Field Test of NutriSmart on Established Turfgrass in Riverside, California

Final Report

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Table 1. Materials and methods outline for the NutriSmart turfgrass field trial (updated February 2002).

Objectives: To demonstrate the fertilizing effect of Y on established turfgrass, compare the effect of different dosages of Y on established turfgrass, and compare the fertilizing effect among Y and commercial chemical fertilizers.

Cultivar: Marathon III tall fescue (*Festuca arundinacea*).

Experimental site: A plot established at the UCR Turfgrass Field Research Center, Riverside, Calif. on 3 Apr. 1996. The root zone is a native soil which is classified as a Hanford fine sandy loam. As of 1 June 2001 the soil pH=6.6; soluble Ca=429 ppm; soluble Mg=90 ppm; soluble Na=154 ppm; soluble K=40.31 ppm; SAR=2; ESP=1%; HCO_3=24 ppm; CO_3<3 ppm; DTPA-extractable Fe=31.8 ppm; CEC=12.9 meq/100g; OM=0.93%; Olsen-P=56.1 ppm; exchangeable K=166 ppm; exchangeable Na=176 ppm; exchangeable Ca=1182 ppm; exchangeable Mg=170 ppm. As of May 1997 the soil EC_e=0.98 mmhos/cm and sand=53%, silt=34%, and clay=13% (see below for detailed information regarding analytical methods).

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, Na, Ca, and Mg = 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 plasmic atomic emission spectrometry; sol. Na and K = s.p. ext., emission spectrometry; HCO_3 and CO_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; EC_e = semi-quantifies the amount of soluble salts in the saturation paste extract using conductivity meter; particle size analysis of sand, silt and clay determined by soil suspension by hydrometer.

Prior fertilization: 6 lb N/1000 ft^2 per year by applying 0.5 lb N/1000 ft^2 per month using a 16N-6P_2O_5-8K_2O fertilizer from April through October and 21N-7P_2O_5-4K_2O fertilizer from November through March. Last fertilization was 19 Mar. 2001.

Prior to treatment applications, all plots were core cultivated [0.375-inch hollow tines (i.d.)] with a hole density equal to or greater than 1 x 1 inch with holes approximately 3 inches deep. All plots were then topdressed with a thin layer of sand. When the product Y was applied, it was swept into the soil surface with a broom.

Experimental design: Randomized complete block (RCB) design with four replications. Plot size was 4.5 x 6.0 ft with 1 ft borders between plots. Overall ANOVA a repeated measures design with date as the repeated measures factor.

Mowing: Once per week with a walk-behind 21-inch width rotary mower set at 1.5-inch mowing height. Clippings were collected.

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

Treatments *(applied 25 May 2001, except as noted)*:

Treatment	Amount of Y and 16-6-8 fertilizer[z]	Application time
1. Control (check)	No Y and no fertilizer	None
2. 16-6-8 fertilizer	No Y and 0.33 lb N/1000 ft^2	Once every month
3. Y 0.35x + 16-6-8 fertilizer	35 g/m^2 and 0.33 lb N/1000 ft^2	Once at study initiation
4. Y 0.50x + 16-6-8 fertilizer	50 g/m^2 and 0.33 lb N/1000 ft^2	Once at study initiation
5. Y 1.00x + 16-6-8 fertilizer	100 g/m^2 and 0.33 lb N/1000 ft^2	Once at study initiation
6. Y 2.00x + 16-6-8 fertilizer	200 g/m^2 and 0.33 lb N/1000 ft^2	Once at study initiation
7. Y 0.35x	35 g/m^2 and no fertilizer	Once at study initiation

[z]16-6-8 fertilizer was TurfSupreme 16-6-8 (16% N, 6% P_2O_5, and 8% K_2O, by dry weight).

Measurements:

- Visual turfgrass quality ratings were taken every 2 weeks beginning 1 week after initial treatment applications, using a 1 to 9 scale (1=worst, 5=minimally acceptable, 9=best tall fescue).
- Visual turfgrass color ratings were taken every 2 weeks beginning 1 week after initial treatment applications, using a 1 to 9 scale (1=brown, 5=minimally acceptable, 9=darkest green tall fescue).
- Clipping yields were taken once every 2 weeks, beginning 2 weeks after initial treatment applications. Yields were from 7 d of growth and were collected using the same 21-inch width mower used for routine mowing with a special attachment to collect the clipping yield. A subsample of clippings was collected from 39% of the total surface area of each plot. Clippings were dried for 48 h in a forced-air oven maintained at 60 ºC, and then weighed.
- Root mass density (mg/cm^3) was determined at two depths (0 to 6 and 6 to 12 inches below the soil/thatch layer) with four 21.4-mm (i.d.) cores per plot.

Results:

1. Visual turfgrass quality.

The only treatment to significantly increase visual turfgrass quality was the 16-6-8 treatment (Table 3, see overall). This increase was relatively minor. All other treatments, including the control treatment, were the same. Normally, we would have observed a significant decline of visual turfgrass quality for a zero-N control treatment, assuming there were sufficient levels of all other plant nutrients in the soil. The probable explanation why the decline did not occur was that there was sufficient available N in the soil during the study.

2. Visual turfgrass color.

The only treatment to significantly increase visual turfgrass color was the 16-6-8 treatment (Table 4, see overall). This increase was relatively minor. All other treatments, including the control treatment, were the same. Normally, we would have observed a significant decline of visual turfgrass color for a zero-N control treatment, assuming there were sufficient levels of all other plant nutrients in the soil. The probable explanation why the decline did not occur was that there was sufficient available N in the soil during the study.

3. Clipping yield.

Normally, clipping yield responses are more evident than visual rating responses to N fertilizer treatments. This is true in this study. The clipping yield response to the 16-6-8 fertilizer used in this study was due to increased soil N because P and K soil levels were sufficient based on a soil test (Table 1). All Y treatments, considered as a group, had a significantly greater clipping yield than the control treatment (Table 5, see overall contrast of 'Control vs. all Y treatments'). These data may show a fertilizing benefit of Y treatment compared to no N fertilization. However, all Y treatments, considered as a group, had a significantly lower clipping yield than the 16-6-8 treatment (Table 5, see overall contrast of '16-6-8 vs. all Y treatments'. On the other hand, the Y0.35x + 16-6-8 treatment was statistically the same as the 16-6-8 treatment (Table 5, see overall contrast of '16-6-8 vs. Y0.35x + 16-6-8') and statistically greater than the control treatment (Table 5, see overall contrast of 'Control vs. Y0.35x + 16-6-8'). For various reasons the Y0.35x + 16-6-8 treatment was the best Y treatment and comparable to the 16-6-8 treatment.

4. Root mass density.

The data in Table 6 show that there was no treatment that significantly affected root mass density in the upper 12 inches of soil.

5. Weather measurements during this study are reported in Table 7.

Table 2. Calendar of major activities.

Date	Activity
18 May 2001	Plots mowed (1.5-inch height). Subsequently mowed once per week.
23 May 2001	Plots core cultivated and topdressed.
25 May 2001	Treatment applications.
1 June 2001	Initial visual turfgrass quality and color ratings. Subsequently taken every 2 weeks.
8 June 2001	Initial clipping yield. Subsequently collected every 2 weeks.
22 June 2001	Second application of Treatment 2.
27 July 2001	Third application of Treatment 2.
31 Aug. 2001	Fourth application of Treatment 2.
28 Sept. 2001	Fifth application of Treatment 2.
26 Oct. 2001	Sixth (final) application of Treatment 2.
9 Nov. 2001	Final clipping yield.
19 Nov. 2001	Final visual turfgrass quality and color ratings.
21 Nov. 2001	Soil cores collected for root mass data.

Table 3. Visual turfgrass quality ratings (scale: 1-9, 1=worst, 5=minimally acceptable, 9=best tall fescue) for seven fertilizing treatments applied to tall fescue in Riverside, Calif.

Treatment			Visual turfgrass quality												
Designation	NutriSmart 0-6-0 (g/m^2)	Turf Supreme 16-6-8 (lb N/1000 ft^2)	1 June 2001	15 June 2001	29 June 2001	11 July 2001	27 July 2001	17 Aug. 2001	31 Aug. 2001	7 Sept. 2001	21 Sept. 2001	5 Oct. 2001	19 Oct. 2001	2 Nov. 2001	19 Nov. 2001	Overall
Control	–	–	6.0[z]	5.9	5.8	5.9	5.8	6.2	6.2	6.1	6.0	6.0	5.9	6.0	5.9	6.0
16-6-8	–	0.33 (monthly)	6.1	6.3	6.1	6.2	6.1	6.3	6.2	6.1	6.1	6.0	6.1	6.1	6.1	6.1
Y 0.35x + 16-6-8	35	0.33	5.9	6.2	5.9	5.9	5.7	6.1	6.1	6.0	6.0	5.8	5.9	6.0	5.9	6.0
Y 0.50x + 16-6-8	50	0.33	6.1	6.3	6.0	5.8	5.8	6.1	6.2	6.2	6.0	5.9	5.9	5.9	5.9	6.0
Y 1.00x + 16-6-8	100	0.33	6.3	6.2	6.0	5.8	5.8	6.2	6.2	6.1	6.0	5.9	6.0	6.1	5.9	6.0
Y 2.00x + 16-6-8	200	0.33	5.9	6.2	5.9	5.9	5.9	6.2	6.2	6.1	5.9	5.8	5.9	6.0	5.9	6.0
Y 0.35x	35	–	5.9	5.9	5.8	5.7	5.7	6.2	6.2	6.1	5.9	5.9	5.9	6.0	6.0	6.0
LSD, $P=0.05$			NS	0.3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.1
ANOVA effect and contrast (P)																
Treatment (T)			NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
Date (D)																**
T x D																NS
Control vs. all Y treatments			NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
16-6-8 vs. all Y treatments			NS	NS	NS	*	*	*	NS	NS	NS	NS	*	*	**	***
Control vs. Y 0.35x + 16-6-8			NS	*	NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS
16-6-8 vs. Y 0.35x + 16-6-8			NS	NS	NS	NS	NS	**	NS	NS	NS	*	**	NS	**	**
Y 0.35x + 16-6-8 vs. Y 0.35x			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
All Y + 16-6-8 treatments (linear)			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Mean			6.0	6.1	5.9	5.9	5.9	6.2	6.2	6.1	6.0	5.9	5.9	6.0	6.0	6.0
C.V. (%)			2.8	3.4	3.9	4.6	4.8	2.1	2.1	2.8	2.3	2.2	2.2	1.5	1.5	2.8

[z]Mean separation by Fisher's protected LSD.
[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Table 4. Visual turfgrass color ratings (scale: 1-9, 1=brown, 5=minimally acceptable, 9=darkest green tall fescue) for seven fertilizing treatments applied to tall fescue in Riverside, Calif.

Treatment			Visual turfgrass color												
Designation	NutriSmart 0-6-0 (g/m^2)	Turf Supreme 16-6-8 (lb N/1000 ft^2)	1 June 2001	15 June 2001	29 June 2001	11 July 2001	27 July 2001	17 Aug. 2001	31 Aug. 2001	7 Sept. 2001	21 Sept. 2001	5 Oct. 2001	19 Oct. 2001	2 Nov. 2001	19 Nov. 2001	Overall
Control	–	–	6.1[z]	6.1	5.9	5.9	5.9	6.2	6.2	6.2	6.2	6.0	6.0	6.1	5.9	6.1
16-6-8	–	0.33 (monthly)	6.3	6.4	6.3	6.4	6.4	6.3	6.3	6.3	6.3	6.1	6.4	6.4	6.4	6.3
Y 0.35x + 16-6-8	35	0.33	6.0	6.3	6.1	6.0	6.0	6.1	6.1	6.2	6.1	5.8	5.9	6.1	6.1	6.1
Y 0.50x + 16-6-8	50	0.33	6.2	6.4	6.1	6.0	6.0	6.2	6.2	6.3	6.2	6.0	6.0	6.1	6.0	6.1
Y 1.00x + 16-6-8	100	0.33	6.5	6.3	6.1	6.0	6.0	6.2	6.2	6.1	6.1	6.0	6.0	6.1	5.9	6.1
Y 2.00x + 16-6-8	200	0.33	6.2	6.4	6.1	6.1	6.1	6.2	6.2	6.1	6.1	5.9	5.9	6.1	6.0	6.1
Y 0.35x	35	–	6.1	6.1	5.9	5.9	5.9	6.2	6.2	6.2	6.1	5.9	6.1	6.1	6.1	6.1
LSD, $P=0.05$			0.2	NS	NS	NS	NS	NS	NS	NS	NS	0.1	0.2	0.1	0.2	0.1
ANOVA effect and contrast (P)																
Treatment (T)			*	NS	NS	NS	NS	NS	NS	NS	NS	**	***	**	***	***
Date (D)																*
T x D																NS
Control vs. all Y treatments			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
16-6-8 vs. all Y treatments			NS	NS	NS	**	*	NS	NS	NS	*	***	***	***	***	***
Control vs. Y 0.35x + 16-6-8			NS	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	NS	NS	NS
16-6-8 vs. Y 0.35x + 16-6-8			*	NS	NS	*	NS	**	*	NS	*	***	***	**	***	***
Y 0.35x + 16-6-8 vs. Y 0.35x			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
All Y + 16-6-8 treatments (linear)			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Mean			6.2	6.3	6.1	6.0	6.0	6.2	6.2	6.2	6.1	6.0	6.0	6.1	6.1	6.1
C.V. (%)			3.3	3.5	4.6	4.2	4.3	1.9	1.8	2.3	1.7	1.5	2.2	1.6	1.8	2.7

[z]Mean separation by Fisher's protected LSD.
[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Table 5. Clipping yields [g dry clippings/0.7 m^2 (7.4 ft^2) per 7 d] for seven fertilizing treatments applied to tall fescue in Riverside, Calif.

Treatment			Clipping yield												
Designation	NutriSmart 0-6-0 (g/m^2)	Turf Supreme 16-6-8 (lb N/1000 ft^2)	8 June 2001	22 June 2001	6 July 2001	20 July 2001	3 Aug. 2001	17 Aug. 2001	31 Aug. 2001	14 Sept. 2001	28 Sept. 2001	12 Oct. 2001	26 Oct. 2001	9 Nov. 2001	Cumulative	Overall
Control	–	–	3.67[z]	2.68	3.85	3.75	5.87	5.05	8.02	8.97	8.85	11.27	6.23	4.77	73.00	6.08
16-6-8	–	0.33 (monthly)	6.01	4.44	7.18	5.61	6.61	8.68	11.48	13.25	10.60	12.93	9.27	9.78	105.85	8.82
Y 0.35x + 16-6-8	35	0.33	6.54	5.29	7.43	5.99	8.57	6.87	10.20	11.28	11.17	10.17	6.92	6.01	96.46	8.04
Y 0.50x + 16-6-8	50	0.33	4.77	4.57	6.00	5.21	6.02	6.74	9.00	11.23	9.39	12.04	6.17	5.32	86.46	7.20
Y 1.00x + 16-6-8	100	0.33	4.66	4.14	5.72	4.02	6.83	6.54	7.33	9.48	9.25	12.80	6.24	4.91	81.92	6.83
Y 2.00x + 16-6-8	200	0.33	4.40	4.30	5.44	4.76	7.15	6.82	8.88	9.19	9.22	10.17	5.89	4.95	81.21	6.77
Y 0.35x	35	–	3.56	3.19	4.29	3.91	5.77	5.36	8.98	9.71	8.38	10.24	6.78	5.62	75.81	6.32
LSD, $P=0.05$			NS	1.56	1.82	1.26	1.72	1.39	NS	2.21	1.48	NS	1.82	1.46	13.49	1.12
ANOVA effect and contrast (P)																
Treatment (T)			NS	*	**	**	*	***	NS	**	**	NS	*	***	***	***
Date (D)																***
T x D																**
Control vs. all Y treatments			NS	**	**	*	NS	**	NS	NS	NS	NS	NS	NS	*	*
16-6-8 vs. all Y treatments			NS	NS	*	NS	NS	***	NS	***	NS	*	***	***	***	***
Control vs. Y 0.35x + 16-6-8			*	**	***	**	**	**	NS	*	**	NS	NS	NS	**	**
16-6-8 vs. Y 0.35x + 16-6-8			NS	NS	NS	NS	*	**	NS	NS	NS	*	**	***	NS	NS
Y 0.35x + 16-6-8 vs. Y 0.35x			*	**	**	**	**	*	NS	NS	***	NS	NS	NS	**	**
All Y + 16-6-8 treatments (linear)			NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS
All Y + 16-6-8 treatments (quadratic)			NS	NS	NS	**	NS	NS	NS	NS	NS	*	NS	NS	NS	NS
Mean			4.80	4.09	5.70	4.75	6.69	6.58	9.13	10.45	9.55	11.38	6.79	5.91	85.82	7.15
C.V.(%)			34.4	25.6	21.4	17.9	17.3	14.3	26.7	14.2	10.4	14.4	18.1	16.6	10.6	16.7

[z]Mean separation by Fisher's protected LSD.
[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Table 6. Root mass density at three depths (0 to 6, 6 to 12, and 0 to 12 inches below the soil-thatch layer) as determined by samples taken on 21 Nov. 2001 for seven fertilizing treatments applied to tall fescue in Riverside, Calif.

Treatment			Root mass density ($mg \cdot cm^{-3}$)		
Designation	NutriSmart 0-6-0 (g/m^2)	Turf Supreme 16-6-8 (lb N/1000 ft^2)	0 to 6 inches	6 to 12 inches	0 to 12 inches
Control	–	–	0.507	0.056	0.281
16-6-8	–	0.33 (monthly)	0.503	0.021	0.262
Y 0.35x + 16-6-8	35	0.33	0.611	0.037	0.324
Y 0.50x + 16-6-8	50	0.33	0.546	0.027	0.287
Y 1.00x + 16-6-8	100	0.33	0.507	0.050	0.278
Y 2.00x + 16-6-8	200	0.33	0.617	0.025	0.321
Y 0.35x	35	–	0.494	0.077	0.286
LSD, $P=0.05$			NS	NS	NS
ANOVA effect and contrast (P)					
Treatment (T)			NS	NS	NS
Control vs. all Y treatments			NS	NS	NS
16-6-8 vs. all Y treatments			NS	NS	NS
Control vs. Y 0.35x + 16-6-8			NS	NS	NS
16-6-8 vs. Y 0.35x + 16-6-8			NS	NS	NS
Y 0.35x + 16-6-8 vs. Y 0.35x			NS	NS	NS
All Y + 16-6-8 treatments (linear)			NS	NS	NS
All Y + 16-6-8 treatments (quadratic)			NS	NS	NS
Mean			0.541	0.042	0.291
C.V. (%)			30.9	92.0	30.4

[z]Mean separation by Fisher's protected LSD.
[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Table 7. Weekly weather measurements collected from 13 May to 24 Nov. 2001 from the UCR Turfgrass Field Research Center, Riverside, Calif.

Date	Cumulative ET_o[z] (mm/week)	Cumulative precipitation (mm/week)	Average daily solar radiation (W/m^2 per d)	Average air daily temperature		Average daily relative humidity (%)	Average daily soil temperature at 15.2 cm depth	
				ºC	ºF		ºC	ºF
13-19 May 2001	32.58	0.1	275	18	64	71	22	72
20-26 May2001	38.35	0.0	303	21	70	68	23	73
27 May-2 June 2001	31.20	0.2	257	20	68	69	23	73
3-9 June 2001	39.94	0.0	318	20	68	65	24	75
10-16 June 2001	41.92	0.0	307	22	72	52	24	75
17-23 June 2001	47.38	0.0	294	26	79	33	24	75
24-30 June 2001	46.35	0.0	317	24	75	43	24	75
1-7 July 2001	37.62	2.1	251	26	79	52	26	79
8-14 July 2001	45.35	0.0	339	22	72	53	25	77
15-21 July 2001	43.31	0.0	336	21	70	58	24	75
22-28 July 2001	42.59	0.0	320	22	72	57	25	77
29 July-4 Aug. 2001	40.81	0.1	309	22	72	64	25	77
5-11 Aug. 2001	43.31	0.7	291	26	79	47	25	77
12-18 Aug. 2001	45.54	0.0	290	27	81	41	26	79
19-25 Aug. 2001	39.37	0.0	282	23	73	55	25	77
26 Aug.-1 Sept. 2001	37.48	0.0	271	23	73	58	25	77
2-8 Sept. 2001	33.42	0.0	255	22	72	66	25	77
9-15 Sept. 2001	32.54	0.0	242	22	72	58	24	75
16-22 Sept. 2001	32.23	0.0	263	21	70	56	23	73
23-29 Sept. 2001	36.06	0.5	241	25	77	37	23	73
30 Sept.-6 Oct. 2001	30.31	0.1	220	24	75	49	23	73
7-13 Oct. 2001	26.50	0.2	208	19	66	53	21	70
14-20 Oct. 2001	24.31	0.9	194	21	70	48	20	68
21-27 Oct. 2001	17.26	0.0	162	18	64	68	20	68
28-3 Nov. 2001	11.40	0.9	117	16	61	76	19	66
4-10 Nov. 2001	16.67	0.1	146	18	64	62	19	66
11-17 Nov. 2001	14.55	8.8	137	16	61	62	18	64
18-24 Nov. 2001	12.93	21.9	116	15	59	59	17	63

[z]Weather data collected from an on-site California Irrigation Management System weather station located approximately 270 ft from the center of the research plot.