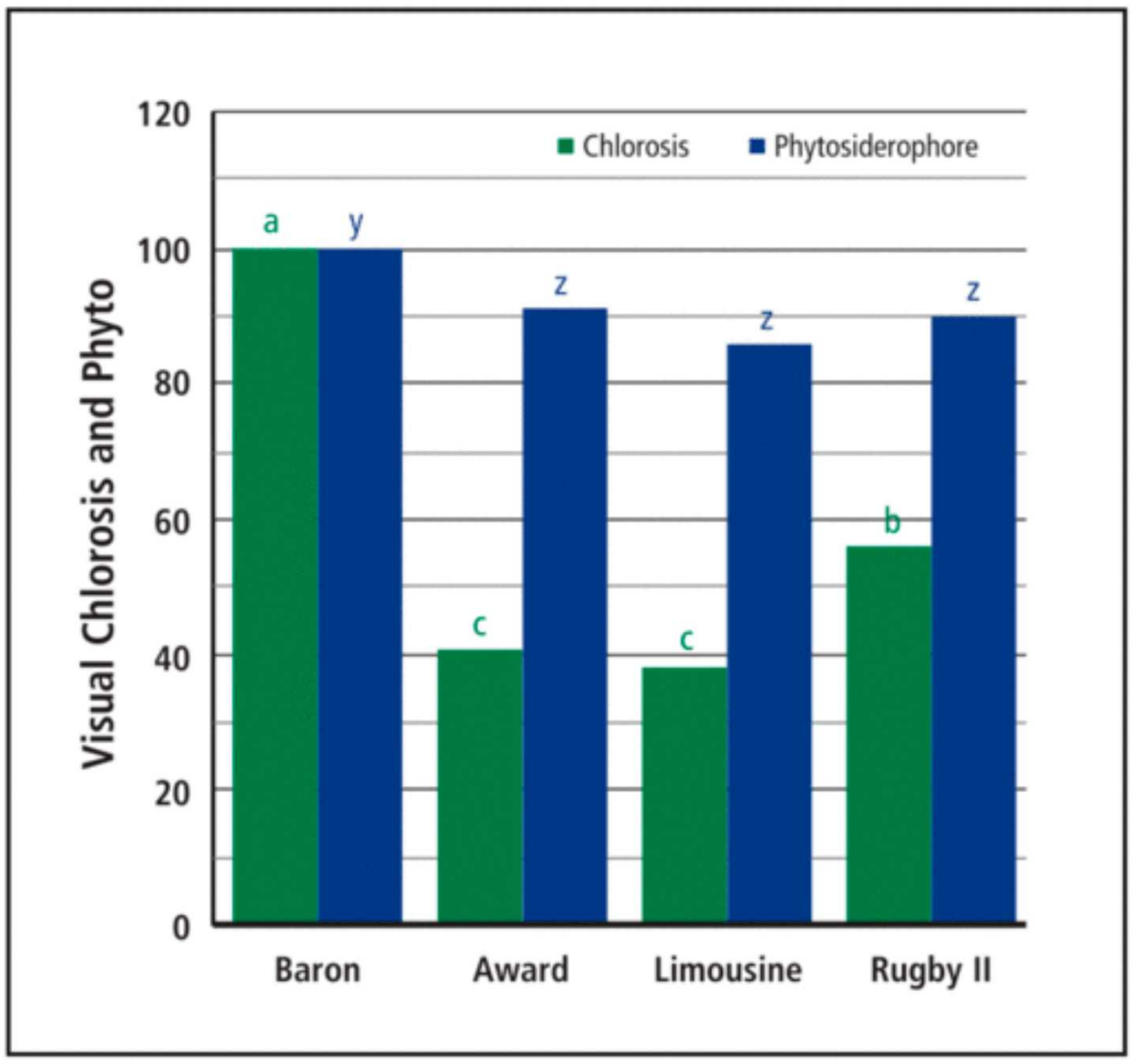

FIGURE 1. *Visual chlorosis ratings and phytosiderophore production for four Kentucky bluegrass cultivars relative to the most chlorotic cultivar (Baron). For comparing among cultivars for chlorosis or phytosiderophore, columns with the same letter are not significantly different.*

Based on previous work with other species, we expected susceptibility to Fe-deficiency chlorosis in KBG to be related to a cultivar's inability to produce adequate phytosiderophore.

After treatment initiation, chlorosis scores were made daily. On days five through 13 of the treatments, phytosiderophore release was measured once daily using an indirect Fe-binding assay (Hansen et al., 1996). Plant tissue was dried, ground to pass a 1 millimeter (mm) screen, digested in nitric-perchloric acid, and analyzed for nutrient content by inductively coupled plasma (ICP, Thermo Electron Corporation, Franklin, Maryland) spectroscopy.

Physiological response

As expected, all cultivars showed much greater chlorosis at 1 than at 10 µM Fe. However, the Baron cultivar developed more severe chlorosis than Award, Rugby II and Limousine at both the high and low levels of Fe (Figure 1). In addition, Baron re-greened after day nine at the higher level of Fe while all other cultivars' chlorosis worsened as the treatment progressed.

For all four cultivars grown at the low level of Fe, chlorosis increased during the course of the treatment.

Expectedly, the low Fe treatments had 25 percent less shoot Fe concentration than the adequate Fe treatments (Figure 2). Similarly, the low Fe treatments had 67 percent less root Fe concentration than the adequate Fe treat-

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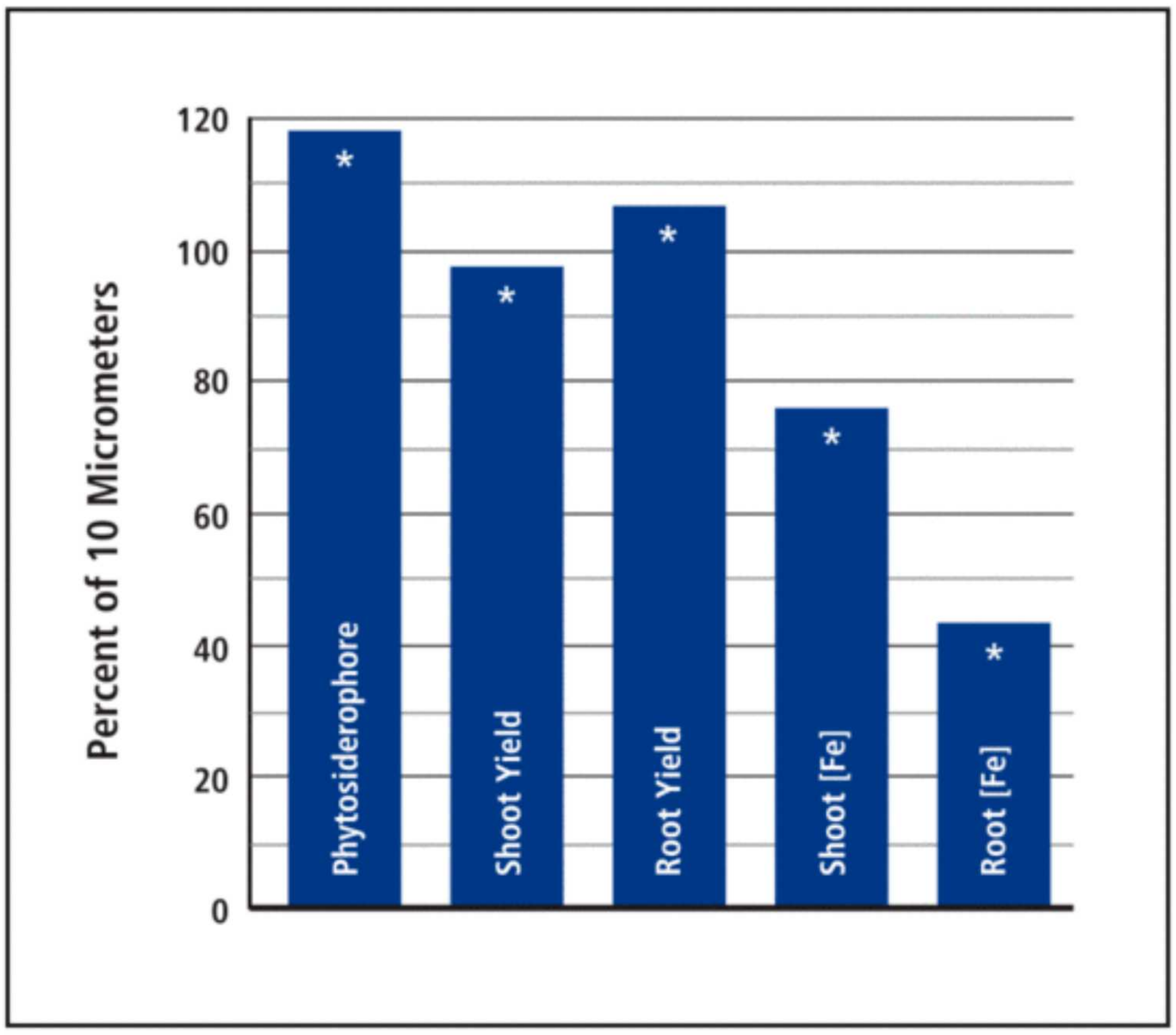

FIGURE 2. ***Phytosiderophore production, shoot yield, root yield, shoot iron concentration and root iron concentration of four Kentucky bluegrass cultivars grown with low (1 micrometer) hydroponic solution iron concentration, relative to the adequate (10 micrometer) level. Asterisk indicates a significant difference ($p<0.05$) between 1 and 10 micrometer levels for the given parameter.***

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ments. The Fe deficiency at the 1 µM Fe level resulted in slightly less average shoot yield but a 7 percent greater root yield than the 10 µM Fe treatment.

All four cultivars produced significant amounts of phytosiderophore in response to Fe deficiency at the low compared to the high level of Fe. Baron, however, surprisingly produced 12 percent more phytosiderophore than the other cultivars.

Physiology implications

Based on previous work with other species (Hansen et al., 2006), we expected susceptibility to Fe-deficiency chlorosis in KBG to be related to a cultivar's inability to produce adequate phytosiderophore.

The unexpected result of our experiment was, however, that the cultivar developing the most chlorosis during the course of the treatment (Baron) also produced the most phytosiderophore and at a significantly higher level than the other cultivars. This finding implies that Fe-deficiency susceptibility in KBG may be related to inefficient uptake, transport or utilization physiology rather than phytosiderophore production and release.

This information is valuable for geneticists seeking the development of new cultivars that have high greenness scores in Fe-limiting soils.

Emily Buxton is an undergraduate majoring in plant biology at Brigham Young University in Provo, Utah. Bryan G. Hopkins, Ph.D., is associate professor of soil science; Von D. Jolley, Ph.D., is professor of environmental science; and Bruce L. Webb, M.S., is senior scientist in the Plant and Wildlife Sciences Department of Brigham Young.

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TURFGRASS TRENDS

SECTION STAFF

Managing Editor
Curt Harler
440-238-4556; 440-238-4116 (fax)
curt@curtharler.com

Graphic Designer
Carrie Parkhill
216-706-3780; 216-706-3712 (fax)
cparkhill@questex.com

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Soil Geospatial Database Enhances Soil Mapping

By Sharon W. Waltman and Daniel P. MacDonald

The National Soil Geospatial Database (NSGD) will enable the National Cooperative Soil Survey (NCSS) to deliver consistent, reliable soil information to golf course superintendents and others in a timely manner for a desired area of interest, overcoming the former county-to-county disparities.

In the past three years, the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) Soil Survey Division recognized the need to geospatially enable the traditionally nonspatial National Soil Information System (NASIS) and to implement a Major Land Resource Area–wide (MLRA region) approach to update of detailed soil survey information.

This effort requires a more institutional use of Geographic Information System (GIS) tools in the daily work of field and regional soil survey staff, compared to the current ad hoc approach.

Technically speaking, NSGD is a national collection of timely, consistent, accurate, reliable and fully attributed soil spatial layers needed to conduct soil survey operations and deliver soil data and information that meets customer's needs (data content). The transactional connection and processes between the spatial and attribute data are transparent to users during development, quality control/quality assurance, delivery and use of these data. (More can be learned about the National Cooperative Soil Survey or NCSS at http://soils.usda.gov/partnerships/).

Presently, traditional county level soil survey information is provided by NRCS to the public through the Web Soil Survey (http://websoilsurvey.nrcs.usda.gov/), the Soil Data Mart (http://soildatamart.nrcs.usda.gov/), and Soil Data Access (http://sdmdataaccess.nrcs.usda.gov/). These sources provide useful information related to soil productivity, soil physical and chemical properties, and soil classification. Current soil survey information often possesses some disparity in attributes for similar soils between and among individual county level soil surveys. This characteristic is an artifact of the county by county approach historically used to prepare soil survey maps and manuscripts.

Though geography has been largely misunderstood, it is the science for understanding physical and cultural patterns.

The NSGD and MLRA approach to soil survey should enhance the ability to deliver consistent, reliable soil information to internal and external customers in a timely manner for an appropriate area of interest.

Because GIS applies geography to complex problems, it's a framework for understanding the relationships and interdependencies of events and conditions. The geographic approach avoids a narrow focus that often characterizes current approaches to solving problems. Though geography has been largely misunderstood and underappreciated in the United States for many decades, it is the science for understanding the physical and cultural patterns of the world.

Applying a geographic approach through the use of GIS enhances collaboration across organization by improving data sharing, workflows and communication. Managing data effectively means avoiding duplication, maintaining currency, and providing timely and appropriate access to data. Early GIS

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