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Foliar Application of N and Fe to Kentucky Bluegrass[1]

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ABSTRACT

The goal of the professional lawn care industry is to provide the homeowner with a dark green weed-free lawn. Members of this industry are interested in techniques to enhance the color of a turfgrass stand in lieu of excessive N fertilization. The purpose of this research was to evaluate the use of foliar applications of Fe alone or in combination with N on the color response of Kentucky bluegrass (*Poa pratensis* L.). Iron sulfate or an iron chelate was applied at the rate of 1.1, 2.2, or 4.5 kg Fe ha^{-1} in combination with either 0, 25, or 49 kg N ha^{-1} to a mixed 'Columbia'/'Touchdown' Kentucky bluegrass turf growing on a Catlin silt loam (fine-silty, mixed, mesic Typic Argiudoll). Color ratings and clipping weights were determined on a weekly basis until treatment effects were no longer significant. In a separate experiment, both sources of Fe were applied at rates of 1.1 to 72.4 kg Fe ha^{-1} to Kentucky bluegrass to evaluate phytotoxicity. The color enhancement due to Fe applications without N lasted from several weeks to several months depending on the weather following application. Use of Fe during cool wet periods enhanced turf color for only 2 to 3 weeks and therefore, was considered of limited value. Iron applications during cool dry periods enhanced turf color for several months. The treatment of 2.2 kg ha^{-1} of Fe from iron chelate was judged to be the most effective Fe treatment because the color enhancement was usually equal to that provided by a 4.5 kg rate of either source but it did not result in any discoloration as was found with the 4.5 kg rate. Combining Fe with the 25 kg ha^{-1} rate of N resulted in color enhancement equal to that caused by applying 49 kg ha^{-1} of N alone. The results of the study indicate that combining Fe with N can result in acceptable turfgrass color with lower rates of N. No permanent damage was caused to turfs receiving Fe at rates up to 72.2 kg ha^{-1} although foliar phytotoxicity was observed.

Additional index words: **Iron sulfate, Iron chelate, Turfgrass color, *Poa pratensis* L.**

DENSITY, color, and uniformity are the major characteristics determining the perceived quality of a turfgrass stand. The professional lawn care industry has interest in techniques to produce dark green turf. Turfgrass color can often be enhanced (darker green) by applications of N or Fe. Several problems such as the increased need for mowing, the potential for increased incidence of certain diseases, and reduced root growth are associated with excessive use of N fertilization. Application of Fe to turfgrass plants may enhance color without some of the negative aspects of excessive N fertilization.

Information is available regarding foliar applications of Fe to creeping bentgrass (*Agrostis palustris* L.) (Snyder and Schmidt, 1974), Kentucky bluegrass (*Poa pratensis* L.) (Deal and Engle, 1965), and bermudagrass (*Cynodon dactylon* L.) (McCaslin and Watson, 1977). Deal and Engle (1965), in a greenhouse study, found that Fe applications to Kentucky bluegrass turf grown at a low level of fertility produced a rapid increase in intensity of green color that lasted 4 to 5 weeks and a slight color improvement that was noticeable for 16 weeks. Harivandi and Butler (1980) reported that Kentucky bluegrass cultivars differ in their ability to take up Fe from alkaline soils.

While Fe deficiencies are not usually found on turfgrass stands in Illinois, information is needed regarding the use of Fe in fertilization programs designed for the liquid lawn care industry. The purpose of this research was to determine the effect of foliar applications of Fe alone and in combination with N on clipping yields and color of Kentucky bluegrass in the field and to determine the application rate at which Fe causes phytotoxicity.

MATERIALS AND METHODS

A 3-year-old turf consisting of a blend of 'Columbia' and 'Touchdown' Kentucky bluegrasses growing on a Catlin silt loam (fine-silty, mixed, mesic Typic Argiudoll) at the Ornamental Horticulture Research Center, Univ. of Illinois, Urbana, IL was used for this research. Soil test levels as

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determined by the soil testing laboratory at the Univ. of Illinois were: pH, 5.9; P, 95.2 kg ha^{-1}; K, 530 kg ha^{-1}; and Fe, 242 kg ha^{-1}.

Effect of Fe and N Application on Color and Growth of Kentucky Bluegrass

Two identical sets of plots were used for this experiment. One set of plots received treatment applications on the following dates: 25 July, 1 Oct. 1980 and 21 Apr., 17 June, 18 Aug., and 3 Oct. 1981. The second set of plots received a single treatment application on 2 Oct. 1980. A randomized complete block design with a factorial arrangement of treatments and three replications was used with plot size of 2.73 m^2.

Treatments consisted of foliar applications of iron sulfate (Mallinkrodt Analytical Reagent ferrous sulfate $FeSO_4$ $7H_2O$) or iron chelate (Ciba Giegy's Sequestrene 330, 10% Fe, chelating agent sodium diethylenetriaminepentaacetic acid) at rates of 0, 1.1, 2.2, or 4.5 kg Fe ha^{-1} (referred to as 1, 2, or 4 FeS for iron sulfate and 1, 2, or 4 FeC for iron chelate) combined with N at 0, 25, or 49 kg ha^{-1} (referred to as 25 N and 49 N).

The N source used was urea (46-0-0). Treatments were applied in solution with water at a spray volume of 1416 L ha^{-1} using a CO_2-pressured backpack sprayer.

Turfgrass color was rated 1 day after the application of treatments and then weekly until no differences in color were apparent between check and treated plots. A 1 to 9 scale with 1 indicating light yellow and 9 indicating dark green turf was used for rating color. Plots were mowed weekly at a height of 3.8 cm. Clippings were collected from a 0.66 m^2 area, dried, and weighed. Total chlorophyll content of the turfgrass clippings was determined on subsamples on selected dates through extraction in an ethanol-water solution according to the procedure of Madison and Anderson (1963) and quantified colorometrically according to the procedure of Comar and Zscheile (1942). On selected dates, dried clippings were analyzed for Fe content by atomic absorbtion spectrophotometry after wet digestion (Maynard et al., 1980, 1981).

All data were subjected to an analysis of variance (ANOVA). The treatment sum of squares on each rating date was partitioned into N effects, Fe effects, and the N × Fe interaction. The sum of squares for N level was partitioned into linear and quadratic components. The sum of squares due to Fe treatment was partitioned using single degree of freedom contrasts as follows: no Fe vs. Fe treatments, iron chelate vs. iron sulfate, and linear and quadratic components of both iron sulfate and iron chelate. The N × Fe interaction was significant on 26 July 1980 (1 day after the 25 July treatment application) and 2 Oct. 1980 (1 day after the 1 October treatment application) when the turf showed a variable response to FE but no response to N. The N × Fe interaction was also significant on three other rating dates where there was a small change in the color ratings between Fe treatments among N levels. Because the N × Fe interaction was significant on only 5 of the 29 dates reported in the tables, no attempt was made to further analyze the interaction.

Phytotoxicity of Iron Sulfate and Iron Chelate

An adjacent and identical turfgrass stand was used for the phytotoxicity evaluation. Iron chelate and iron sulfate were applied on 6 Sept. 1981 at the rates of 1.1, 2.2, 4.5, 9.0, 11.2, 17.9, 35.8, and 71.7 kg Fe ha^{-1}. Two weeks prior to application of treatments, the experimental site was fertilized with 25 kg ha^{-1} of N from a granular 18-5-9. The treatments were applied in water at 1416 L ha^{-1} using a CO_2-pressured backpack sprayer. Phytotoxicity was evaluated 24 h after treatment and weekly for the next 2 weeks by visually rating the plots for percent injury.

Table 1. Average weekly high and low temperature and total precipitation for the time period following each spray when treatment effects were significant.

Weather statistic	Week after application									
	1	2	3	4	5	6	7	8	9	10
25 July 1980										
High (°C)	29	31	32	29	--	--	--	--	--	--
Low (°C)	18	20	19	19	--	--	--	--	--	--
Precipitation (mm)	23	6	51	44	--	--	--	--	--	--
1 Oct. 1980†										
High (°C)	19	21	19	10	14	15	10	7	6	9
Low (°C)	5	5	8	2	1	3	1	−2	−7	2
Precipitation (mm)	15	2	16	24	0	0	3	8	31	29
20 Apr. 1981										
High (°C)	17	21	19	17	--	--	--	--	--	--
Low (°C)	6	10	7	7	--	--	--	--	--	--
Precipitation (mm)	21	25	67	50	--	--	--	--	--	--

† Weather following 2 Oct. 1980 application identical to that following 1 Oct. 1980 application except no precipitation in Week 1.

Data from this experiment was subjected to an analysis of variance where the treatment sum of squares was partitioned into a source, rate, and source × rate effect. A regression equation was generated to characterize the effect of Fe rate on turfgrass phytotoxicity for the ratings taken 1 day after treatment application.

RESULTS

Application of the Fe and N treatments to Kentucky bluegrass enhanced turfgrass color from several weeks to several months depending on the growing conditions after treatment. The color enhancement lasted longest after the 2 Oct. 1980 spray when cool, dry weather followed treatment; color enhancement was brief after the 20 Apr. 1981 application which was followed by very wet weather. The trends in color enhancement due to treatment application for the seven application dates can be illustrated by data from the 25 July, 1 Oct., 2 Oct. 1980, and 20 Apr. 1981 spray dates. A summary of the weather conditions following each of these spray dates is presented in Table 1.

25 July 1980 Application

Color ratings for a 27-day period following the 25 July 1980 application are presented in Table 2. There were no significant differences in color due to treatment after the 21 August rating date. Color enhancement due to Fe was evident 1 day after application and lasted until 15 August (3 weeks). Nitrogen enhanced turfgrass color until 21 August with higher color ratings assigned to turf receiving 49 N vs. 25 N. The short period of color enhancement due to N application was attributed to the unusually wet weater during this time period. On all dates, turf receiving 25 N in combination with any rate of Fe received color ratings numerically equal to or higher than turf receiving 49 N only. Except for the 26 July rating, there was no difference in color response due to the sulfate source compared to the chelate source. There was a significant FeS rate response evident on 26 July, 31 July, and 7 August while there was a significant FeC rate response only on 26 July.

Clipping weights for three dates after the 25 July treatment (Table 3) indicate that there was no signif-

Table 2. Color rating of Kentucky bluegrass treated with Fe and N fertilizer combinations on 25 July 1980. Color rating is the mean of three replications rated on a 1 to 9 scale with 9 = dark green and 1 = light yellow.

Treatment†	Date (Days after application)				
	26 July (1)	31 July (6)	7 August (13)	15 August (21)	21 August (27)
Check	5.0	6.3	6.3	7.0	6.7
1 FeS	6.7	7.0	7.0	8.3	7.3
2 FeS	6.7	6.7	7.7	8.7	6.7
4 FeS	8.0	8.0	8.0	8.7	7.3
1 FeC	7.3	7.0	7.7	8.7	7.0
2 FeC	7.3	7.7	8.0	8.0	7.3
4 FeC	9.0	8.0	8.0	8.0	7.0
25 N	5.3	7.0	7.3	8.0	8.0
25 N/1 FeS	6.7	8.3	8.7	9.0	8.0
25 N/2 FeS	7.0	8.3	8.7	8.3	8.0
25 N/4 FeS	7.3	9.0	9.0	8.7	8.0
25 N/1 FeC	7.3	8.7	9.0	8.3	7.7
25 N/2 FeC	9.0	8.7	9.0	8.3	8.0
25 N/4 FeC	9.0	8.7	8.7	9.0	7.7
49 N	5.3	8.0	8.3	8.3	8.3
49 N/1 FeS	5.3	8.3	9.0	8.3	8.3
49 N/2 FeS	7.0	8.7	9.0	9.0	8.7
49 N/4 FeS	7.7	8.7	9.0	8.7	8.7
49 N/1 FeC	7.3	9.0	9.0	9.0	8.0
49 N/2 FeC	7.7	9.0	9.0	9.0	8.3
49 N/4 FeC	9.0	9.0	9.0	9.0	8.3
CV (%)	7.1	7.3	5.4	7.2	6.6
N_L‡	NS	**	**	**	**
N_Q‡	*	**	**	NS	NS
No Fe vs. Fe treatments	**	**	**	**	NS
Chelate vs. sulfate	**	NS	NS	NS	NS
FeS_L	**	*	*	NS	NS
FeS_Q	NS	NS	NS	NS	NS
FeC_L	**	NS	NS	NS	NS
FeC_Q	NS	NS	NS	NS	NS

*,** Significant at 0.05 and 0.01 levels, respectively.
† Treatment code: FeS = iron sulfate; FeC = iron chelate; 1, 2, 4 = 1.1, 2.2, 4.5 kg Fe ha^{-1}; 25, 49 = 25, 49 kg N ha^{-1}.
‡ L = linear component, Q = quadratic component, CV = coefficient of variation.

Table 3. Clipping yield of Kentucky bluegrass treated with Fe and N fertilizer combinations on 25 July 1980. Clipping yield is the mean of three replications expressed on a dry weight basis.

Treatment†	Date (Days after application)		
	31 July (6)	7 August (13)	21 August (27)
	g $plot^{-1}$		
Check	8.6	8.2	15.3
1 FeS	8.4	10.1	18.6
2 FeS	9.3	9.3	19.0
4 FeS	11.3	11.8	18.6
1 FeC	8.2	9.7	17.1
2 FeC	11.0	10.8	18.9
4 FeC	11.1	12.4	22.0
25 N	14.8	15.1	27.1
25 N/1 FeS	14.9	15.1	26.2
25 N/2 FeS	14.0	14.5	23.5
25 N/4 FeS	14.2	16.6	27.0
25 N/1 FeC	14.5	16.2	27.3
25 N/2 FeC	13.8	17.3	30.3
25 N/4 FeC	11.6	13.3	22.6
49 N	16.3	18.9	33.8
49 N/1 FeS	13.5	17.8	29.2
49 N/2 FeS	13.0	17.2	31.0
49 N/4 FeS	11.4	17.1	27.6
49 N/1 FeC	14.5	17.2	30.0
49 N/2 FeC	14.2	17.2	31.0
49 N/4 FeC	11.2	16.1	27.2
CV (%)	16.4	12.5	16.0
N_L‡	**	**	**
N_Q‡	**	**	NS
No Fe vs. Fe treatments	NS	NS	NS
Chelate vs. sulfate	NS	NS	NS
FeS_L	NS	NS	NS
FeS_Q	NS	NS	NS
FeC_L	NS	NS	NS
FeC_Q	NS	NS	NS

*,** Significant at 0.05 and 0.01 levels, respectively.
† Treatment code: FeS = iron sulfate; FeC = iron chelate; 1, 2, 4 = 1.1, 2.2, 4.5 kg Fe ha^{-1}; 25, 49 = 25, 49 kg N ha^{-1}.
‡ L = linear component, Q = quadratic component, CV = coefficient of variation.

icant effect on growth due to Fe application. Because of the trend for clipping weights to follow N level, clipping weights will not be presented for the other spray dates. Chlorophyll content had a significant correlation with color ratings on all dates after the 25 July spray when both were measured (correlation coefficients of 0.86, 0.82, and 0.61 for 31 July, 7 August, and 21 August, respectively, all significant at $P=0.01$). Color ratings only will be presented for the remaining spray dates. Yust (1982) has previously reported that tissue Fe content did not correlate with color ratings. The lack of a significant correlation between plant color and Fe content has been reported (Bennett, 1945; Linder and Harley, 1944).

1 Oct. 1980 Application

Within 1 h of the 1 October application of treatments, 1.50 cm of precipitation fell on the test plots. Nitrogen level had a significant effect on turf color for this test period but the effect of Fe was not persistent (Table 4). A color response due to Fe was evident until 22 October and during the period 7 to 11 November. Wet weather prior to the 22 October and 1 November rating dates probably affected the Fe-induced color response. On most rating dates after the 1 October application, there was no effect due to rate of Fe application. Apparently, the rainfall immediately after treatment application reduced Fe uptake and altered the effect of Fe rate on the color of the turf.

2 Oct. 1980 Application

Because of the rainfall following the 1 October application, an application of treatments was made to an adjacent set of plots on 2 Oct. 1980. Color enhancement due to Fe application lasted for several months after the 2 October spray. The color response due to Fe treatments was still apparent on 6 December and into the following spring (Table 5). Unlike the 1 October test period, there was rate response for both the chelate and sulfate sources. In addition, the chelate source enhanced turfgrass color more than the sulfate source. On most of the rating dates following the 2 October treatment, the turf treated with 25 N in combination with 2 FeS 4 FeS, 2 FeC, or 4 FeC received color ratings similar to the turf treated with 49 N.

20 Apr. 1981 Application

Turfgrass color enhancement due to treatments of N and Fe was brief after the 20 Apr. 1981 spray; by 27 May, there were no significant effects on color. Between 8 and 20 May (Table 6), the effects of Fe on color dissipated.

Table 4. Color rating of Kentucky bluegrass treated with Fe and N fertilizer combinations on 1 Oct. 1980. Color rating is the mean of three replications rated on a 1 to 9 scale with 9 = dark green and 1 = light yellow.

	Date (Days after application)									
	1980								1981	
Treatment†	2 Oct. (1)	8 Oct. (7)	15 Oct. (14)	22 Oct. (21)	1 Nov. (31)	7 Nov. (37)	11 Nov. (44)	6 Dec. (66)	4 Apr. (185)	13 Apr. (194)
Check	5.7	6.0	5.7	6.0	6.3	6.0	5.3	5.0	5.0	6.7
1 FeS	6.7	6.7	6.0	6.0	6.0	6.3	5.7	5.3	5.7	7.0
2 FeS	7.0	7.3	6.0	6.0	6.7	7.0	5.7	6.0	5.7	6.7
4 FeS	7.3	8.0	6.3	6.3	6.7	7.0	6.0	5.7	6.0	7.0
1 FeC	6.7	7.3	6.0	6.0	6.7	7.0	6.0	5.0	5.7	7.3
2 FeC	7.0	7.7	6.0	6.0	6.0	6.3	5.7	5.3	5.0	7.0
4 FeC	7.7	7.3	6.3	6.7	6.0	6.0	5.7	5.0	5.3	6.7
25 N	7.0	7.3	7.0	7.3	7.3	7.7	7.0	6.3	5.3	7.7
25 N/1 FeS	7.7	7.3	7.3	7.0	7.3	7.7	7.3	6.3	6.0	8.3
25 N/2 FeS	8.0	7.3	7.7	8.0	8.0	8.0	7.0	6.3	6.0	8.0
25 N/4 FeS	7.7	7.7	7.3	8.0	7.7	7.7	7.3	6.7	5.7	8.0
25 N/1 FeC	8.0	7.7	6.7	7.3	6.7	7.3	7.0	6.3	6.0	8.3
25 N/2 FeC	7.7	8.0	7.7	7.7	7.3	7.7	7.0	6.3	5.3	8.0
25 N/4 FeC	8.0	7.7	8.0	8.3	8.3	8.3	7.0	6.3	5.3	7.7
49 N	8.0	7.3	7.7	8.0	8.0	8.0	7.7	7.0	5.7	8.7
49 N/1 FeS	8.0	7.7	8.0	7.7	7.7	8.0	7.7	7.0	5.3	8.0
49 N/2 FeS	8.0	7.7	8.7	8.3	8.3	8.3	8.3	7.0	6.0	9.0
49 N/4 FeS	8.0	7.7	9.0	8.7	8.3	8.7	8.0	7.0	6.0	8.7
49 N/1 FeC	8.0	8.0	8.0	8.3	8.3	8.7	8.0	7.0	6.3	9.0
49 N/2 FeC	8.0	7.7	8.3	8.3	8.3	8.7	8.0	7.0	6.0	9.0
49 N/4 FeC	8.0	8.0	8.3	8.7	9.0	9.0	9.0	6.7	6.7	9.0
CV (%)	5.8	6.4	6.7	6.0	6.9	6.9	7.6	10.9	12.4	5.7
N_L‡	**	*	**	**	**	**	**	**	*	**
N_Q‡	*	NS	NS	**	NS	NS	NS	NS	NS	NS
No Fe vs. Fe treatments	**	*	**	NS	NS	*	*	NS	NS	NS
Chelate vs. sulfate	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
FeS_L	NS	*	NS	**	NS	NS	NS	NS	NS	NS
FeS_Q	NS	NS	NS	NS	*	NS	NS	NS	NS	NS
FeC_L	NS	NS	**	**	*	NS	NS	NS	NS	*
FeC_Q	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*,** Significant at 0.05 and 0.01 levels, respectively. † Treatment code: FeS = iron sulfate; FeC = iron chelate; 1, 2, 4 = 1.1, 2.2, 4.5 kg Fe ha^{-1}; 25, 49 = 25, 29 kg N ha^{-1}. ‡ L = linear component, Q = quadratic component, CV = coefficient of variation.

Table 5. Color rating of Kentucky bluegrass treated with Fe and N fertilizer combinations on 2 Oct. 1980. Color rating is the mean of three replications rated on a 1 to 9 scale with 9 = dark green and 1 = light yellow.

	Date (Days after application)									
	1980								1981	
Treatment†	3 Oct. (1)	8 Oct. (6)	15 Oct. (13)	22 Oct. (20)	1 Nov. (30)	7 Nov. (36)	14 Nov. (43)	6 Dec. (65)	4 Apr. (184)	13 Apr. (193)
Check	5.7	6.0	6.0	6.0	6.0	6.3	5.0	5.0	4.3	6.7
1 FeS	7.3	6.7	6.3	6.3	6.0	6.0	5.0	5.0	4.3	6.7
2 FeS	7.7	7.0	6.0	6.3	6.3	5.7	5.3	5.0	4.0	6.3
4 FeS	7.3	7.7	8.0	7.0	7.0	7.7	7.0	7.0	6.0	8.3
1 FeC	7.3	8.0	6.0	6.3	6.0	6.0	5.7	5.3	4.3	7.0
2 FeC	7.7	7.7	7.3	7.3	7.3	7.3	7.0	6.7	5.0	7.0
4 FeC	8.3	8.7	8.3	8.0	8.0	7.7	7.0	7.0	6.0	8.0
25 N	6.0	6.3	6.3	7.0	7.0	7.0	6.3	6.0	5.0	7.3
25 N/1 FeS	7.7	7.3	7.0	7.3	7.3	7.3	6.3	6.3	5.7	7.7
25 N/2 FeS	7.7	7.7	7.3	7.7	7.7	7.7	7.3	6.7	6.0	7.7
25 N/4 FeS	8.0	8.0	8.0	8.0	8.0	8.0	7.0	6.7	5.7	8.0
25 N/1 FeC	7.7	8.3	8.0	7.7	7.7	7.3	6.7	7.0	5.7	7.7
25 N/2 FeC	7.7	8.3	8.0	8.0	8.0	8.3	7.7	6.7	6.3	8.0
25 N/4 FeC	8.3	8.7	9.0	9.0	8.3	8.7	8.3	8.0	6.7	8.0
49 N	6.3	7.3	7.3	7.7	7.7	7.7	7.7	7.3	5.7	8.0
49 N/1 FeS	7.0	7.7	7.3	7.3	7.7	8.0	7.0	7.7	6.0	8.0
49 N/2 FeS	7.3	7.7	7.3	7.0	7.3	7.7	7.0	7.3	5.7	7.7
49 N/4 FeS	7.7	8.0	7.0	7.3	7.7	8.0	8.3	8.0	6.0	8.0
49 N/1 FeC	8.3	8.3	8.0	8.0	7.7	8.0	8.3	8.0	6.0	8.0
49 N/2 FeC	8.3	9.0	8.7	8.3	8.7	8.3	8.3	8.0	6.3	7.7
49 N/4 FeC	8.7	9.0	8.7	8.7	8.7	8.7	8.7	8.0	7.0	8.3
CV (%)	7.2	6.7	8.5	7.2	7.4	7.0	8.0	8.2	9.4	6.9
N_L‡	NS	**	**	**	**	**	**	**	**	**
N_Q‡	NS	NS	*	**	**	**	NS	NS	**	NS
No Fe vs. Fe treatments	**	**	**	**	**	**	**	**	**	NS
Chelate vs. sulfate	**	**	**	**	**	**	**	**	**	NS
FeS_L	NS	**	**	NS	*	**	**	**	*	**
FeS_Q	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
FeC_L	**	**	**	**	**	**	**	**	*	**
FeC_Q	NS	NS	NS	NS	*	*	NS	NS	NS	NS

*,** Significant at 0.05 and 0.01 levels, respectively. † Treatment code: FeS = iron sulfate; FeC = iron chelate; 1, 2, 4 = 1.1, 2.2, 4.5 kg Fe ha^{-1}; 25, 49 = 25, 49 kg N ha^{-1}. ‡ L = linear component, Q = quadratic component, CV = coefficient of variation.

Table 6. Color rating of Kentucky bluegrass treated with Fe and N fertilizer combinations on 20 Apr. 1981. Color rating is the mean of three replications rated on a 1 to 9 scale with 9 = dark green and 1 = light yellow.

	Date (Days after application)			
Treatment†	21 April (1)	28 April (8)	8 May (18)	20 May (30)
Check	6.3	6.7	6.3	8.0
1 FeS	7.3	7.0	7.3	8.3
2 FeS	6.7	7.3	7.0	8.3
4 FeS	7.0	7.3	7.3	8.7
1 FeC	6.3	6.7	6.7	8.7
2 FeC	6.7	7.3	7.0	8.3
4 FeC	6.7	7.3	7.3	9.0
25 N	7.7	8.0	8.0	9.0
25 N/1 FeS	8.0	8.3	8.0	9.0
25 N/2 FeS	8.3	8.7	8.7	8.7
25 N/4 FeS	8.3	9.0	8.7	9.0
25 N/1 FeC	7.7	8.3	8.0	9.0
25 N/2 FeC	8.3	8.3	8.7	9.0
25 N/4 FeC	8.3	8.7	8.7	8.7
49 N	8.3	8.3	8.7	8.7
49 N/1 FeS	9.0	9.0	9.0	9.0
49 N/2 FeS	9.0	9.0	9.0	9.0
49 N/4 FeS	9.0	9.0	9.0	9.0
49 N/1 FeC	9.0	8.7	9.0	9.0
49 N/2 FeC	9.0	9.0	9.0	9.0
49 N/4 FeC	9.0	9.0	9.0	9.0
CV (%)	6.1	5.8	4.8	4.1
N_L‡	**	**	**	**
N_Q‡	*	**	**	NS
No Fe vs. Fe treatments	**	**	**	NS
Chelate vs. sulfate	NS	NS	NS	NS
FeS_L	NS	NS	NS	NS
FeS_Q	NS	NS	NS	NS
FeC_L	NS	NS	*	NS
FeC_Q	NS	NS	NS	NS

*,** Significant at 0.05 and 0.01 levels, respectively.
† Treatment code: FeS = iron sulfate; FeC = iron chelate; 1, 2, 4 = 1.1, 2.2, 4.5 kg Fe ha^{-1}; 25, 49 = 25, 49 kg N ha^{-1}.
‡ L = linear component, Q = quadratic component, CV = coefficient of variation.

Turfgrass Phytotoxicity to Iron Applications

The results of the phytotoxicity study indicated that serious injury did not occur to the turfgrass plants until a 17.7 kg ha^{-1} rate of Fe was exceeded (Table 7). Serious injury was considered to be foliar dieback. Turf treated with Fe in the range of 4.5 to 17.7 kg ha^{-1} suffered discoloration to a blackish green color. Tissue Fe content was not measured during the course of the phytotoxicity study. Thus, it was impossible to define a phytotoxicity level based on Fe content. The percent injury ratings taken 2 weeks after treatment application (Table 7) indicated that the injury was only temporary and that with favorable growing conditions recovery was rapid.

DISCUSSION

The data taken following the 2 Oct. 1980 spray were used to answer questions as to which Fe treatment would provide greatest color enhancement with or without N. The data indicated both a rate response and that the chelated source was more effective than the sulfate source. However, the data do not reflect the blackish cast that was seen on turf immediately following treatment with 4 FeS or 4 FeC. This coloration was not considered as injury but it was considered objectionable. The 2 FeC treatment was judged to be the most effective since it provided a long-term response without objectionable discoloration of the turf.

Table 7. Injury rating of Kentucky bluegrass treated with Fe fertilizers on 6 Sept. 1981.

	Percent injury	
	Days after application	
Iron treatment (kg Fe ha^{-1})†	1	7
17.9 FeS	8.3	0.0
17.9 FeC	10.0	0.0
35.8 FeS	25.0	6.7
35.8 FeC	25.0	6.7
71.7 FeS	56.7	8.3
71.7 FeC	61.7	10.0
Source	NS	NS
Rate (R)	**	**
Source × rate	NS	NS
Regression equation $y = 1.05R - 7.91$ ($R^2 = 0.98$)		

*,** Significant at P = 0.05 and P = 0.01, respectively.
† Treatment code: FeS = iron sulfate; FeC = iron chelate.

The results of this study also indicate that the use of Fe to improve color and reduce N use is feasible. The color response produced by the 25 N plus Fe treatments compared favorably to that produced by 49 N. However, the use of Fe in combination with N during very rapid periods of turfgrass growth, as illustrated by the ratings taken after the 20 Apr. 1981 spray, is questionable. During these time periods, a reduction in the amount of N applied still provided acceptable color without the added expense of including Fe in the spray. Since there was neither a rate or source response after the 20 Apr. 1981 treatment application, 1 FeS would be the best Fe treatment to use by those people still wanting to include Fe in a spray.

Based on the observations made during this research, a practical recommendation would be that the 2.2 kg ha^{-1} rate of Fe should not be exceeded. There is a large margin for error when applying Fe since even the highest rate of Fe did not permanently injure the turfgrass stand.

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