1998 Agrium Slow-Release Nitrogen Product Trial on Bonsai Tall Fescue in Riverside, California

Final Report

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UCR TURF

Table 1. Materials and methods outline for the 1998 Agrium slow-release nitrogen product trial on Bonsai tall fescue.

Objectives:
To evaluate the nitrogen performance and nitrogen release in terms of visual turfgrass color ratings and clipping yields of seven nitrogen fertilizers applied on tall fescue at two rates.

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. Soil analyses as of April 1997 from the 0- to 6-inch root zone below the crown/thatch layer: pH = 6.9; Olsen-P = 31 ppm; exchangeable K = 129 ppm; DTPA-extractable Fe = 45 ppm; soluble forms of (in meq/L) Ca = 4.8, Mg = 1.5, Na = 2.9, HCO_3 = 1.6; 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 measured (meas.) by spectrophotometry; exchangeable K = equilibrium (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 = 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; particle size analysis of sand, silt and clay determined by soil suspension by hydrometer.

Experimental Design:
Randomized complete block (RCB) design (15 treatments) with four replications. Plot size 4.5 x 6.0 ft. ANOVA of treatments can also be structured in a 7 (product) x 2 (rate) factorial in a RCB design (14 treatments), and the no-fertilizer check treatment is excluded. Overall ANOVA for both designs is a repeated measures design which generally splits each plot by measurement date.

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

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

Fertilizer Treatments *(applied June 24, 1998)*:
Nitrogen fertilizers ($N\text{-}P_2O_5\text{-}K_2O$):
- Urea (46-0-0) (Hydro Agri)
- Agrium 98-F.25 (43-0-0)
- Agrium 98-G.01 (43-0-0)
- Agrium 98-G.10 (43-0-0)
- Trikote (42-0-0) (Best)
- Nutralene (40-0-0) (Best)
- Polyon (43-0-0) (Best)

- Two rates of application:
  1.0 lb N/1000 ft^2 and 3.0 lb N/1000 ft^2

- Check (no fertilizer)

Measurements *(collected until fertilizer treatments were not significantly different from the no-fertilizer check treatment)*:
- Visual turfgrass color ratings taken every week beginning 2 weeks after treatment application, using a 1 to 9 scale (1=brown, 5=minimally acceptable, 9=darkest green tall fescue).

- Clipping yields taken once every 2 weeks, beginning 2 weeks after treatment application. Yields were from 7 days of growth and were collected using the same mower used for routine mowing (with a special attachment to collect the clipping yield). A subsample of clippings was collected from 27% of the total surface area of each plot. Clippings were dried for 48 hours in a forced-air oven maintained at 60ºC, and then weighed.

Table 1 *(continued)*. Materials and methods outline for the 1998 Agrium slow-release nitrogen product trial on Bonsai tall fescue.

Results:

Seven N fertilizers were applied on Bonsai tall fescue at the 1.0 and 3.0 lb N/1000 ft² rate and evaluated for 16 weeks, from June 24 to October 16, 1998, for visual turfgrass color and clipping yields. The visual turfgrass color scale was 1 to 9 (1=brown, 5=minimally acceptable, and 9=darkest green tall fescue). Please note that a rating of 6.5 to 7.5 would be considered quality tall fescue lawns, parks, recreational fields, and commercial areas.

In terms of visual turfgrass color for the 3.0 lb N/1000 ft² application rate, the three Agrium products and Polyon performed similarly with 16-week overall ratings ranging from 6.1 to 6.2. These same ratings were significantly lower for Nutralene and urea, which had overall ratings of 5.9 and 5.8, respectively. In terms of the 1.0 lb N/1000 ft² application rate, the three Agrium products, Polyon, and urea performed similarly, with 16-week overall visual turfgrass color ratings ranging from 5.5 to 5.7. These ratings were significantly higher than for Nutralene, which had an overall rating of 5.3.

Generally, clipping yield data was positively associated with visual turfgrass color ratings. There were significant differences among the N fertilizers for clipping yields on selected dates for the 3.0 lb N/1000 ft² application rate. However, clipping yields were not significantly different among N fertilizers for the 1.0 lb N/1000 ft² application rate.

Figure 1. Plot plan for the 1998 Agrium slow-release nitrogen product trial on Bonsai tall fescue. Treatments applied on June 24, 1998.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
11	9	5	12	13	1	4	2	9	10	3	11	7	6	14	8	15
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	13	7	6	15	--	12	--	5	2	10	3	8	4	14	12	13
35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
--	15	14	8	6	4	14	1	5	3	10	15	11	7	9	2	--
52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
10	4	--	2	3	5	9	--	12	11	8	7	6	1	--	13	--

I II III IV

Treatment (N-P-K)	Rate
1. Urea (46-0-0)	1 lb N/1000 ft^2
2. Agrium 98-F.25 (43-0-0)	1 lb N/1000 ft^2
3. Agrium 98-G.01 (43-0-0)	1 lb N/1000 ft^2
4. Agrium 98-G.10 (43-0-0)	1 lb N/1000 ft^2
5. Trikote (42-0-0)	1 lb N/1000 ft^2
6. Nutralene (40-0-0)	1 lb N/1000 ft^2
7. Polyon (43-0-0)	1 lb N/1000 ft^2

Treatment (N-P-K)	Rate
8. Urea (46-0-0)	3 lb N/1000 ft^2
9. Agrium 98-F.25 (43-0-0)	3 lb N/1000 ft^2
10. Agrium 98-G.01 (43-0-0)	3 lb N/1000 ft^2
11. Agrium 98-G.10 (43-0-0)	3 lb N/1000 ft^2
12. Trikote (42-0-0)	3 lb N/1000 ft^2
13. Nutralene (40-0-0)	3 lb N/1000 ft^2
14. Polyon (43-0-0)	3 lb N/1000 ft^2
15. Check	0 lb N/1000 ft^2

NOTE: I-IV indicate replications.

Table 2. Calendar of major activities for the 1998 Agrium slow-release nitrogen product trial on Bonsai tall fescue.

Date	Activity
June 24, 1998	Application of fertility treatments.
July 8, 1998	Initial clipping yield samples taken (subsequently taken every 2 weeks).
July 10, 1998	Initial visual turfgrass color rating (subsequent ratings every week).
October 13, 1998	Final clipping yield sample taken.
October 16, 1998	Final visual turfgrass color rating.
December 4, 1998	Final report drafted.

Table 3a. Visual turfgrass color ratings for the 1998 Agrium slow-release nitrogen product trial on Bonsai tall fescue. Scale: 1-9 (1=brown, 5=minimally acceptable, 9=darkest green tall fescue). Treatments were applied on June 24, 1998; 15 treatments arranged in a RCB design.

Product (N-P_2O_5-K_20 Analysis)	**App. Rate** (lb N/1000 ft^2)	**Jul 10** *1998*	**Jul 17** *1998*	**Jul 24** *1998*	**Jul 31** *1998*	**Aug 07** *1998*	**Aug 14** *1998*	**Aug 21** *1998*	**Aug 28** *1998*	**Sep 04** *1998*	**Sep 09** *1998*	**Sep 18** *1998*	**Sep 25** *1998*	**Oct 02** *1998*	**Oct 09** *1998*	**Oct 16** *1998*	**Overall**
Urea (46-0-0)	1	6.5	6.3	6.1	5.8	5.7	5.5	5.5	5.5	5.5	5.5	5.7	5.6	5.6	5.3	5.3	5.7
	3	6.6	6.5	6.4	6.1	5.9	5.8	5.9	5.7	5.6	5.6	5.8	5.7	5.6	5.3	5.3	5.8
Agrium 98-F.25 (43-0-0)	1	6.1	5.9	5.8	5.6	5.7	5.6	5.8	5.8	5.6	5.6	5.8	5.6	5.4	5.2	5.1	5.6
	3	6.8	6.8	6.7	6.5	6.8	6.6	6.4	6.0	5.9	5.8	5.9	5.9	5.8	5.5	5.4	6.2
Agrium 98-G.01 (43-0-0)	1	6.2	5.9	5.9	5.7	5.7	5.4	5.6	5.5	5.6	5.6	5.6	5.6	5.4	5.1	5.2	5.6
	3	6.8	6.7	6.6	6.6	6.8	6.6	6.4	6.1	5.9	5.9	6.1	6.1	5.9	5.6	5.6	6.2
Agrium 98-G.10 (43-0-0)	1	6.3	6.1	6.0	5.7	5.7	5.6	5.6	5.6	5.6	5.6	5.8	5.6	5.5	5.3	5.3	5.7
	3	6.8	6.7	6.6	6.4	6.6	6.3	6.3	6.2	5.9	5.9	5.9	5.8	5.8	5.4	5.5	6.1
Trikote (42-0-0)	1	6.2	5.9	5.8	5.8	5.8	5.6	5.8	5.7	5.6	5.6	5.7	5.6	5.6	5.3	5.3	5.7
	3	6.8	6.8	6.8	6.5	6.4	6.3	6.3	5.9	5.7	5.7	5.9	5.9	5.8	5.5	5.4	6.1
Nutralene (40-0-0)	1	5.7	5.5	5.3	5.1	5.1	4.9	5.1	5.2	5.3	5.3	5.6	5.5	5.3	5.3	5.3	5.3
	3	6.5	6.4	6.3	6.2	5.9	5.9	5.9	5.8	5.7	5.7	5.9	5.9	5.8	5.4	5.4	5.9
Polyon (43-0-0)	1	5.8	5.7	5.6	5.3	5.5	5.5	5.6	5.6	5.6	5.6	5.7	5.6	5.6	5.4	5.3	5.5
	3	6.4	6.6	6.6	6.6	6.8	6.5	6.5	6.1	5.9	5.8	6.1	6.1	5.9	5.6	5.4	6.2
Check	0	5.3	4.9	4.8	4.6	4.6	4.4	4.8	5.0	5.1	5.2	5.4	5.4	5.2	5.1	5.1	5.0
LSD $P \leq 0.05$		0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2
C.V. (%)		3.6	3.6	3.0	3.4	5.1	4.3	3.4	4.6	3.8	3.5	3.7	3.4	3.6	2.7	3.3	2.8

Table 3b. Visual turfgrass color ratings for the 1998 Agrium slow-release nitrogen product trial on Bonsai tall fescue. Scale: 1-9 (1=brown, 5=minimally acceptable, 9=darkest green tall fescue). Treatments were applied on June 24, 1998; 14 treatments arranged in a 7 x 2 Factorial and assigned to a RCB design.

Product (N-P_2O_5-K_20 Analysis)	**Jul 10** *1998*	**Jul 17** *1998*	**Jul 24** *1998*	**Jul 31** *1998*	**Aug 07** *1998*	**Aug 14** *1998*	**Aug 21** *1998*	**Aug 28** *1998*	**Sep 04** *1998*	**Sep 09** *1998*	**Sep 18** *1998*	**Sep 25** *1998*	**Oct 02** *1998*	**Oct 09** *1998*	**Oct 16** *1998*	**Overall**
1.0 lb N/1000 ft² application[z]																
Urea (46-0-0)	6.5	6.3	6.1	5.8	5.7	5.5	5.5	5.5	5.5	5.5	5.7	5.6	5.6	5.3	5.3	5.7
Agrium 98-F.25 (43-0-0)	6.1	5.9	5.8	5.6	5.7	5.6	5.8	5.8	5.6	5.6	5.8	5.6	5.4	5.2	5.1	5.6
Agrium 98-G.01 (43-0-0)	6.2	5.9	5.9	5.7	5.7	5.4	5.6	5.5	5.6	5.6	5.6	5.6	5.4	5.1	5.2	5.6
Agrium 98-G.10 (43-0-0)	6.3	6.1	6.0	5.7	5.7	5.6	5.6	5.6	5.6	5.6	5.8	5.6	5.5	5.3	5.3	5.7
Trikote (42-0-0)	6.2	5.9	5.8	5.8	5.8	5.6	5.8	5.7	5.6	5.6	5.7	5.6	5.6	5.3	5.3	5.7
Nutralene (40-0-0)	5.7	5.5	5.3	5.1	5.1	4.9	5.1	5.2	5.3	5.3	5.6	5.5	5.3	5.3	5.3	5.3
Polyon (43-0-0)	5.8	5.7	5.6	5.3	5.5	5.5	5.6	5.6	5.6	5.6	5.7	5.6	5.6	5.4	5.3	5.5
LSD P≤0.05	0.3	0.3	0.2	0.3	0.4	0.3	0.3	NS	NS	NS	NS	NS	NS	0.1	NS	0.2
3.0 lb N/1000 ft² application[z]																
Urea (46-0-0)	6.6	6.5	6.4	6.1	5.9	5.8	5.9	5.7	5.6	5.6	5.8	5.7	5.6	5.3	5.3	5.8
Agrium 98-F.25 (43-0-0)	6.8	6.8	6.7	6.5	6.8	6.6	6.4	6.0	5.9	5.8	5.9	5.9	5.8	5.5	5.4	6.2
Agrium 98-G.01 (43-0-0)	6.8	6.7	6.6	6.6	6.8	6.6	6.4	6.1	5.9	5.9	6.1	6.1	5.9	5.6	5.6	6.2
Agrium 98-G.10 (43-0-0)	6.8	6.7	6.6	6.4	6.6	6.3	6.3	6.2	5.9	5.9	5.9	5.8	5.8	5.4	5.5	6.1
Trikote (42-0-0)	6.8	6.8	6.8	6.5	6.4	6.3	6.3	5.9	5.7	5.7	5.9	5.9	5.8	5.5	5.4	6.1
Nutralene (40-0-0)	6.5	6.4	6.3	6.2	5.9	5.9	5.9	5.8	5.7	5.7	5.9	5.9	5.8	5.4	5.4	5.9
Polyon (43-0-0)	6.4	6.6	6.6	6.6	6.8	6.5	6.5	6.1	5.9	5.8	6.1	6.1	5.9	5.6	5.4	6.2
LSD P≤0.05	NS	NS	0.3	0.3	0.6	0.4	0.3	NS	NS	NS	NS	NS	NS	NS	NS	0.2
7 x 2 Factorial effects and Overall ANOVA effects																
Product	***	***	***	***	***	***	***	**	NS	NS	NS	NS	NS	NS	NS	***
Rate	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Product x Rate	NS	NS	**	***	*	**	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
Date	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	***
Date x Product	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	***
Date x Rate	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	***
Date x Product x Rate	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*

[z]Separate, RCB ANOVA for each rate of application.

Figure 2. 1998 Agrium slow-release nitrogen product trial on Bonsai tall fescue: visual color ratings (scale: 1-9; 9=darkest green tall fescue). Treatments applied June 24, 1998.

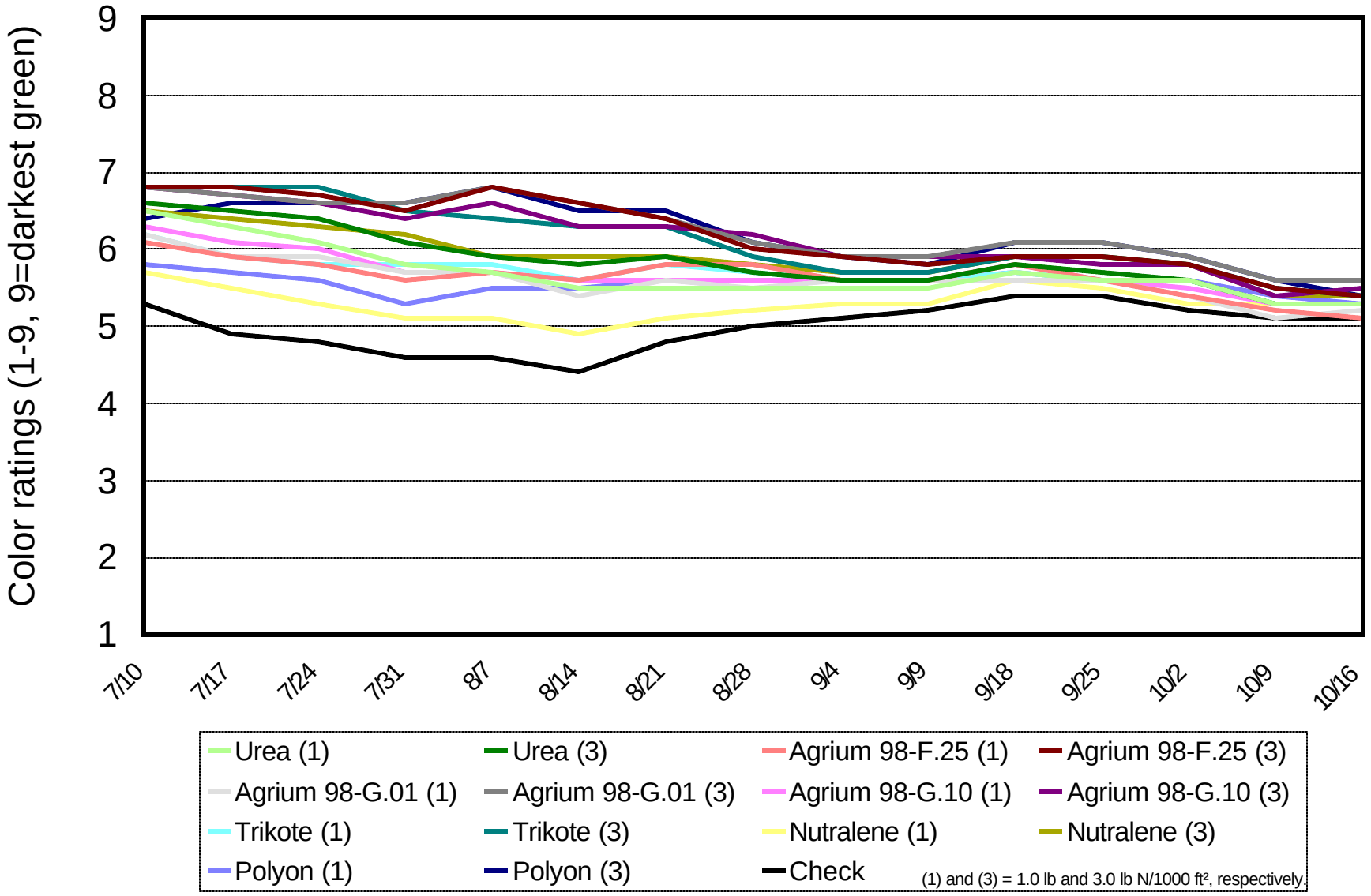
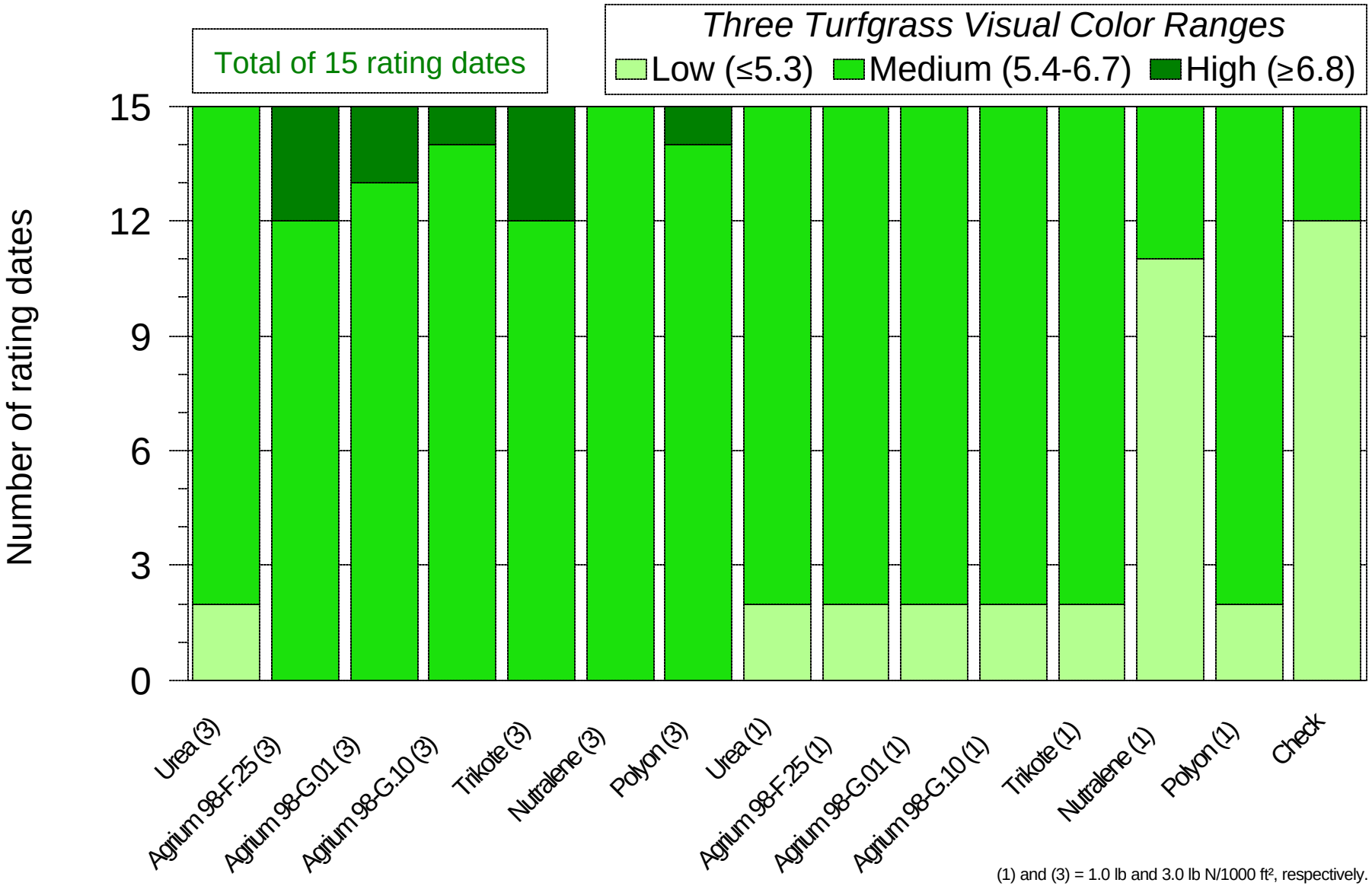


Figure 3. 1998 Agrium slow-release nitrogen product trial on Bonsai tall fescue: number of rating dates within three ranges of visual turfgrass color.



(1) and (3) = 1.0 lb and 3.0 lb N/1000 ft², respectively.

Table 4a. Clipping yields (g dry clippings/7.44 ft² per 7 days) for the 1998 Agrium slow-release nitrogen product trial on Bonsai tall fescue. Treatments were applied on June 24, 1998; 15 treatments arranged in a RCB design.

Product (N-P_2O_5-K_20 Analysis)	**App. Rate** (lb N/1000 ft²)	**Jul 08** ***1998***	**Jul 24** ***1998***	**Aug 07** ***1998***	**Aug 18** ***1998***	**Sep 01** ***1998***	**Sep 15** ***1998***	**Oct 13** ***1998***	**Accumulative yield**
Urea (46-0-0)	1	6.74	7.15	5.78	5.39	9.24	8.54	5.94	48.78
	3	8.76	13.30	8.86	7.58	10.41	10.87	7.17	66.95
Agrium 98-F.25 (43-0-0)	1	6.62	8.41	6.23	5.29	9.08	8.81	5.30	49.74
	3	8.84	14.92	10.79	9.55	11.21	12.09	9.10	76.50
Agrium 98-G.01 (43-0-0)	1	6.98	9.50	7.07	5.93	9.14	8.88	4.88	52.38
	3	10.57	16.45	9.82	9.12	11.85	11.04	8.21	77.06
Agrium 98-G.10 (43-0-0)	1	6.44	7.63	6.16	7.24	8.12	8.93	6.44	50.96
	3	9.67	13.73	9.59	9.27	10.31	10.04	6.85	69.46
Trikote (42-0-0)	1	6.06	7.12	6.18	6.24	8.26	8.23	5.74	47.83
	3	9.95	12.31	11.11	9.46	11.24	11.83	7.22	73.12
Nutralene (40-0-0)	1	5.61	6.14	5.72	4.83	7.40	7.35	5.28	42.33
	3	6.76	10.23	7.91	5.39	9.96	10.43	7.35	58.03
Polyon (43-0-0)	1	5.88	10.34	6.78	5.85	8.63	8.81	5.99	52.28
	3	6.74	16.49	10.14	8.85	12.35	11.56	8.37	74.50
Check	0	4.31	5.46	3.90	4.29	6.42	6.31	3.70	34.39
LSD $P \leq 0.05$		2.60	4.20	1.50	1.85	1.63	1.65	1.54	—
C.V. (%)		24.8	27.7	13.6	18.7	11.9	12.1	16.6	—

Table 4b. Clipping yields (g dry clippings/7.44 ft² per 7 days) for the 1998 Agrium slow-release nitrogen product trial on Bonsai tall fescue. Treatments were applied on June 24, 1998; 14 treatments arranged in a 7 x 2 Factorial and assigned to a RCB design.

Product (N-P_2O_5-K_20 Analysis)	**Jul 08** *1998*	**Jul 24** *1998*	**Aug 07** *1998*	**Aug 18** *1998*	**Sep 01** *1998*	**Sep 15** *1998*	**Oct 13** *1998*	**Accumulative yield**
1.0 lb N/1000 ft² application[z]								
Urea (46-0-0)	6.74	7.15	5.78	5.39	9.24	8.54	5.94	48.78
Agrium 98-F.25 (43-0-0)	6.62	8.41	6.23	5.29	9.08	8.81	5.30	49.74
Agrium 98-G.01 (43-0-0)	6.98	9.50	7.07	5.93	9.14	8.88	4.88	52.38
Agrium 98-G.10 (43-0-0)	6.44	7.63	6.16	7.24	8.12	8.93	6.44	50.96
Trikote (42-0-0)	6.06	7.12	6.18	6.24	8.26	8.23	5.74	47.83
Nutralene (40-0-0)	5.61	6.14	5.72	4.83	7.40	7.35	5.28	42.33
Polyon (43-0-0)	5.88	10.34	6.78	5.85	8.63	8.81	5.99	52.28
LSD P≤0.05	NS	NS	NS	NS	NS	NS	NS	—
3.0 lb N/1000 ft² application[z]								
Urea (46-0-0)	8.76	13.30	8.86	7.58	10.41	10.87	7.17	66.95
Agrium 98-F.25 (43-0-0)	8.84	14.92	10.79	9.55	11.21	12.09	9.10	76.50
Agrium 98-G.01 (43-0-0)	10.57	16.45	9.82	9.12	11.85	11.04	8.21	77.06
Agrium 98-G.10 (43-0-0)	9.67	13.73	9.59	9.27	10.31	10.04	6.85	69.46
Trikote (42-0-0)	9.95	12.31	11.11	9.46	11.24	11.83	7.22	73.12
Nutralene (40-0-0)	6.76	10.23	7.91	5.39	9.96	10.43	7.35	58.03
Polyon (43-0-0)	6.74	16.49	10.14	8.85	12.35	11.56	8.37	74.50
LSD P≤0.05	2.78	NS	1.65	2.16	1.43	NS	NS	—
7x2 Factorial effects								
Product	NS	**	**	***	*	NS	NS	—
Rate	***	***	***	***	***	***	***	—
Product x Rate	NS	NS	NS	NS	NS	NS	*	—

[z]Separate, RCB ANOVA for each rate of application.

Figure 4. 1998 Agrium slow-release nitrogen product trial on Bonsai tall fescue: clipping yields (g dry clippings / 7.44 ft² per 7 days). Treatments applied June 24, 1998.

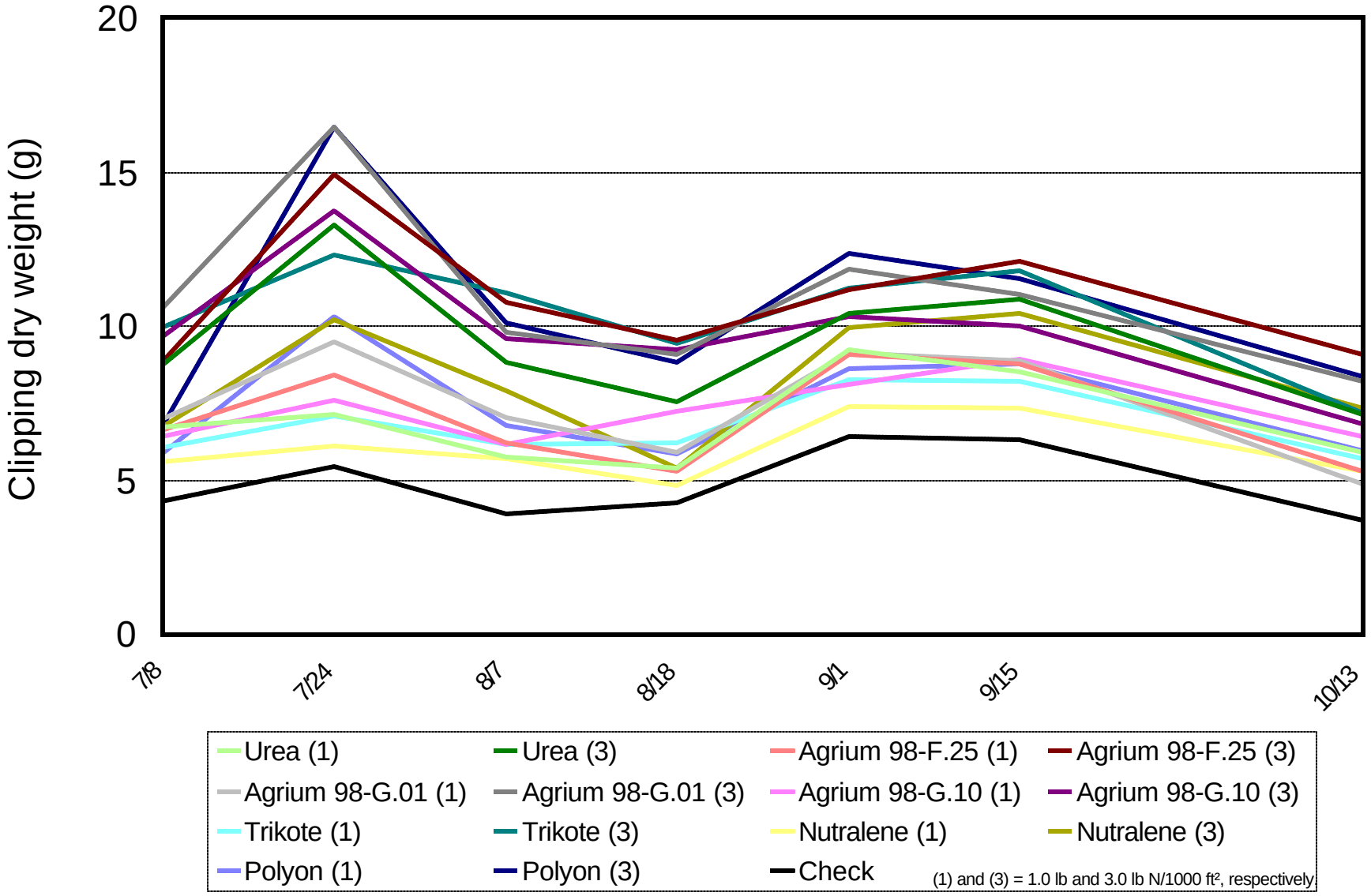


Table 5. Weather measurements collected[z] from June 21, 1998 to October 17, 1998 in Riverside, CA.

Date	Accumulative ET_o[y] (mm/week)	Accumulative Precipitation (mm/week)	Average Daily Solar Radiation (W/m^2/day)	Average Daily Temperature (^0C)	(^0F)	Average Daily Relative Humidity (%)	Average Daily Soil Temperature at 15.2 cm Depth (^0C)	(^0F)
06/21/98 - 06/27	41.94	0.00	336	21	70	55	27	81
06/28 - 07/04	42.05	0.00	323	24	75	54	29	84
07/05 - 07/11	46.03	0.00	337	27	81	52	29	84
07/12 - 07/18	44.76	0.00	324	29	84	52	30	86
07/19 - 07/25	39.01	0.00	282	26	79	54	31	88
07/26 - 08/01	45.01	0.00	345	29	84	52	32	90
08/02 - 08/08	46.24	0.00	323	29	84	53	31	88
08/09 - 08/15	40.51	14.00	274	29	84	52	32	90
08/16 - 08/22	40.80	0.00	299	26	79	53	31	88
08/23 - 08/29	44.57	0.00	310	33	91	52	31	88
08/30 - 09/05	38.47	0.00	234	35	95	54	31	88
09/06 - 09/12	34.14	0.00	270	25	77	56	30	86
09/13 - 09/19	33.22	0.00	262	24	75	56	28	82
09/20 - 09/26	21.73	0.00	170	20	68	56	26	79
09/27 - 10/03	25.24	0.00	206	19	66	57	25	77
10/04 - 10/10	30.00	0.00	248	22	72	52	23	73
10/11 - 10/17	23.34	0.00	191	19	66	56	21	70

[z] Weather data collected from an on-site California Irrigation Management Information System weather station located approximately 270 feet from the study plot.
[y] ET_o = Reference evapotranspiration.

Figure 5. Environmental data for Riverside, CA for 6/21/98 to 10/17/98.
Average weekly temperatures for air (maximum, minimum, and average) and soil (average at a 15 cm depth).

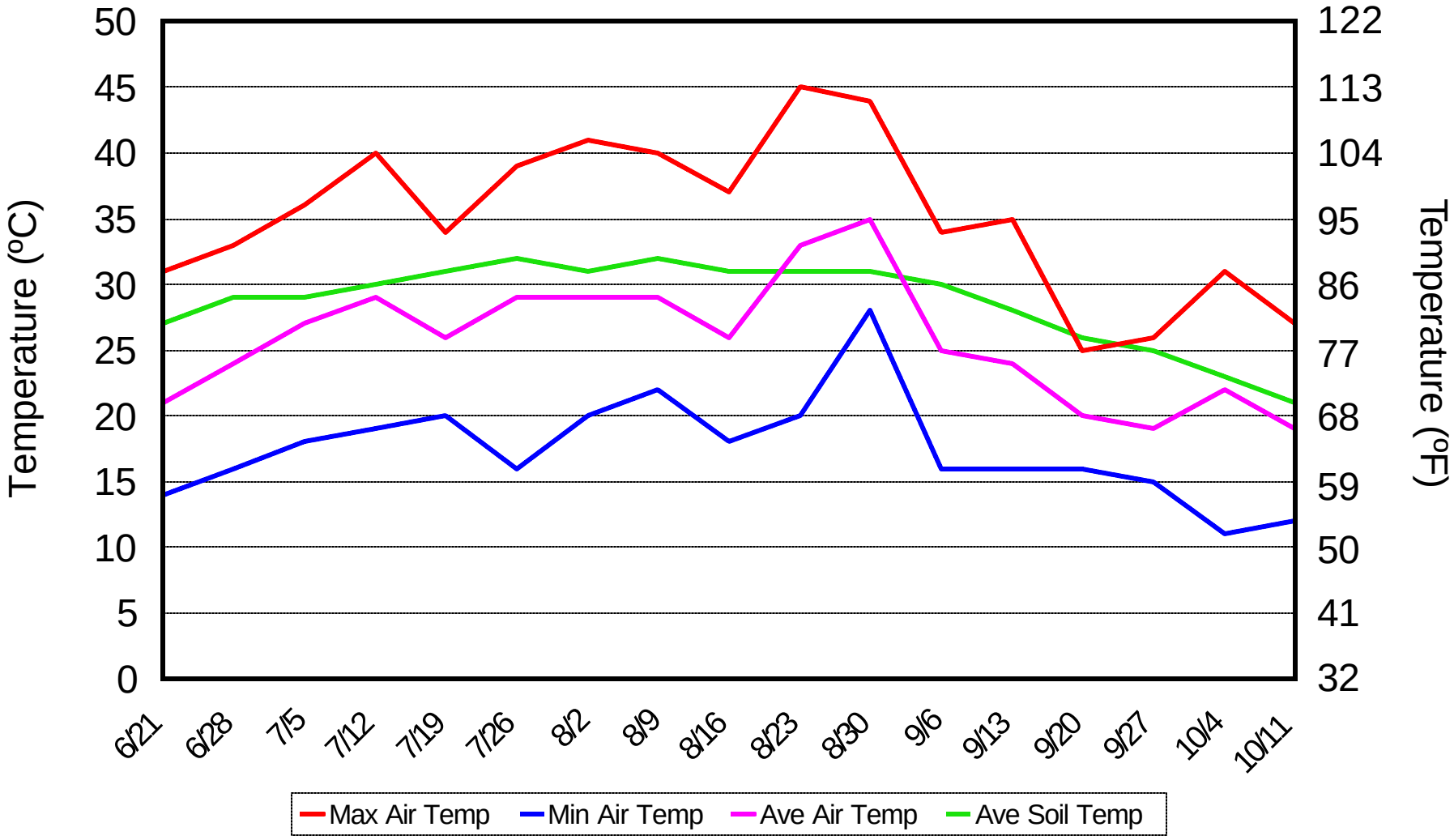


Table 6. DANR Analytical Laboratory soil, plant and water analyses methods.

Note: The soil and plant analyses information excerpted from the DANR Analytical Laboratory methodology and citation handout dated 3/5/97. The water analyses information was provided by DANR in May 1998 upon request.

SOIL SALINITY / ALKALINITY / TOXICITY ANALYSES

pH	Semi-quantifies soil pH using the saturated paste and pH meter. Determination: U.S. Salinity Laboratory Staff, 1954.
EC_e	Semi-quantifies the amount of soluble salts in the saturation paste extract using conductivity meter. Determination: Rhoades, 1982.
HCO_3, CO_3	Quantification of the bicarbonate (HCO_3) and carbonate (CO_3) in the saturated paste extract by titration with 0.05 Normal H_2SO_4 acid. Determination: Nelson, 1982.
Cl	Amount of chloride based on electrometric titration of the saturated paste extract by chloridometer. Determination: Rhoades, 1982.
B	ICP-AES determination of amount of boron in saturated paste extract. Extraction: Rhoades, 1982; determination: Soltanpour, et al, 1982.
Ca, Mg	Amounts of soluble calcium and magnesium in the saturated paste extract by inductively coupled plasmic atomic emission spectrometry. Extraction: Lanyon and Heald, 1982; determination, Soltanpour, et al, 1982.
Na, K(sol)	Amounts of soluble potassium and sodium in the saturated paste extract by emission spectometry. Determination: Knudsen, Peterson and Pratt, 1982.
SAR	Sodium Absorption Ratio estimated calculation from calcium, magnesium and sodium on saturated paste extract. Calculation: U.S. Salinity Laboratory, 1954.
ESP	Estimated value for exchangeable sodium percentage. Calculated from SAR values. Calculation: U.S. Salinity Laboratory, 1954.

SOIL FERTILITY ANALYSES

X-K, X-Na, X-Ca, X-Mg	Equilibrium extraction of soil for plant available exchangeable potassium, sodium, calcium and magnesium using 1 Normal ammonium acetate (pH 7.0) and subsequent determination by atomic absorption/emission spectrometry. Extraction: Knudsen, Peterson and Pratt, 1982 and Lanyon and Heald, 1982. Measurement of exchangeable minerals residing on the soil colloid exchange sites is by displacement with buffered ammonium acetate solution. Determination: Franson, 1985.
Cu, Zn Mn, Fe	Equilibrium extraction of soil using DTPA and subsequent determination by atomic absorption spectrometry. Extraction: Lindsay and Norvell, 1978; determination: Franson, 1985.
Olsen-P	Extractable phosphate based on alkaline extraction by 0.5 Normal $NaHCO_3$. Plant available phosphate for soil with pH greater than 6.5 by ascorbic acid reduction of phosphomolybdate complex and measurement by spectrophotometry. Extraction and determination: Olsen, et al, 1954.

SOIL PHYSIO-CHEMICAL ANALYSES

OM	Organic Matter by potassium dichromate reduction of organic carbon and subsequent spectrophotometric measurement (modified Walkley-Black). Determination: Nelson and Sommers, 1982.
CEC	Cation Exchange Capacity by barium acetate saturation and calcium replacement. Determination: Rible and Quick, 1960 and Janitzky, 1986.
PSA	Particle Size Analysis of sand, silt and clay in soil suspension by hydrometer. Determination: Gee and Bauder, 1979.

Table 6 *(continued)*. DANR Analytical Laboratory soil, plant and water analyses methods.

PLANT TISSUE ANALYSES

N	Total Nitrogen by Nitrogen Gas Analyzer utilizing induction furnace and thermal conductivity (LECO FP-428). Sample size 100 mg, results corrected to 100% dry matter basis. Determination: Sweeney, 1989.
K	Total K, extraction by 2% acetic acid extraction. Quantitative determination by atomic emission spectrometry (AES). Extraction: Johnson and Ulrich, 1959; determination: Franson, 1985.
B, Ca, Mg, Mo, P, S	Totals, microwave acid digestion/dissolution of sample. Quantitative determination by atomic emission spectroscopy (ICP-AES). Digestion: Sah and Miller, 1992.
Na	Totals, microwave acid digestion/dissolution of sample. Quantitative determination by atomic emission spectrometry (AES). Digestion: Sah and Miller, 1992; determination, Franson, 1985.
Cu, Fe, Mn, Zn	Totals, microwave acid digestion/dissolution of sample. Quantitative determination by atomic emission spectrometry (AAS). Digestion: Sah and Miller, 1992; determination, Franson, 1985.

WATER SALINITY / ALKALINITY / TOXICITY ANALYSES

pH	Semi-quantifies H_2O pH using the pH meter. U.S. Salinity Laboratory, 1954.
ECe	Semi-quantifies the amount of soluble salts in H_2O using the conductivity meter. Rhoades, 1982.
HCO_3, CO_3	Quantification of the bicarbonate (HCO_3) and carbonate (CO_3) in H_2O by titration with 0.05 Normal H_2SO_4 acid. Rhoades, 1982.
Cl	Amount of chloride based on electrometric titration of H_2O by chloridometer. Rhoades, 1982.
P	Quantitative determination by ascorbic acid reduction of phosphomolybdate complex and quantitative measurement by flow injection analysis. Franson, 1985.
SO_4-S	Amount of sulfate sulfur present in H_2O, by inductively coupled plasmic emission spectrometry. Soltanpour, et al, 1982.
B	ICP-AES determination of amount of boron in H_2O. Soltanpour, et al, 1982.
Ca, Mg	Amounts of soluble calcium and magnesium in H_2O by inductively coupled plasmic atomic emission spectrometry. Soltanpour, et al, 1982.
Na, K (sol)	Amounts of soluble potassium and sodium in H_2O by emission spectrometry. Knudsen, 1982.
SAR	Sodium Absorption Ratio estimated calculation from calcium, magnesium and sodium in H_2O. Calculation: U.S. Salinity Laboratory Staff, 1954.
ESP	Estimated value for exchangeable sodium percentage. Calculated from SAR values. Calculation: U.S. Salinity Laboratory Staff, 1954.
NO_3-N, NH_4-N	Determination by diffusion-conductivity analyzer. Carlson, 1978.
TKN	Total Kjeldahl Nitrogen in H_2O. Total reduced nitrogen by the wet oxidation of H_2O using standard Kjeldahl procedure with sulfuric acid and digestion catalyst. Carlson, 1978.
Zn, Cu, Mn, Fe	Determination by atomic absorption spectrometry. DeBoer and Reisenauer, 1973.
Se	Total selenium using nitric/perchloric acid digestion/dissolution of sample. Quantitative determination by vapor generation by inductively coupled plasma atomic emission spectroscopy (ICP-AES). Determination: Tracy and Moeller, 1990.

Table 6 *(continued)*. DANR Analytical Laboratory soil, plant and water analyses methods.

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