# 1997-98 Agrium Coated Urea Fertility Trial Applied on Tall Fescue in Riverside, California

## *Final Report*


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**Table 1.** Materials and methods outline for the 1997-98 Agrium Coated Urea Fertility Trial on Tall Fescue.

**Objectives:**
To evaluate the 12-month performance and nitrogen release, in terms of visual turfgrass color ratings and clipping yields, of four coated urea fertilizers and a standard urea fertilizer when applied on tall fescue in four applications at 1.0 lb N/1000 ft² and 1.5 lb N/1000 ft² (4.0 and 6.0 lb N/1000 ft² per year, respectively).

**Cultivar:**
Marathon III tall fescue.

**Experimental Site:**
A plot established at the UCR Turfgrass Field Research Center, Riverside, CA on April 3, 1996. The root zone is a native soil which is classified as a Hanford fine sandy loam. As of May 1997 the soil pH = 7.2; EC=0.98 mmhos/cm; soluble Ca=106.2 ppm; soluble Mg=19.5 ppm; soluble Na=73.6 ppm; SAR=2; ESP=2%; $HCO_3$=91.5 ppm; DTPA-extractable Fe=18.6 ppm; CEC=13.5 meq/100g; OM=0.71%; Olsen-P=33 ppm; exchangeable K=140 ppm; Sand=53%; Silt=34%; Clay=13% (see DANR methodology sheet for more detailed information).

**Experimental Design:**
Randomized complete block (RCB) design with four replications. Plot size was 4.5 x 6.0 ft. Overall analysis was a repeated measures design with fertilizer treatments as the main plot factor and rating date as the repeated measures factor.

**Mowing:**
Once per week with a rotary mower set at a 1.5-inch mowing height. Clippings collected.

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

**Fertilizer Treatments *(see Table 2 for application dates)*:**

- Coated urea fertilizers (*four applications per year*):
  97-2A (43-0-0), 97-2C (43-0-0), 97-5C (43-0-0), Scotts PCSCU (40-0-0*)
  * Note: first application was with Scotts PCSCU 38-0-0.
- Standard urea fertilizer (*four applications per year*):
  Urea (46-0-0)
- Two rates of nitrogen:
  1.0 lb N/1000 ft² per application and 1.5 lb N/1000 ft² per application (for a total of 4 lb N/1000 ft² per year and 6 lb N/1000 ft² per year, respectively)
- Check (no fertilizer)
- Initial treatment applications made on May 8 and 9, 1997 and final applications were made on February 13, 1998.

**Measurements:**
Visual turfgrass color ratings were taken every week beginning two weeks after initial treatment applications, using a 1 to 9 scale (1=brown, 5=acceptable, 9=darkest green tall fescue).

Clipping yields were taken once every two weeks, beginning three weeks after initial treatment applications. Yields were from 7 days of growth (clippings were taken with a 21-inch walk-behind mower equipped with a yield box attachment. This mower was not used for routine mowing). 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 1997-98 Agrium Coated Urea Fertility Trial on Tall Fescue.

**Results:**

Five fertilizers were evaluated for 1 year on Marathon III tall fescue (plot established on April 3, 1996 from seed). Each fertilizer was applied on May 8 to 9, 1997; July 21, 1997; October 21 to 22,1997; and February 13, 1998 at both 1.0 and 1.5 lb N/1000 ft² per application rate (4.0 and 6.0 lb N/1000 ft² per 12 months). Visual turfgrass color ratings were taken once per week from May 23, 1997 to May 8, 1998, while clipping yields were taken once per 2 weeks from May 28, 1997 to April 29, 1998. 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 ratings for the five fertilizer products applied at 4.0 and 6.0 lb N/1000 ft² per year, the 97-2A product had the best performance, while the 97-5C had the worst performance. This evaluation was made on three criteria: overall visual turfgrass color mean, data in Figure 3, and number of ratings dates a product was ranked the best and worst (data not shown). It should be noted that for an unknown reason, the visual turfgrass color ratings were not as high as we have come to expect when applying slow-release fertilizers at these rates to fall fescue. Typically, 6.0 lb N/1000 ft² per year of a slow-release N source would result in a 6.5 annual turfgrass quality rating. Visual turfgrass quality and visual turfgrass color scores for tall fescue are typically similar.

In terms of clipping yield, all products were similar, with the exception of Scotts PCSCU, which caused a relatively lower production of clipping yields at the 6.0 lb N/1000 ft² per year rate.

**Figure 1.** Plot plan for the 1997-98 Agrium Coated Urea Fertility Trial Applied on Tall Fescue in Riverside, California.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| I | 1 8 | 2 6 | 3 7 | 4 4 | 5 9 | 6 1 | 7 5 | 8 10 | 9 11 | 10 3 |
| | 11 11 | 12 8 | 13 2 | 14 3 | 15 9 | 16 5 | 17 4 | 18 11 | 19 7 | 20 2 |
| II | 21 1 | 22 | 23 | 24 | 25 | 26 | 27 | 28 8 | 29 10 | 30 1 |
| III | 31 7 | 32 2 | 33 9 | 34 11 | 35 5 | 36 8 | 37 6 | 38 | 39 | 40 6 |
| | 41 4 | 42 | 43 5 | 44 | 45 4 | 46 3 | 47 | 48 | 49 | 50 |
| IV | 51 3 | 52 6 | 53 10 | 54 1 | 55 2 | 56 7 | 57 9 | 58 10 | 59 | 60 |
| | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |

Unused (skip) plots

**TREATMENTS**

1. 97-2A (43-0-0): 4 lb N/1000 ft²/year
2. 97-2A (43-0-0): 6 lb N/1000 ft²/year
3. 97-2C (43-0-0): 4 lb N/1000 ft²/year
4. 97-2C (43-0-0): 6 lb N/1000 ft²/year
5. 97-5C (43-0-0): 4 lb N/1000 ft²/year
6. 97-5C (43-0-0): 6 lb N/1000 ft²/year
7. Urea (46-0-0): 4 lb N/1000 ft²/year
8. Urea (46-0-0): 6 lb N/1000 ft²/year
9. PCSCU (40-0-0) 4 lb N/1000 ft²/year
10. PCSCU (40-0-0) 6 lb N/1000 ft²/year
11. Check 0 lb N/1000 ft²/year

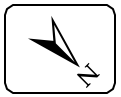

**Table 2.** Calendar of major activities for the 1997-98 Agrium Coated Urea Fertility Trial on Tall Fescue.

| Date | Activity |
|---|---|
| May 8 and 9, 1997 | Initial application of fertility treatments. |
| May 15, 1997 | Application of Triple Super Phosphate 0-45-0 at 1 lb $P_2O_5$/1000 ft². |
| May 23, 1997 | Application of potassium sulfate 0-0-62 at 1 lb $K_2O$/1000 ft². |
| | Initial visual turfgrass color rating (subsequent ratings every week). |
| May 28, 1997 | Initial clipping yield samples taken (subsequently taken every two weeks). |
| July 21, 1997 | Second application of fertility treatments. |
| October 21 and 22, 1997 | Third application of fertility treatments. |
| February 13, 1998 | Fourth (final) application of fertility treatments. |
| April 29, 1998 | Final clipping yield sample taken. |
| May 8, 1998 | Final visual turfgrass color rating. |

**Table 3.** Visual turfgrass color ratings during the 1997-98 Agrium Coated Urea Fertility Trial on Tall Fescue. Scale: 1-9 (1=brown, 5=minimally acceptable, 9=darkest green tall fescue).

| **Product** ($N$-$P_2O_5$-$K_2O$ Analysis) | **Annual Rate** (lb N/1000 ft$^2$) | **May 23** *1997* | **May 30** *1997* | **Jun 06** *1997* | **Jun 13** *1997* | **Jun 27** *1997* | **Jul 02** *1997* | **Jul 11** *1997* | **Jul 18** *1997* | **Aug 01** *1997* | **Aug 08** *1997* | **Aug 15** *1997* | **Aug 22** *1997* | **Aug 29** *1997* | **Sep 05** *1997* | **Sep 12** *1997* | **Sep 19** *1997* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 97-2A (43-0-0) | 4 | 6.1 | 6.1 | 6.2 | 6.3 | 6.1 | 6.3 | 6.1 | 6.3 | 6.6 | 6.6 | 6.6 | 6.4 | 6.4 | 6.3 | 6.3 | 5.9 |
| | 6 | 6.1 | 6.2 | 6.3 | 6.3 | 6.1 | 6.3 | 6.2 | 6.3 | 6.6 | 6.7 | 6.6 | 6.6 | 6.4 | 6.4 | 6.3 | 6.0 |
| 97-2C (43-0-0) | 4 | 6.0 | 6.0 | 6.2 | 6.2 | 6.0 | 6.2 | 6.1 | 6.2 | 6.3 | 6.4 | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 | 5.9 |
| | 6 | 6.0 | 6.2 | 6.4 | 6.4 | 6.3 | 6.4 | 6.2 | 6.3 | 6.6 | 6.6 | 6.4 | 6.4 | 6.4 | 6.3 | 6.3 | 6.1 |
| 97-5C (43-0-0) | 4 | 5.9 | 6.0 | 6.1 | 6.1 | 6.1 | 6.3 | 6.1 | 6.1 | 6.1 | 6.2 | 6.3 | 6.1 | 6.1 | 6.3 | 6.3 | 6.0 |
| | 6 | 6.0 | 6.0 | 6.1 | 6.3 | 6.2 | 6.4 | 6.3 | 6.3 | 6.5 | 6.5 | 6.4 | 6.4 | 6.3 | 6.3 | 6.3 | 6.0 |
| Urea (46-0-0) | 4 | 6.2 | 6.3 | 6.2 | 6.1 | 6.1 | 6.1 | 6.0 | 6.3 | 6.6 | 6.6 | 6.4 | 6.3 | 6.3 | 6.2 | 6.1 | 5.8 |
| | 6 | 6.3 | 6.3 | 6.3 | 6.3 | 5.8 | 6.1 | 5.9 | 6.3 | 6.6 | 6.8 | 6.6 | 6.4 | 6.4 | 6.2 | 6.1 | 5.9 |
| PCSCU (40-0-0) | 4 | 5.9 | 5.9 | 6.2 | 6.1 | 6.1 | 6.1 | 6.2 | 6.3 | 6.5 | 6.5 | 6.4 | 6.3 | 6.3 | 6.2 | 6.3 | 5.9 |
| | 6 | 6.1 | 6.1 | 6.3 | 6.2 | 6.1 | 6.2 | 6.2 | 6.5 | 6.8 | 6.8 | 6.7 | 6.4 | 6.4 | 6.3 | 6.3 | 5.9 |
| Check | 0 | 5.9 | 5.9 | 5.8 | 5.7 | 5.6 | 5.8 | 5.6 | 5.9 | 5.4 | 5.5 | 5.4 | 5.4 | 5.4 | 5.4 | 5.3 | 5.2 |
| LSD P≤0.05 | | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 | 0.3 | 0.3 | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 |
| C.V. (%) | | 3.0 | 2.7 | 2.1 | 2.1 | 2.8 | 2.8 | 3.0 | 2.2 | 3.4 | 3.2 | 3.9 | 3.3 | 3.3 | 3.4 | 3.3 | 4.3 |

Fertilizer application dates were:May 8-9, 1997; July 21, 1997; October 21-22, 1997; February 13, 1998.

**Table 3 *(continued)*.** Visual turfgrass color ratings during the 1997-98 Agrium Coated Urea Fertility Trial on Tall Fescue. Scale: 1-9 (1=brown, 5=minimally acceptable, 9=darkest green tall fescue).

| **Product** ($N$-$P_2O_5$-$K_2O$ Analysis) | **Annual Rate** (lb N/1000 ft²) | **Sep 26** *1997* | **Oct 03** *1997* | **Oct 10** *1997* | **Oct 17** *1997* | **Oct 24** *1997* | **Oct 31** *1997* | **Nov 07** *1997* | **Nov 14** *1997* | **Nov 21** *1997* | **Dec 05** *1997* | **Dec 12** *1997* | **Dec 19** *1997* | **Jan 02** *1998* | **Jan 09** *1998* | **Jan 16** *1998* | **Jan 23** *1998* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 97-2A (43-0-0) | 4 | 5.9 | 5.9 | 5.8 | 5.7 | 5.6 | 5.8 | 6.1 | 6.1 | 6.1 | 6.0 | 5.8 | 5.7 | 5.6 | 5.4 | 5.2 | 5.2 |
| | 6 | 6.1 | 5.9 | 5.9 | 5.9 | 5.8 | 6.4 | 6.8 | 6.5 | 6.4 | 6.4 | 6.2 | 6.3 | 6.2 | 6.1 | 5.9 | 5.9 |
| 97-2C (43-0-0) | 4 | 5.9 | 5.8 | 5.6 | 5.6 | 5.4 | 5.8 | 5.9 | 5.8 | 5.9 | 5.8 | 5.8 | 5.7 | 5.5 | 5.4 | 5.4 | 5.4 |
| | 6 | 5.8 | 5.7 | 5.8 | 5.7 | 5.7 | 5.9 | 6.2 | 6.2 | 6.1 | 6.1 | 5.9 | 5.8 | 5.6 | 5.6 | 5.6 | 5.5 |
| 97-5C (43-0-0) | 4 | 5.9 | 5.8 | 5.7 | 5.8 | 5.5 | 5.7 | 6.0 | 5.9 | 5.8 | 5.8 | 5.8 | 5.4 | 5.4 | 5.4 | 5.3 | 5.0 |
| | 6 | 5.9 | 5.8 | 5.7 | 5.7 | 5.6 | 5.9 | 6.2 | 5.9 | 5.9 | 5.9 | 5.8 | 5.8 | 5.6 | 5.6 | 5.5 | 5.4 |
| Urea (46-0-0) | 4 | 5.8 | 5.7 | 5.6 | 5.6 | 5.6 | 6.4 | 6.8 | 6.4 | 6.3 | 6.2 | 5.9 | 5.9 | 5.6 | 5.6 | 5.4 | 5.1 |
| | 6 | 5.9 | 5.8 | 5.8 | 5.6 | 5.6 | 6.8 | 7.1 | 6.9 | 6.8 | 6.8 | 6.5 | 6.4 | 6.0 | 5.8 | 5.6 | 5.3 |
| PCSCU (40-0-0) | 4 | 5.9 | 5.9 | 5.9 | 5.8 | 5.8 | 6.4 | 6.6 | 6.5 | 6.4 | 6.4 | 6.1 | 6.0 | 5.7 | 5.6 | 5.4 | 5.3 |
| | 6 | 6.0 | 5.8 | 5.8 | 5.8 | 5.6 | 6.3 | 6.3 | 6.4 | 6.3 | 6.3 | 5.9 | 5.9 | 5.7 | 5.4 | 5.3 | 5.3 |
| Check | 0 | 5.1 | 5.1 | 5.4 | 5.2 | 5.1 | 4.9 | 4.8 | 4.7 | 4.6 | 4.5 | 4.5 | 4.3 | 4.2 | 4.2 | 4.1 | 3.9 |
| LSD P≤0.05 | | 0.4 | 0.4 | NS | NS | 0.3 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.6 | 0.5 | 0.6 | 0.5 |
| C.V. (%) | | 4.8 | 4.8 | 5.7 | 4.9 | 4.1 | 5.3 | 5.7 | 5.1 | 4.8 | 4.2 | 4.3 | 5.2 | 7.2 | 7.0 | 7.8 | 6.5 |

Fertilizer application dates were:May 8-9, 1997; July 21, 1997; October 21-22, 1997; February 13, 1998.

**Table 3 *(continued)*.** Visual turfgrass color ratings during the 1997-98 Agrium Coated Urea Fertility Trial on Tall Fescue. Scale: 1-9 (1=brown, 5=minimally acceptable, 9=darkest green tall fescue).

| **Product** ($N$-$P_2O_5$-$K_2O$ Analysis) | **Annual Rate** (lb N/1000 $ft^2$) | **Jan 30** ***1998*** | **Feb 13** ***1998*** | **Feb 20** ***1998*** | **Feb 27** ***1998*** | **Mar 06** ***1998*** | **Mar 20** ***1998*** | **Mar 27** ***1998*** | **Apr 03** ***1998*** | **Apr 10** ***1998*** | **Apr 17** ***1998*** | **Apr 24** ***1998*** | **May 08** ***1998*** | **Overall** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 97-2A (43-0-0) | 4 | 5.1 | 5.1 | 5.4 | 5.6 | 6.5 | 6.6 | 6.4 | 6.2 | 6.1 | 5.9 | 6.0 | 5.8 | 6.0 |
| | 6 | 5.8 | 5.9 | 5.9 | 5.9 | 6.8 | 6.4 | 6.3 | 6.1 | 6.1 | 6.1 | 6.0 | 5.8 | 6.2 |
| 97-2C (43-0-0) | 4 | 5.2 | 5.1 | 5.3 | 5.5 | 6.6 | 6.4 | 6.4 | 6.4 | 6.3 | 5.9 | 5.9 | 5.9 | 5.9 |
| | 6 | 5.4 | 5.6 | 5.7 | 5.9 | 6.9 | 6.7 | 6.4 | 6.3 | 6.3 | 6.2 | 6.1 | 6.0 | 6.1 |
| 97-5C (43-0-0) | 4 | 4.9 | 5.1 | 5.3 | 5.5 | 6.4 | 6.4 | 6.4 | 6.1 | 6.0 | 5.8 | 5.8 | 5.8 | 5.9 |
| | 6 | 5.3 | 5.5 | 5.8 | 5.8 | 6.7 | 6.6 | 6.4 | 6.3 | 6.2 | 6.1 | 6.1 | 6.0 | 6.0 |
| Urea (46-0-0) | 4 | 4.9 | 4.8 | 5.3 | 5.8 | 6.9 | 6.8 | 6.4 | 6.3 | 6.1 | 6.0 | 5.9 | 5.7 | 6.0 |
| | 6 | 5.2 | 5.3 | 5.8 | 5.9 | 7.0 | 6.8 | 6.6 | 6.3 | 6.2 | 6.1 | 6.0 | 5.7 | 6.2 |
| PCSCU (40-0-0) | 4 | 5.1 | 4.9 | 5.3 | 5.4 | 6.7 | 6.3 | 6.2 | 5.9 | 5.9 | 5.8 | 5.8 | 5.6 | 6.0 |
| | 6 | 5.2 | 5.1 | 5.6 | 5.9 | 6.9 | 6.9 | 6.8 | 6.4 | 6.3 | 6.1 | 5.9 | 5.8 | 6.1 |
| Check | 0 | 3.9 | 4.0 | 4.4 | 4.6 | 5.2 | 5.3 | 5.5 | 5.3 | 5.3 | 5.3 | 5.1 | 4.9 | 5.1 |
| LSD $P \leq 0.05$ | | 0.5 | 0.5 | 0.5 | 0.5 | 0.7 | 0.6 | NS | 0.6 | NS | NS | 0.5 | 0.5 | 0.1 |
| C.V. (%) | | 6.5 | 7.2 | 6.7 | 6.7 | 7.0 | 6.8 | 7.3 | 6.5 | 6.3 | 6.8 | 6.3 | 5.6 | 4.8 |

Fertilizer application dates were:May 8-9, 1997; July 21, 1997; October 21-22, 1997; February 13, 1998.

**Figure 2.** 1997-1998 Agrium coated urea fertility trial on tall fescue: visual color ratings (scale: 1-9; 9=darkest green tall fescue).

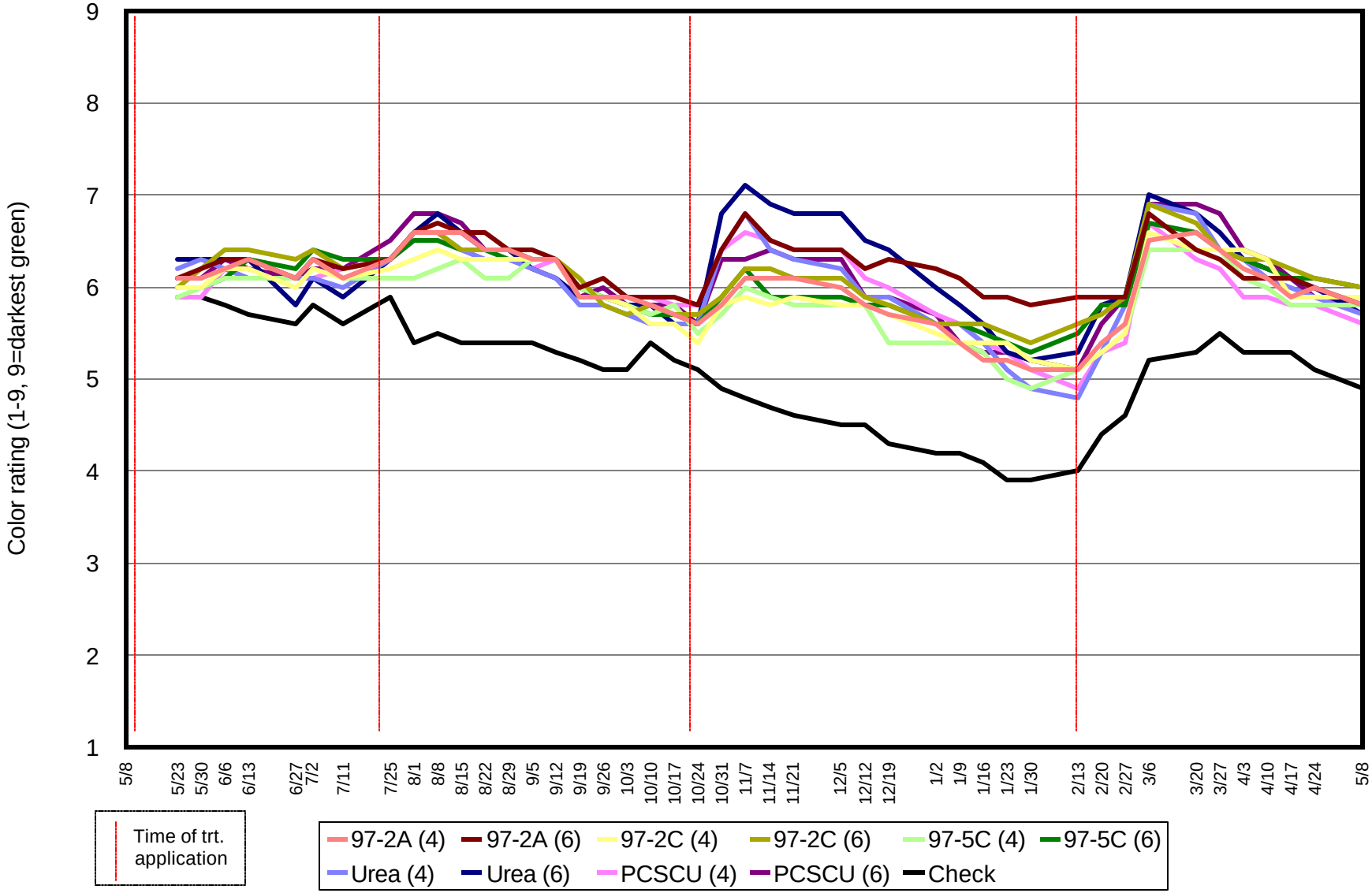

**Figure 3.** 1997-1998 Agrium coated urea fertility trial on tall fescue: number of rating dates within three levels visual turfgrass color.

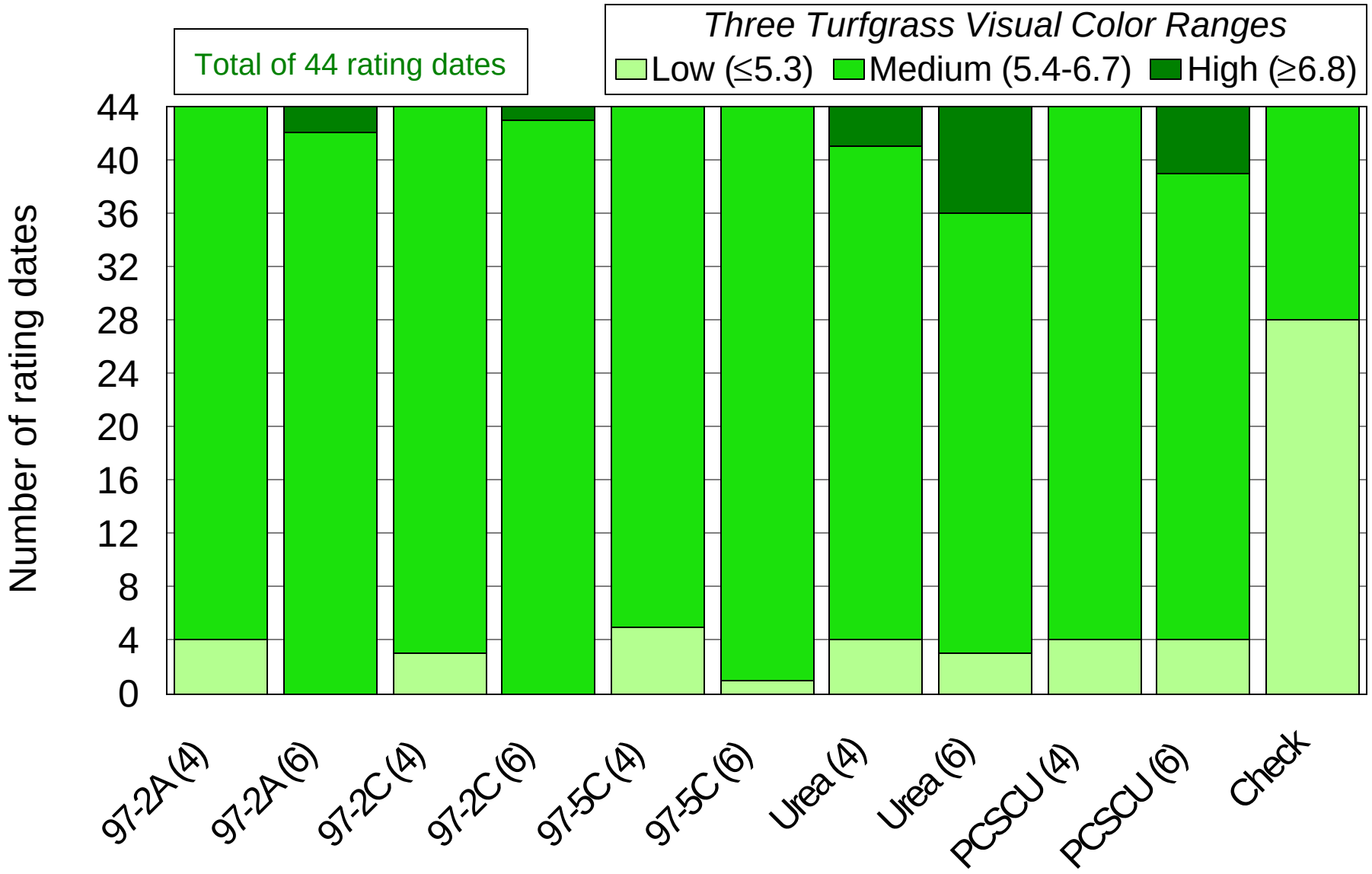

**Table 4.** Clipping yields (g dry clippings/7.44 ft² per 7 days) during the 1997-98 Agrium Coated Urea Fertility Trial on Tall Fescue.

| **Product** ($N$-$P_2O_5$-$K_2O$ Analysis) | **Annual Rate** (lb N/1000 ft²) | **May 28** *1997* | **Jun 11** *1997* | **Jun 27** *1997* | **Jul 09** *1997* | **Jul 23** *1997* | **Aug 06** *1997* | **Aug 20** *1997* | **Sep 03** *1997* | **Sep 17** *1997* | **Oct 01** *1997* | **Oct 15** *1997* | **Oct 29** *1997* | **Nov 12** *1997* | **Dec 04** *1997* | **Jan 16** *1998* | **Jan 30** *1998* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 97-2A (43-0-0) | 4 | 13.25 | 8.14 | 7.68 | 4.72 | 2.71 | 5.92 | 10.87 | 6.43 | 5.95 | 9.19 | 6.36 | 2.32 | 2.82 | 1.99 | 0.06 | 0.06 |
| | 6 | 17.78 | 11.98 | 7.99 | 3.95 | 2.40 | 9.77 | 8.30 | 6.04 | 6.35 | 8.28 | 6.65 | 2.08 | 3.44 | 2.05 | 0.04 | 0.14 |
| 97-2C (43-0-0) | 4 | 11.77 | 9.13 | 7.26 | 4.73 | 2.62 | 6.13 | 8.92 | 5.75 | 7.38 | 10.08 | 5.88 | 2.13 | 2.95 | 0.78 | 0.04 | 0.03 |
| | 6 | 12.52 | 11.95 | 6.81 | 4.67 | 3.32 | 5.52 | 9.36 | 7.61 | 8.99 | 11.35 | 6.12 | 2.36 | 4.14 | 1.88 | 0.04 | 0.06 |
| 97-5C (43-0-0) | 4 | 12.69 | 8.09 | 7.07 | 6.23 | 2.97 | 4.89 | 6.47 | 5.73 | 7.39 | 8.94 | 6.71 | 1.82 | 2.72 | 1.37 | 0.04 | 0.04 |
| | 6 | 16.88 | 12.25 | 8.20 | 5.81 | 3.27 | 6.86 | 9.03 | 7.10 | 9.82 | 9.17 | 8.20 | 2.54 | 3.61 | 1.56 | 0.09 | 0.08 |
| Urea (46-0-0) | 4 | 15.12 | 9.16 | 7.17 | 4.43 | 2.28 | 8.63 | 7.29 | 4.37 | 5.62 | 8.10 | 5.81 | 1.19 | 3.30 | 1.60 | 0.03 | 0.06 |
| | 6 | 21.61 | 11.03 | 6.93 | 4.64 | 4.25 | 6.68 | 7.97 | 5.14 | 5.39 | 8.23 | 5.90 | 2.29 | 3.67 | 2.09 | 0.08 | 0.15 |
| PCSCU (40-0-0) | 4 | 14.88 | 8.72 | 7.05 | 4.40 | 4.42 | 10.46 | 9.02 | 6.62 | 7.72 | 10.23 | 7.33 | 2.00 | 3.65 | 1.82 | 0.05 | 0.06 |
| | 6 | 12.87 | 7.37 | 7.12 | 4.22 | 3.08 | 10.97 | 12.14 | 6.89 | 7.95 | 9.03 | 6.83 | 2.41 | 4.49 | 2.00 | 0.06 | 0.05 |
| Check | 0 | 10.56 | 6.81 | 5.99 | 2.61 | 4.09 | 4.15 | 4.08 | 2.75 | 3.48 | 5.60 | 2.96 | 1.10 | 1.34 | 0.64 | 0.03 | 0.02 |
| LSD P≤0.05 | | 5.38 | 3.88 | NS | NS | NS | 3.16 | 4.06 | 2.15 | 2.23 | NS | 2.29 | NS | NS | NS | NS | 0.07 |
| C.V. (%) | | 25.6 | 22.3 | 34.0 | 31.2 | 38.7 | 30.1 | 33.1 | 25.4 | 22.4 | 36.5 | 25.2 | 34.8 | 36.6 | 48.3 | 77.4 | 77.9 |

Fertilizer application dates were:May 8-9, 1997; July 21, 1997; October 21-22, 1997; February 13, 1998.

**Table 4 *(continued)*.** Clipping yields (g dry clippings/7.44 ft² per 7 days) during the 1997-98 Agrium Coated Urea Fertility Trial on Tall Fescue.

| **Product** ($N$-$P_2O_5$-$K_20$ Analysis) | **Annual Rate** (lb N/1000 ft²) | **Feb 11** ***1998*** | **Feb 25** ***1998*** | **Mar 11** ***1998*** | **Apr 03** ***1998*** | **Apr 15** ***1998*** | **Apr 29** ***1998*** | **Accum.** |
|---|---|---|---|---|---|---|---|---|
| 97-2A (43-0-0) | 4 | 0.15 | 1.18 | 5.07 | 8.17 | 7.07 | 6.62 | 116.73 |
| | 6 | 0.44 | 3.71 | 8.18 | 11.45 | 14.44 | 11.54 | 147.00 |
| 97-2C (43-0-0) | 4 | 0.62 | 1.36 | 2.93 | 8.68 | 8.14 | 7.49 | 114.80 |
| | 6 | 0.64 | 2.97 | 5.80 | 11.86 | 13.80 | 13.27 | 145.04 |
| 97-5C (43-0-0) | 4 | 0.26 | 2.20 | 3.43 | 9.39 | 8.62 | 7.72 | 114.79 |
| | 6 | 0.46 | 3.17 | 5.99 | 10.77 | 10.84 | 11.32 | 147.02 |
| Urea (46-0-0) | 4 | 0.28 | 2.08 | 5.54 | 7.81 | 9.04 | 7.95 | 116.86 |
| | 6 | 0.42 | 3.86 | 9.11 | 15.95 | 10.49 | 7.84 | 143.72 |
| PCSCU (40-0-0) | 4 | 0.51 | 1.86 | 3.32 | 6.65 | 8.76 | 6.81 | 126.34 |
| | 6 | 0.30 | 2.05 | 4.52 | 8.80 | 7.64 | 6.22 | 127.01 |
| Check | 0 | 0.12 | 0.62 | 0.77 | 3.43 | 4.14 | 4.35 | 69.64 |
| LSD $P \leq 0.05$ | | NS | 2.03 | 3.67 | 5.98 | 4.35 | 3.83 | -- |
| C.V. (%) | | 88.9 | 61.7 | 51.1 | 44.3 | 32.2 | 32.0 | -- |

Fertilizer application dates were:May 8-9, 1997; July 21, 1997; October 21-22, 1997; February 13, 1998.

**Figure 4.** 1997-1998 Agrium coated urea fertility trial on tall fescue: clipping yields (g dry clippings / 7 days / 7.44 ft²).

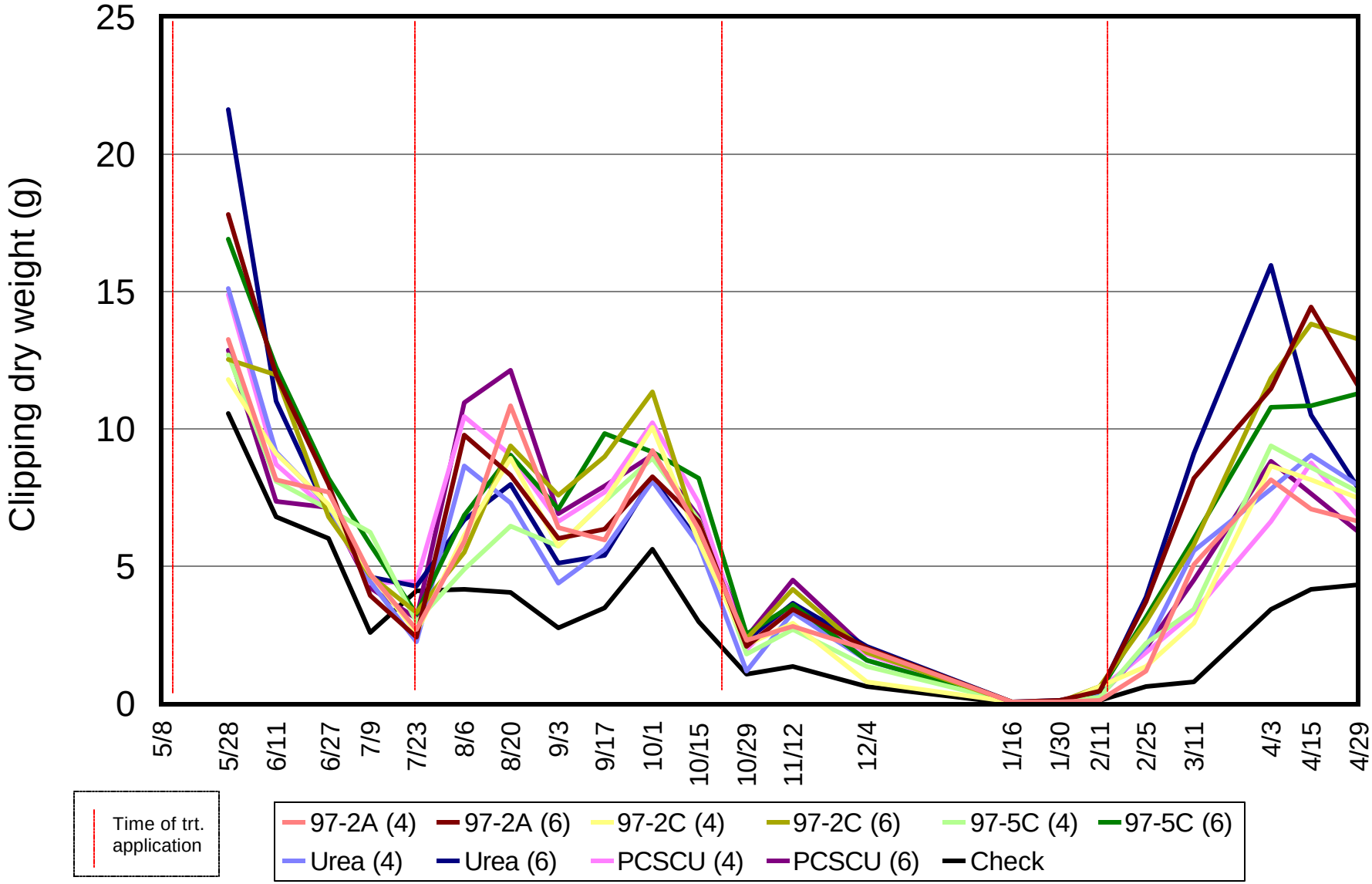

**Table 5.** Weather measurements collected[z] from May 4, 1997 to May 9, 1998 in Riverside, CA.

| Date | Accumulative $ET_o$[y] (mm/week) | Accumulative Precipitation (mm/week) | Average Daily Solar Radiation ($W/m^2$/day) | Average Daily Temperature ($^0$C) | ($^0$F) | Average Daily Relative Humidity (%) | Average Daily Soil Temperature at 15.2 cm Depth ($^0$C) | ($^0$F) |
|---|---|---|---|---|---|---|---|---|
| 05/04/97 - 05/10 | 42.30 | 0.00 | 330 | 22 | 72 | 46 | 23 | 73 |
| 05/11 - 05/17 | 38.60 | 0.00 | 288 | 22 | 72 | 55 | 24 | 75 |
| 05/18 - 05/24 | 36.99 | 0.00 | 284 | 20 | 68 | 56 | 24 | 75 |
| 05/25 - 05/31 | 45.91 | 0.00 | 341 | 24 | 75 | 48 | 24 | 75 |
| 06/01 - 06/07 | 36.85 | 0.00 | 290 | 20 | 68 | 55 | 24 | 75 |
| 06/08 - 06/14 | 31.81 | 0.00 | 261 | 19 | 66 | 55 | 23 | 73 |
| 06/15 - 06/21 | 42.57 | 0.00 | 338 | 22 | 72 | 55 | 24 | 75 |
| 06/22 - 06/28 | 40.88 | 0.00 | 328 | 21 | 70 | 55 | 24 | 75 |
| 06/29 - 07/05 | 48.29 | 0.00 | 361 | 25 | 77 | 43 | 24 | 75 |
| 07/06 - 07/12 | 42.99 | 1.00 | 305 | 22 | 72 | 54 | 26 | 79 |
| 07/13 - 07/19 | 41.88 | 0.00 | 317 | 24 | 75 | 51 | 26 | 79 |
| 07/20 - 07/26 | 34.71 | 0.00 | 268 | 22 | 72 | 56 | 26 | 79 |
| 07/27 - 08/02 | 41.41 | 0.00 | 311 | 23 | 73 | 49 | 25 | 77 |
| 08/03 - 08/09 | 44.12 | 0.00 | 301 | 28 | 82 | 45 | 27 | 81 |
| 08/10 - 08/16 | 37.10 | 0.00 | 283 | 21 | 70 | 55 | 25 | 77 |
| 08/17 - 08/23 | 37.96 | 0.00 | 302 | 26 | 79 | 59 | 26 | 79 |
| 08/24 - 08/30 | 36.67 | 0.00 | 302 | 25 | 77 | 70 | 25 | 77 |
| 08/31 - 09/06 | 35.64 | 0.00 | 269 | 27 | 81 | 69 | 26 | 79 |
| 09/07 - 09/13 | 33.87 | 0.00 | 274 | 25 | 77 | 70 | 26 | 79 |
| 09/14 - 09/20 | 25.74 | 4.00 | 209 | 24 | 75 | 59 | 25 | 77 |
| 09/21 - 09/27 | 27.66 | 15.00 | 203 | 24 | 75 | 54 | 24 | 75 |
| 09/28 - 10/04 | 27.28 | 0.00 | 216 | 23 | 73 | 61 | 25 | 77 |
| 10/05 - 10/11 | 22.73 | 0.00 | 200 | 18 | 64 | 56 | 22 | 72 |
| 10/12 - 10/18 | 33.38 | 0.00 | 229 | 22 | 72 | 36 | 19 | 66 |
| 10/19 - 10/25 | 21.25 | 0.00 | 180 | 17 | 63 | 54 | 19 | 66 |
| 10/26 - 11/01 | 22.30 | 0.00 | 193 | 18 | 64 | 47 | 17 | 63 |
| 11/02 - 11/08 | 20.49 | 0.00 | 171 | 20 | 68 | 50 | 18 | 64 |

[z] Weather data collected from an on-site CIMIS weather station located approximately 355 feet from the study plot.
[y] $ET_o$ = Reference evapotranspiration.

**Table 5 *(continued)*.** Weather measurements collected[z] from May 4, 1997 to May 9, 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 ($^0C$) | ($^0F$) |
|---|---|---|---|---|---|---|---|---|
| 11/09 - 11/15 | 9.72 | 11.00 | 109 | 13 | 55 | 62 | 17 | 63 |
| 11/16 - 11/22 | 14.39 | 0.00 | 148 | 15 | 59 | 54 | 16 | 61 |
| 11/23 - 11/29 | 10.30 | 12.00 | 121 | 13 | 55 | 59 | 15 | 59 |
| 11/30 - 12/06 | 9.92 | 63.00 | 106 | 12 | 54 | 57 | 14 | 57 |
| 12/07 - 12/13 | 17.76 | 10.00 | 133 | 11 | 52 | 43 | 11 | 52 |
| 12/14 - 12/20 | 15.66 | 2.00 | 135 | 12 | 54 | 47 | 11 | 52 |
| 12/21 - 12/27 | 19.13 | 3.00 | 143 | 10 | 50 | 43 | 9 | 48 |
| 12/28 - 01/03/98 | 13.50 | 1.00 | 116 | 16 | 61 | 54 | 11 | 52 |
| 01/04 - 01/10 | 8.82 | 53.00 | 102 | 10 | 50 | 58 | 11 | 52 |
| 01/11 - 01/17 | 9.16 | 1.00 | 108 | 12 | 54 | 63 | 13 | 55 |
| 01/18 - 01/24 | 12.75 | 2.00 | 150 | 12 | 54 | 55 | 13 | 55 |
| 01/25 - 01/31 | 13.49 | 9.00 | 146 | 12 | 54 | 57 | 13 | 55 |
| 02/01 - 02/07 | 11.15 | 83.00 | 106 | 11 | 52 | 58 | 13 | 55 |
| 02/08 - 02/14 | 13.62 | 36.00 | 150 | 11 | 52 | 59 | 14 | 57 |
| 02/15 - 02/21 | 13.30 | 27.00 | 161 | 10 | 50 | 56 | 13 | 55 |
| 02/22 - 02/28 | 14.66 | 84.00 | 171 | 11 | 52 | 58 | 13 | 55 |
| 03/01 - 03/07 | 18.78 | 9.00 | 162 | 13 | 55 | 54 | 15 | 59 |
| 03/08 - 03/14 | 25.09 | 18.00 | 240 | 15 | 59 | 53 | 15 | 59 |
| 03/15 - 03/21 | 21.46 | 0.00 | 199 | 15 | 59 | 58 | 17 | 63 |
| 03/22 - 03/28 | 20.37 | 29.00 | 177 | 14 | 57 | 57 | 17 | 63 |
| 03/29 - 04/04 | 18.19 | 17.00 | 190 | 9 | 48 | 57 | 14 | 57 |
| 04/05 - 04/11 | 26.55 | 2.00 | 252 | 13 | 55 | 55 | 15 | 59 |
| 04/12 - 04/18 | 29.61 | 1.00 | 275 | 13 | 55 | 53 | 16 | 61 |
| 04/19 - 04/25 | 36.29 | 0.00 | 290 | 18 | 64 | 53 | 19 | 66 |
| 04/26 - 05/02 | 40.22 | 0.00 | 319 | 19 | 66 | 53 | 20 | 68 |
| 05/03 - 05/09 | 23.26 | 13.00 | 202 | 16 | 61 | 56 | 21 | 70 |

[z] Weather data collected from an on-site CIMIS weather station located approximately 355 feet from the study plot.
[y] $ET_o$ = Reference evapotranspiration.

**Figure 5.** Environmental data for Riverside, CA for 5/04/97 to 5/09/98.
Average weekly temperatures for air (maximum, minimum, and average) and soil (15 cm depth).

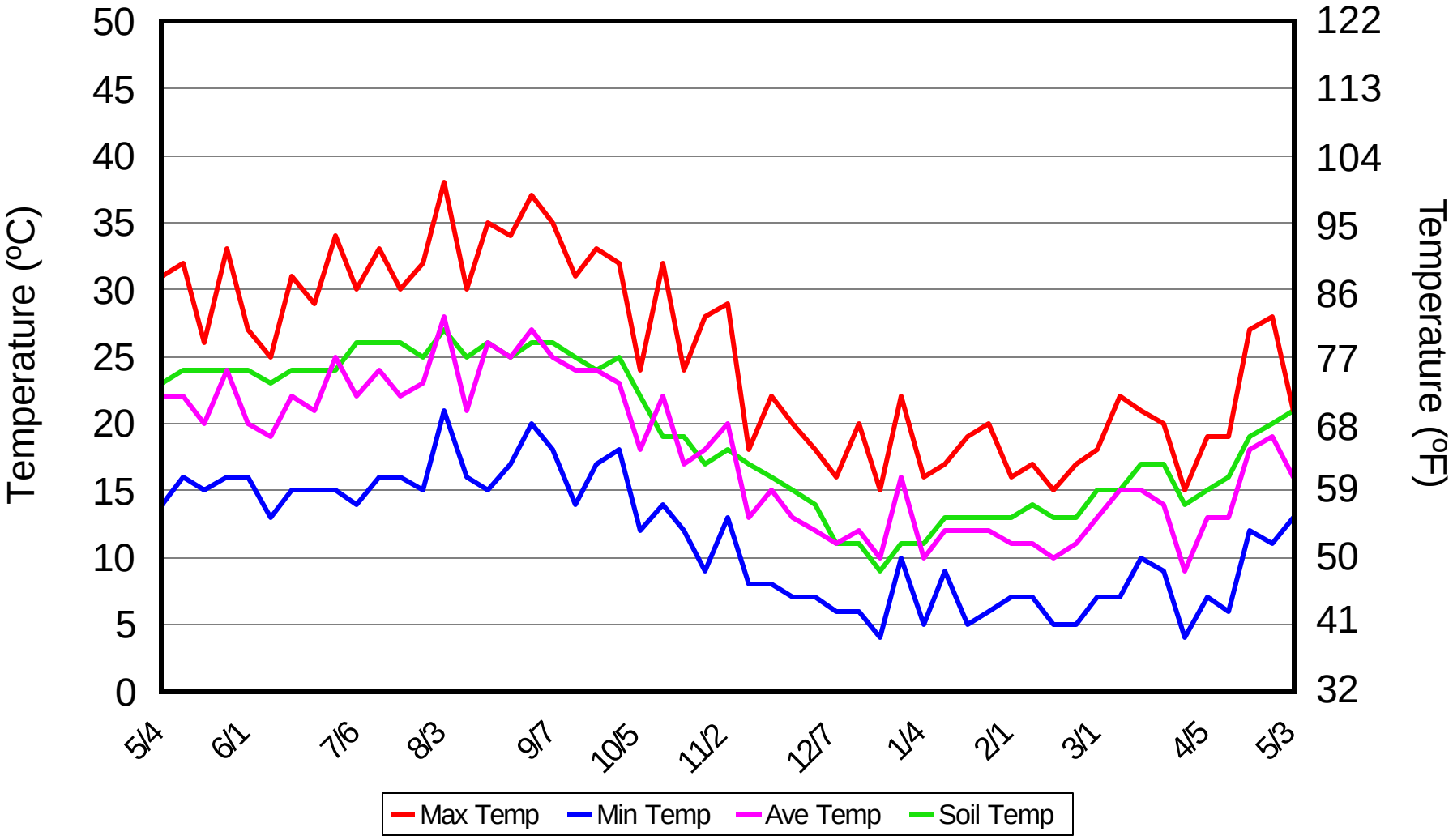

**Table 6.** DANR Analytical Laboratory soil, plant and water analyses methods.

*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.

**References:**


Carlson, R. M. 1978. Automated separation and conductimetric determination of ammonia and dissolved carbon dioxide. Anal. Chem. 50:1528-1531.

DeBoer, G. J. and H. M. Reisenauer, 1973. DTPA as an Extractant of Available Soil Iron. 121-128. Comm. In Soil Sci. Plant Anal. 4 (2).

Franson, M.A.H. (ed.) 1985. Method 303A. 157-160. In: Standard Methods for the Examination of Water and Wastewater. 16th Edition. APHA, AWWA, WPCF; Washington, D.C.

Gee, G.W. and J.W. Bauder. 1979. Particle size analysis by hydrometer: a simplified method for routine textural analysis and a sensitivity test of measurement parameters. Soil Sci. Soc. Am. J., Madison, WI 43:1004-1007.

Janitzky, P. 1986. Cation exchange capacity. 21-23. In: Singer, M.J. and P. Janitzky (ed.) Field and Laboratory Procedures Used in a Soil Chromosequence Study. U.S. Geological Survey Bulletin 1648.

Johnson, C.M. and A. Ulrich. 1959. Analytical methods for use in plant analysis. Bulletin 766. Berkeley: University of California, Agricultural Experiment Station. 26-78.

Knudsen, D., G.A. Peterson and P.F. Pratt. 1982. Lithium, sodium, and potassium. 225-246. In: A. L. Page (ed.) Methods of Soil Analysis: Part 2: Chemical and Microbiological Properties. Monograph Number 9 (Second Edition). ASA, Madison, WI.

Lanyon, L.E. and W.R. Heald. 1982. Magnesium, calcium, strontium, and barium. 247-262. In: A. L. Page (ed.) Methods of Soil Analysis: Part 2: Chemical and Microbiological Properties. Monograph Number 9 (Second Edition). ASA, Madison, WI.

Lindsay, W.L. and W.A. Norvell. 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Sci. Soc. Am. J. Madison, WI. 42:421-428.

Nelson, D.W. and L.E. Sommers. 1982. Total carbon, organic carbon, and organic matter. 539-579. In: A. L. Page (ed.) Methods of Soil Analysis: Part 2: Chemical and Microbiological Properties. Monograph Number 9 (Second Edition). ASA, Madison, WI.

Nelson, R.E. 1982. Carbonate and gypsum. 181-197. In: A. L. Page (ed.) Methods of Soil Analysis: Part 2: Chemical and Microbiological Properties. Monograph Number 9 (Second Edition). ASA, Madison, WI.

Olsen, S.R., C.V. Cole, F.S. Watanabe, and L.A. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Dept. Agr. Cir. 939: 1-19.

Rhoades, J.D. 1982. Soluble salts. 167-179. In: A. L. Page (ed.) Methods of Soil Analysis: Part 2: Chemical and Microbiological Properties. Monograph Number 9 (Second Edition). ASA, Madison, WI.

Rible, J.M. and J. Quick. April, 1960. Water Soil Plant Tissue Tentative methods of analysis for diagnostic purposes. Method S-19:0. University of California Agricultural Experiment Service.

Sah, R.N. and R.O. Miller. 1992. Spontaneous reaction for acid dissolution of biological tissues in closed vessels. Anal. Chem. 64:230-233.

Soltanpour, P.N., J. Benton Jones, Jr., and S. M. Workman. 1982. Optical emission spectrometry. 29-65. In: A. L. Page (ed.) Methods of Soil Analysis: Part 2: Chemical and Microbiological Properties. Monograph Number 9 (Second Edition). ASA, Madison, WI.

Sweeney, R.A. 1989. Generic combustion method for determination of crude protein in feeds: collaborative study. J. Assoc. Off. Anal. Chem. 72:770-774.

Tracy, M. L. and G. Moeller. 1990. Continuous flow vapor generation for inductively coupled argon plasma spectrometric analysis. Part I. Selenium. J. Assoc. Off. Anal. Chem. 73:404-410.

U.S. Salinity Laboratory Staff. 1954. L.A. Richards (ed.) Diagnosis and Improvement of Saline and Alkali Soils. U.S. Department of Agriculture Handbook no. 60.