One-Year Evaluation of Iron Applications Applied with Three Nitrogen Fertility Rates on Tall Fescue in Riverside, California: 1996-1997

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UCR TURF

1996-97 TALL FESCUE IRON (Fe) STUDY

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Objectives: To evaluate the performance of iron treatments when applied to tall fescue fertilized at 3 different nitrogen levels.

Duration of Study: One year.

Cultivar: Bonsai tall fescue.

Experimental Site:
A mature plot established at the UCR Turfgrass Field Research Center, Riverside, CA on September 28, 1993. The root zone is a native soil which is classified as a Hanford fine sandy loam. Pre-trial soil analysis (April 1996) from samples no deeper than six inches from the crown/thatch layer: pH = 7.0; Olsen-P = 38 ppm; exchangeable K = 123 ppm; **Fe = 67 ppm**. Similar analysis on adjacent plot (May 1996): soluble forms of (in meq/L) Ca = 6.8, Mg = 2.5, Na = 5.0; HCO_3 = 0.6 meq/L; ESP = 2%; SAR = 2; CEC = 11.7 meq/100 g; OM = 1.51%; Sand = 51%; Silt = 40%; Clay = 9%; EC = 1.25 mmhos/cm. Post-trial soil analysis (April 1997) from samples no deeper than six inches from the crown/thatch layer and taken from the high-Fe Vigoro treatment subplots only: pH = 6.9; Olsen-P = 31 ppm; exchangeable K = 129 ppm; **Fe = 45 ppm**; soluble forms of (in meq/L) Ca = 4.8, Mg = 1.5, Na = 2.9; HCO_3 = 1.6 meq/L; ESP = 2%; SAR = 2; CEC = 13.5 meq/100 g; OM = 1.42%; Sand = 51%; Silt = 38%; Clay - 11%.

DANR Analytical Lab. soil analysis methods: pH = saturated paste (s.p.), pH meter; Olsen-P = alkaline extraction (ext.) by 0.5 Normal $NaHCO_3$ for soils with pH > 6.5 by ascorbic acid reduction of phosphomolybdate complex and meas. by spectrophotometry; exchangeable K = equilib. ext. using 1 Normal ammonium acetate (pH 7.0), subsequent determination by atomic absorption/emission spectrophotometry; **Fe = equilib. ext. using DTPA, subsequent determination by atomic absorption spectrometry**; soluble (sol.) Ca and Mg = s.p. ext., inductively coupled plasma atomic emission spectrometry; sol. Na = s.p. ext., emission spectrometry; HCO_3 = s.p. ext., titration with 0.05 Normal H_2SO_4 acid; SAR = est. calc. from Ca, Mg, and Na on s.p. ext.; CEC = barium acetate saturation and calcium replacement; OM = potassium dichromate reduction of organic carbon and subsequent spectrophotometric measurement.

Experimental Design:
Split plot design with N treatments forming main plots and Fe treatments forming subplots. Main plots = 27 ft x 6 ft.; subplots = 4.5 ft. x 6 ft. Main-plot treatments arranged in a randomized complete block design (RCB) with three replications. Analysis of variance also conducted by N levels. In this situation, treatments arranged in a RCB design. Overall analysis conducted using the appropriate repeated measures design.

Mowing: Once per week with a walk-behind rotary mower set at 1.5 inches. Clippings collected.

Irrigation: Plots irrigated to prevent visual drought symptoms and overwatering.

Fertilizer Treatments *(see protocol for specific dates)*:
- Annual N rates: 6.25, 3.25, and 0.25 pounds / 1000 ft^2.
- Annual iron rates range from 0.08 to 3.3 pounds Fe / 1000 ft^2.
- Test conducted from April 1996 through March 1997.

Measurements:
Visual turfgrass quality was estimated once every two weeks beginning two weeks after initial treatment of all iron applications using a 1 to 9 scale (1=poorest, 5=acceptable, 9=best tall fescue).

Findings:
There is no clear explanation for the lack of iron response indicated in the study. The application rates of Fe were within the range which has been shown to provide a color response in turfgrass. (In a summary of some of the research regarding Fe response on turfgrass, rates from 0.015 - 0.092 lb Fe/1000 ft^2 per application were cited as providing at least short-term improvements in turfgrass color [Turner and Hummel, 1992].) The rates tested in the present study ranged from 0.0112 to 1.650 lb Fe/1000 ft^2 per application. Both the pre- and post-trial soil tests indicated a sufficient level of Fe (a deficiency of Fe is indicated at 5-7 ppm [Brown and De Boer, 1976], and the Fe rates here were 67 and 45 ppm, respectively), however most studies involve a Fe color response despite a sufficient level of Fe in the soil. Further, the soil tests did not indicate anything in the soil chemistry which would be limiting to an Fe response, although acidification of the fairly neutral soil might have assisted in Fe response. Finally, we believe we have observed a response to Fe on tall fescue during N fertilizer product testing trials.

Turner, T.R. and Hummel, N.W., Jr. 1992. Nutritional requirements and fertilization. p. 385-439. *In* D.V. Waddington, R.N. Carrow, and R.C. Shearmen (eds.) Turfgrass. Agron. Monogr. 32. ASA, Madison, WI.

Brown, A.L. and De Boer, G.J. 1976. Soil tests for zinc, iron, manganese, and copper. p. 40-42. *In* H.M. Reisenauer (ed.) Soil and plant-tissue testing in California. Division of Ag. Sci. Univ. of Calif. Bulletin 1879. Univ. of Calif.

1996-1997 Tall Fescue Fe Study

Treatment	Program : Nitrogen Product (lb N / 1000 ft²) or Fe Product (lb Fe / 1000 ft²)													Tot. lb N or Fe / 1000ft² / 12 months
Main plot factor = N														
Nitrogen applications	**Turf Supreme 16-6-8**			**Urea 46-0-0 at 0.5 lb N / 1000 ft² and Ammonium Nitrate 34-0-0 at 0.5 lb N / 1000 ft² for a total of 1.0 lb N / 1000 ft² per app.**										
	Apr '96	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan '97	Feb	Mar	Apr	
A	1.0	0.25	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--	--	6.25[z]
B	1.0	0.25	--	--	1.0	--	--	--	1.0	--	--	--	--	3.25[y]
C	--	0.25	--	--	--	--	--	--	--	--	--	--	--	0.25[x]
Sub-plot factor = Fe														
Ironite 2-0-0-11% Fe applications	Apr '96	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan '97	Feb	Mar	Apr	
A	--	--	--	1.650	--	--	1.650	--	--	--	--	--	--	3.300
B	--	--	--	0.825	--	--	0.825	--	--	--	--	--	--	1.650
Gold'n'Gro Iron 5-0-0-5% Fe (w/v) applications	Apr '96	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan '97	Feb	Mar	Apr	
A	--	0.0147	--	0.0147	--	0.0294	--	0.0294	--	0.0294	--	0.0294	--	0.1470
B	--	0.0056	0.0056	0.0056	--	0.0112	0.0112	0.0112	--	0.0112	0.0112	0.0112	--	0.0840
Vigoro 4-0-0-21% Fe applications	Apr '96	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan '97	Feb	Mar	Apr	
A	--	--	--	1.650	--	--	1.650	--	--	--	--	--	--	3.300
B	--	--	--	0.825	--	--	0.825	--	--	--	--	--	--	1.650

[z] Fe applied from Turf Supreme applications: 0.21 lb Fe / 1000 ft².
[y] Fe applied from Turf Supreme applications: 0.12 lb Fe / 1000 ft².
[x] Fe applied from Turf Supreme applications: 0.02 lb Fe / 1000 ft².

Evaulation of Iron Applications on Tall Fescue

Block 1

	1	2	3	4	5	6
C	3	1	2	4	6	5
	7	8	9	10	11	12
B	4	3	1	2	5	6
	13	14	15	16	17	18
A	6	5	2	1	3	4

TREATMENTS

Nitrogen (total N per study):
A - 6.0 lb N/M
B - 3.0 lb N/M
C - 0.0 lb. N/M
(all N treatments in 1.0 lb N/M apps.)

Iron applications (total Fe for study):
1. Ironite 2-0-0-11% Fe (3.6 lb Fe/M)
2. Ironite 2-0-0-11% Fe (1.8 lb Fe/M)
3. Gold'n'Gro 5-0-0-5% Fe (0.15 lb Fe/M) [w/v]
4. Gold'n'Gro 5-0-0-5% Fe (0.08 lb Fe/M) [w/v]
5. Vigoro 4-0-0-21% Fe (3.6 lb Fe/M)
6. Vigoro 4-0-0-21% Fe (1.8 lb Fe/M)

Block 2

Block 3

	19	20	21	22	23	24		37	38	39	40	41	42	
B	1	4	3	2	5	6		5	1	4	3	2	6	A
	25	26	27	28	29	30		43	44	45	46	47	48	
A	5	4	1	3	6	2		3	4	2	1	6	5	C
	31	32	33	34	35	36		49	50	51	52	53	54	
C	2	5	3	6	4	1		2	5	3	6	4	1	B

1996-97 Tall Fescue Iron (Fe) Study: Calendar of Activities

Date	Activity
March 8, 1996	Pre-study application of 6-20-20 at 1.0 lb N/1000 ft^2
March 13, 1996	Mowing regime set at once per week at 1.5", clippings removed.
April 1, 1996	Study begins. Initial nitrogen applications of Turf Supreme 16-6-8 at 1.0 lb N/1000 ft^2 to rows A and B.
May 15, 1996	Initial application of Gold'n'Gro Iron 5-0-0-5% Fe, high (A) and low (B) rates.
May 18, 1996	Nitrogen application of Turf Supreme 16-6-8 at 0.25 lb N/1000 ft^2 to all rows.
June 12, 1996	Nitrogen applications of Turf Supreme 16-6-8 at 1.0 lb N/1000 ft^2 to row A.
June 17, 1996	Application of Gold'n'Gro Iron 5-0-0-5% Fe, low rate (B).
July 10, 1996	Application of Gold'n'Gro Iron 5-0-0-5% Fe, high (A) and low (B) rates.
July 12, 1996	Initial application of Ironite 2-0-0-11% Fe and Vigoro 4-0-0-21 Fe for both high (A) and low (B) rates.
July 26, 1996 - March 28, 1997	Visual quality ratings, every two weeks.
August 16, 1996	Nitrogen applications of Urea 46-0-0 at 0.5 lb N/1000 ft^2 and Ammonium Nitrate 34-0-0 at 0.5 lb N/1000 ft^2 to rows A and B.
September 23, 1996	Application of Gold'n'Gro Iron 5-0-0-5% Fe, high (A) and low (B) rates (at double the initial rates from this point on).
October 18, 1996	Second application of Ironite 2-0-0-11% Fe and Vigoro 4-0-0-21 Fe for both high (A) and low (B) rates.
October 25, 1996	Nitrogen applications of Urea 46-0-0 at 0.5 lb N/1000 ft^2 and Ammonium Nitrate 34-0-0 at 0.5 lb N/1000 ft^2 to row A. Application of Gold'n'Gro Iron 5-0-0-5% Fe, low (B) rate.
December 2, 1996	Application of Gold'n'Gro Iron 5-0-0-5% Fe, high (A) and low (B) rates.
December 16, 1996	Nitrogen applications of Urea 46-0-0 at 0.5 lb N/1000 ft^2 and Ammonium Nitrate 34-0-0 at 0.5 lb N/1000 ft^2 to rows A and B.
January 17, 1997	Application of Gold'n'Gro Iron 5-0-0-5% Fe, high (A) and low (B) rates.
February 13, 1997	Nitrogen applications of Urea 46-0-0 at 0.5 lb N/1000 ft^2 and Ammonium Nitrate 34-0-0 at 0.5 lb N/1000 ft^2 to row A.
February 28, 1997	Application of Gold'n'Gro Iron 5-0-0-5% Fe, low (B) rate.
March 14, 1997	Application of Gold'n'Gro Iron 5-0-0-5% Fe, high (A) and low (B) rates

1996-97 Tall Fescue Iron (Fe) Study: Quality Ratings (Scale 1-9, 9=best tall fescue)

Iron Source		NITROGEN (A): 6.25 lb N / 1000 ft² / year										
Product	lb Fe/M	Jul 26	Aug 07	Aug 21	Sep 04	Sep 18	Oct 02	Oct 16	Nov 06	Nov 13	Nov 27	Dec 13
Ironite	3.6	6.2	6.3	6.3	6.2	6.3	6.1	6.3	7.3	7.2	6.9	6.1
Ironite	1.8	5.9	6.3	6.3	6.3	6.3	6.2	6.3	7.3	7.2	6.9	6.0
Gold'n'Gro	0.15	5.9	6.2	6.3	6.3	6.3	6.1	6.3	7.0	7.0	6.8	5.9
Gold'n'Gro	0.08	6.1	6.3	6.3	6.2	6.3	6.1	6.3	7.1	7.0	6.8	6.0
Vigoro	3.6	6.4	6.6	6.5	6.4	6.5	6.2	6.3	7.3	7.3	6.9	6.3
Vigoro	1.8	6.0	6.4	6.5	6.3	6.4	6.2	6.3	7.2	7.1	6.9	6.0
LSD P=0.05		NS	NS	NS	0.2	NS	NS	NS	NS	NS	NS	NS

Iron Source		NITROGEN (B): 3.25 lb N / 1000 ft² / year										
Product	lb Fe/M	Jul 26	Aug 07	Aug 21	Sep 04	Sep 18	Oct 02	Oct 16	Nov 06	Nov 13	Nov 27	Dec 13
Ironite	3.6	6.1	6.3	6.3	6.1	6.1	6.1	6.3	6.3	6.5	6.2	5.5
Ironite	1.8	5.7	6.0	6.2	6.1	6.0	6.0	6.3	6.3	6.3	6.1	5.3
Gold'n'Gro	0.15	5.8	6.1	6.3	6.1	6.0	5.6	6.3	6.2	6.2	5.9	5.4
Gold'n'Gro	0.08	6.0	6.2	6.3	6.2	6.2	6.2	6.3	6.3	6.3	6.1	5.5
Vigoro	3.6	5.8	6.2	6.3	6.2	6.1	6.0	6.3	6.3	6.3	5.9	5.2
Vigoro	1.8	5.7	6.0	6.1	6.2	6.0	6.0	6.3	6.2	6.3	6.0	5.1
LSD P=0.05		NS	NS	NS	NS	NS	NS	NS	NS	0.1	NS	NS

Iron Source		NITROGEN (C): 0.25 lb N / 1000 ft² / year										
Product	lb Fe/M	Jul 26	Aug 07	Aug 21	Sep 04	Sep 18	Oct 02	Oct 16	Nov 06	Nov 13	Nov 27	Dec 13
Ironite	3.6	5.8	6.2	6.1	5.8	5.7	5.8	6.3	6.4	5.9	5.8	5.3
Ironite	1.8	5.6	6.0	6.0	5.9	5.5	5.8	6.3	6.3	5.8	5.7	5.1
Gold'n'Gro	0.15	5.6	6.0	5.8	5.9	5.7	6.1	6.3	6.2	5.8	5.7	5.3
Gold'n'Gro	0.08	5.3	5.9	5.7	5.6	5.3	5.8	6.3	6.1	5.5	5.5	4.9
Vigoro	3.6	5.8	6.3	6.0	6.0	5.8	5.8	6.3	6.3	5.8	5.9	5.2
Vigoro	1.8	5.5	5.9	5.7	5.6	5.5	5.4	6.2	6.1	5.7	5.8	5.1
LSD P=0.05		NS	NS	NS	NS	NS	NS	NS	0.2	NS	0.2	0.2

	SPLIT-PLOT STATISTICAL EFFECTS										
	Jul 26	Aug 07	Aug 21	Sep 04	Sep 18	Oct 02	Oct 16	Nov 06	Nov 13	Nov 27	Dec 13
Iron	NS	**	NS	NS	NS	NS	NS	***	**	*	NS
Nitrogen	NS	NS	**	NS	**	NS	NS	*	**	*	***
Iron*N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*

*, **, *** Significant at P=.05, .01, .001, respectively; NS= Nonsignificant.

1996-97 Tall Fescue Iron (Fe) Study: Quality Ratings (Scale 1-9, 9=best tall fescue)

Iron Source		NITROGEN (A): 6.25 lb N / 1000 ft² / year								
Product	lb Fe/M	Dec 23	Jan 08	Jan 24	Jan 31	Feb 14	Feb 28	Mar 14	Mar 28	Overall
Ironite	3.6	6.3	6.3	6.2	6.2	6.3	6.8	7.3	6.8	6.5
Ironite	1.8	6.2	6.3	6.3	6.3	6.4	6.9	7.3	6.8	6.5
Gold'n'Gro	0.15	6.3	6.3	6.3	6.2	6.3	6.8	7.3	6.8	6.4
Gold'n'Gro	0.08	6.2	6.3	6.3	6.1	6.3	6.9	7.4	6.8	6.5
Vigoro	3.6	6.2	6.4	6.3	6.3	6.4	6.8	7.5	6.9	6.6
Vigoro	1.8	6.3	6.5	6.3	6.3	6.5	6.9	7.4	6.8	6.5
LSD P=0.05		NS	NS	NS	NS	NS	NS	NS	NS	NS

Iron Source		NITROGEN (B): 3.25 lb N / 1000 ft² / year								
Product	lb Fe/M	Dec 23	Jan 08	Jan 24	Jan 31	Feb 14	Feb 28	Mar 14	Mar 28	Overall
Ironite	3.6	5.7	6.1	6.0	5.9	6.0	6.2	6.2	6.6	6.1
Ironite	1.8	5.7	5.8	5.8	5.8	5.8	5.9	5.9	6.6	6.0
Gold'n'Gro	0.15	5.8	5.9	6.1	5.8	6.1	6.2	6.2	6.6	6.0
Gold'n'Gro	0.08	5.6	6.0	6.1	5.8	5.9	6.3	6.3	6.6	6.1
Vigoro	3.6	5.6	5.7	5.8	5.6	5.9	6.1	5.9	6.6	6.0
Vigoro	1.8	5.5	5.8	5.8	5.3	5.7	6.2	6.0	6.6	5.9
LSD P=0.05		NS	NS	NS	NS	NS	NS	NS	NS	NS

Iron Source		NITROGEN (C): 0.25 lb N / 1000 ft² / year								
Product	lb Fe/M	Dec 23	Jan 08	Jan 24	Jan 31	Feb 14	Feb 28	Mar 14	Mar 28	Overall
Ironite	3.6	4.8	4.4	5.1	3.7	3.8	4.7	4.4	5.7	5.3
Ironite	1.8	4.7	4.3	5.1	3.8	3.8	4.5	4.3	5.4	5.2
Gold'n'Gro	0.15	5.0	4.4	5.4	4.3	4.3	5.0	4.8	5.9	5.4
Gold'n'Gro	0.08	4.6	4.1	5.1	3.7	3.6	4.4	4.4	5.4	5.1
Vigoro	3.6	5.1	4.5	5.3	3.9	3.8	4.7	4.7	5.7	5.4
Vigoro	1.8	4.8	4.2	5.1	3.7	3.7	4.4	4.4	5.5	5.2
LSD P=0.05		0.3	NS	0.1	NS	NS	NS	NS	0.3	NS

	SPLIT-PLOT STATISTICAL EFFECTS								
	Dec 23	Jan 08	Jan 24	Jan 31	Feb 14	Feb 28	Mar 14	Mar 28	Overall
Iron	NS	NS	*	NS	NS	NS	NS	*	NS
Nitrogen	**	***	***	*	**	**	**	*	**
Iron*N	NS	*	NS	NS	NS	NS	NS	**	*

*, **, *** Significant at P=.05 , .01, .001, respectively; NS= Nonsignificant.

CIMIS environmental measurements from March 31, 1996 to March 29, 1997 in Riverside, CA.

Date	Accumulative Weekly ET_o (mm/week)	Accumulative Weekly Precipitation (mm/week)	Average Solar Radiation (W/m^2/day)	Average Daily Temperature (^0C)	Average Relative Humidity (%)	Average Daily Soil Temperature at 10.2 cm Depth (^0C)
03/31/96 - 04/06	39.91	1.00	266	17	36	17
04/07 - 04/13	33.19	0.00	253	16	45	18
04/14 - 04/20	34.83	3.00	255	17	42	18
04/21 - 04/27	42.60	0.00	291	21	39	20
04/28 - 05/04	44.83	0.00	292	22	38	21
05/05 - 05/11	42.51	0.00	302	21	44	22
05/12 - 05/18	40.81	0.00	287	21	47	23
05/19 - 05/25	36.60	0.00	270	17	50	22
05/26 - 06/01	36.71	0.00	273	18	50	21
06/02 - 06/08	44.63	0.00	304	24	43	24
06/09 - 06/15	41.47	0.00	294	21	48	24
06/16 - 06/22	41.51	0.00	296	21	47	24
06/23 - 06/29	37.52	0.00	274	20	47	22
06/30 - 07/06	46.34	0.00	303	28	36	25
07/07 - 07/13	43.31	0.00	298	24	45	25
07/14 - 07/20	41.98	0.00	293	23	48	25
07/21 - 07/27	43.23	0.00	284	26	42	26
07/28 - 08/03	45.29	0.00	291	27	43	27
08/04 - 08/10	39.72	0.00	275	23	50	26
08/11 - 08/17	41.62	0.00	263	27	44	27
08/18 - 08/24	39.62	0.00	259	25	41	25
08/25 - 08/31	41.69	0.00	265	27	33	25
09/01 - 09/07	35.64	0.00	249	24	49	25
09/08 - 09/14	33.65	0.00	245	23	46	24
09/15 - 09/21	30.13	0.00	224	21	50	23
09/22 - 09/28	22.16	0.00	205	20	71	23
09/29 - 10/05	22.39	0.00	199	22	79	22
10/06 - 10/12	24.60	0.00	208	24	72	22

ET_o = Reference evapotranspiration.

CIMIS environmental measurements from March 31, 1996 to March 29, 1997 in Riverside, CA *(continued)*.

Date	Accumulative Weekly ET_o (mm/week)	Accumulative Weekly Precipitation (mm/week)	Average Solar Radiation (W/m^2/day)	Average Daily Temperature (^0C)	Average Relative Humidity (%)	Average Daily Soil Temperature at 10.2 cm Depth (^0C)
10/13 - 10/19	15.50	0.00	162	18	83	21
10/20 - 10/26	20.86	1.00	172	15	63	17
10/27 - 11/02	12.55	2.00	99	12	68	14
11/03 - 11/09	23.31	0.00	157	16	40	15
11/10 - 11/16	16.18	0.00	132	17	49	16
11/17 - 11/23	11.44	41.00	114	14	61	16
11/24 - 11/30	21.39	0.00	142	15	41	14
12/01 - 12/07	12.36	6.00	124	12	55	12
12/08 - 12/14	9.86	14.00	82	14	65	14
12/15 - 12/21	16.21	0.00	121	12	41	12
12/22 - 12/28	8.59	7.00	79	12	61	12
12/29 - 01/04/97	5.71	12.00	65	14	70	14
01/05 - 01/11	15.20	5.00	108	11	49	12
01/12 - 01/18	9.54	57.00	92	10	59	11
01/19 - 01/25	7.14	19.00	82	11	68	12
01/26 - 02/01	17.22	19.00	147	15	55	14
02/02 - 02/08	15.87	0.00	155	11	58	13
02/09 - 02/15	17.44	5.00	142	13	56	12
02/16 - 02/22	23.83	0.00	195	16	50	13
02/23 - 03/01	24.12	2.00	177	12	49	12
03/02 - 03/08	25.36	0.00	224	14	50	13
03/09 - 03/15	28.19	0.00	227	19	50	15
03/16 - 03/22	27.90	0.00	227	19	57	17
03/23 - 03/29	24.68	0.00	205	16	63	18

ET_o = Reference evapotranspiration.