

# Evaluation of Fertilizers at Fairway Height of Cut

E. Lyons, K. Jordan, and K. Carey

Department of Plant Agriculture and the Guelph Turfgrass Institute,  
University of Guelph, Ontario.

Sponsor: Koch Agronomic Services

The objective of this research project was to determine the release and sustainable growth maintenance of different fertilizer on turfgrass maintained at fairway heights.

Data collected included visual color, quality, and clippings biomass and N content and canopy reflectance (NDVI).

## MATERIALS / METHODS

Plots were located in turf research area at the Guelph Turfgrass Institute, Guelph, ON. The site is an area of creeping bentgrass/annual bluegrass fairway type turf on a sandy loam soil rootzone. Turf was maintained with a typical fairway maintenance regime: experimental fertility only; irrigated to prevent stress; mowed at 9 mm. Fungicides were to be applied curatively only in the instance of severe outbreaks; no fungicide treatments were needed.

Five fertilizer treatments and an untreated control were arranged in randomized complete block

design with 4 replications (Table 1, Figure 1). Plots were 1 x 2 m.

Fertilizers were applied by hand (shakers) on June 17, 2014.

Tissue testing for nitrogen was conducted on samples collected 1 week after application, 6 weeks after application and 11 weeks after application of the fertilizers. Nitrogen content was determined by flame combustion.

An anecdotal photographic record of the experiment was kept.

Table 1. Treatment

Treatment	N %	N rate (g m <sup>-2</sup> )
1 XCU	43	5
2 XCU/Urea		5
XCU (20%)	43	1
Urea (80%)	46	4
3 UMAXX	46	5
4 UFLEXX	46	5
5 Urea	46	5
6 Control	—	



Figure 1. Plot area June 5, 2014 (2 weeks prior to treatment application).

All measurements were analyzed by appropriate statistical analyses (mixed or general linear models).

**Data Collection:**

Plots were rated visually and using canopy reflectance (normalized-difference vegetation index) regularly after treatment. Clippings were collected pretreatment and at 1, 6, and 11 weeks after treatment, dried at 80°C for 24 hours, and measured for biomass accumulation. Clippings were also analyzed for nitrogen content.

Environmental conditions were noted at treatment application and during the trial.

**RESULTS**

*Environmental data*

Daily air temperatures, evapotranspiration demand, and rainfall data for summer 2014 are presented in Figures 2 - 4.

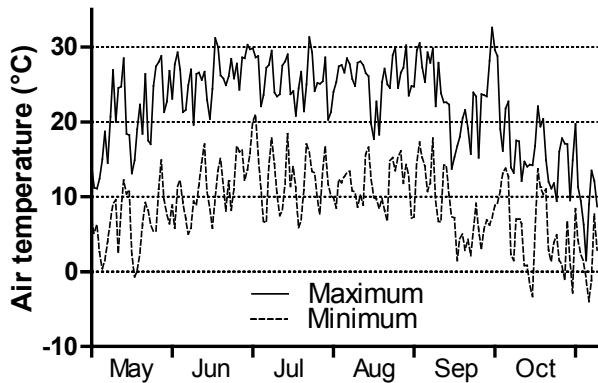


Figure 2. Daily air temperatures at GTI, summer 2014.

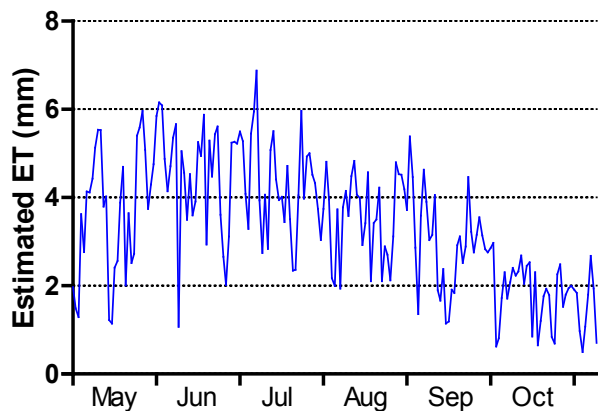


Figure 3. Daily estimated ET at GTI, summer 2014.

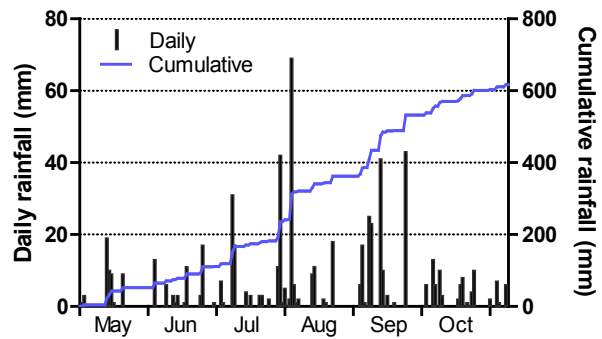


Figure 4. Daily and cumulative rainfall at GTI, summer 2014.

*Visual ratings*

Color differences between treated and control plots appeared by 2 DAT (Table 2), but the differences between fertilizer treatments were very small. There were few visible differences among treated plots for quality or uniformity. The NDVI values are a reasonable proxy for visual color, with observed range of differences in NDVI (0.077 units) corresponding to less than 2 ranks of visual color differences.

*Canopy reflectance*

The canopy reflectance (normalized-difference vegetation index) data collected with the Greenseeker gave a very precise picture of the response to the fertilizer treatments. Index values were calculated both as the raw NDVI values and as values corrected by subtracting the value of the untreated control to remove background variation, since the NDVI value is affected by mowing, moisture status, and other factors in addition to nitrogen status. Figure 5 shows the pattern of change of the raw NDVI values (averaged across all plots) and the  $\Delta$ NDVI

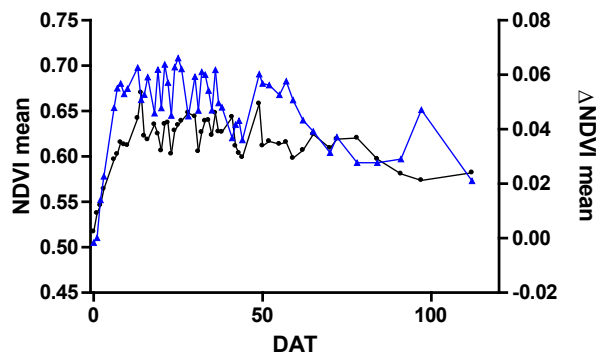


Figure 5. Changes in overall mean NDVI (black •) and DNDVI (corrected to remove control value; blue ▲) during the experiment.



Table 2. Visual ratings of treated plots.

Treatment	Colour				Quality				Uniformity	
	2 DAT	20 DAT	34 DAT	37 DAT	2 DAT	20 DAT	34 DAT	37 DAT	34 DAT	37 DAT
Control	6.3 b	6.0 b	6.0 b	6.3 b	8.0	6.5 b	6.8	6.8	7.3	7.3
UFLEXX	7.0 a	8.5 a	7.5 a	7.8 a	8.0	7.3 ab	7.0	7.5	6.8	7.3
UMAXX	7.0 a	7.8 a	7.5 a	8.0 a	8.0	7.5 a	7.8	7.8	7.5	7.8
Urea	6.8 ab	7.8 a	7.3 a	7.5 a	8.0	7.0 ab	7.3	7.5	7.0	7.5
XCU	7.0 a	7.8 a	7.3 a	7.8 a	8.0	7.0 ab	7.0	8.0	6.8	7.3
XCU/Urea	7.0 a	7.5 a	7.8 a	8.0 a	8.0	7.0 ab	7.3	7.5	7.0	7.0
msd p=0.05	0.6	1.3	1.0	1.1	NS	0.8	NS	NS	NS	NS

<sup>1</sup> Visual ratings 0-10, 10 = best, 6 = acceptable. Means of 4 replicates; means within columns followed by the same letter are not significantly different (Tukey's HSD test, p=0.05).

values (averaged across all non-control plots) during the experiment. Compared to other trials in earlier years, there was less difference between the corrected and uncorrected pattern, probably because of the more uniform and moderate weather during 2014.

There were significant differences in canopy reflectance between the treatments and control beginning 7 DAT and lasting until the last measurement date (Table 3). Generally the UFLEXX and UMAXX had significantly higher

Table 3. Change in canopy reflectance ( $\Delta$ NDVI, relative to untreated control) in treated plots.

Treatment	0 DAT	1	2	3	6	7	8	9	10	13
Control	0.000 <sup>1</sup>	0.001	-0.001	-0.002	0.001	-0.002 b	-0.002 b	0.002	-0.003 b	0.000 b
UFLEXX	0.006	0.006	0.020	0.037	0.064	0.069 a	0.068 a	0.063	0.065 a	0.073 a
UMAXX	0.000	0.003	0.025	0.032	0.061	0.068 a	0.068 a	0.064	0.068 a	0.074 a
Urea	0.002	0.005	0.021	0.030	0.061	0.067 a	0.066 a	0.063	0.067 a	0.071 a
XCU	-0.011	-0.010	0.002	0.008	0.030	0.038 ab	0.042 ab	0.042	0.039 ab	0.053 ab
XCU/Urea	-0.003	-0.004	0.008	0.008	0.027	0.034 ab	0.038 ab	0.033	0.034 ab	0.042 ab
msd p=0.05	NS	NS	NS	NS	NS	0.067	0.057	NS	0.059	0.067
	14	15	16	18	19	20	21	22	23	24
Control	-0.002 b	-0.001	-0.001 b	-0.001 b	0.000 b	0.000	-0.001 b	-0.001 b	0.000 b	0.001 b
UFLEXX	0.063 ab	0.060	0.071 a	0.050 a	0.071 a	0.051	0.076 a	0.073 a	0.054 a	0.075 a
UMAXX	0.065 a	0.065	0.069 a	0.054 a	0.071 a	0.061	0.072 a	0.063 a	0.058 a	0.076 a
Urea	0.062 ab	0.065	0.068 a	0.053 a	0.072 a	0.056	0.072 a	0.065 a	0.048 a	0.072 a
XCU	0.042 ab	0.033	0.052 ab	0.042 ab	0.056 ab	0.036	0.057 a	0.046 ab	0.033 ab	0.049 ab
XCU/Urea	0.022 ab	0.041	0.035 ab	0.030 ab	0.036 ab	0.033	0.042 ab	0.039 ab	0.027 ab	0.040 ab
msd p=0.05	0.066	NS	0.054	0.044	0.062	NS	0.055	0.057	0.047	0.049
	25	26	28	30	31	32	33	34	35	36
Control	0.001 b	-0.001 b	-0.001 b	-0.001 b	0.000 b	0.000 b	0.000 b	0.001 b	-0.001 b	0.002 b
UFLEXX	0.075 a	0.070 a	0.054 a	0.070 a	0.056 a	0.068 a	0.069 a	0.059 ab	0.061 a	0.074 a
UMAXX	0.077 a	0.074 a	0.056 a	0.067 a	0.054 a	0.072 a	0.070 a	0.068 a	0.052 a	0.067 a
Urea	0.077 a	0.072 a	0.047 a	0.071 a	0.050 a	0.068 a	0.067 a	0.067 a	0.051 a	0.068 a
XCU	0.059 ab	0.061 ab	0.041 a	0.043 ab	0.040 a	0.054 ab	0.054 ab	0.047 ab	0.039 ab	0.053 ab
XCU/Urea	0.040 ab	0.034 ab	0.024 ab	0.046 ab	0.034 ab	0.041 ab	0.037 ab	0.027 ab	0.033 ab	0.047 ab
msd p=0.05	0.063	0.068	0.039	0.063	0.039	0.060	0.064	0.060	0.046	0.064
	37	38	41	42	43	44	49	50	52	55
Control	0.000 b	-0.002	0.000	0.000 b	-0.001 b	0.002	0.000 b	0.002 b	-0.003 b	0.001
UFLEXX	0.061 a	0.062	0.050	0.056 a	0.049 a	0.045	0.067 a	0.067 a	0.060 a	0.060
UMAXX	0.058 a	0.052	0.038	0.052 a	0.057 a	0.039	0.070 a	0.065 a	0.068 a	0.063
Urea	0.051 a	0.052	0.044	0.044 a	0.044 a	0.028	0.074 a	0.067 a	0.066 a	0.058
XCU	0.042 ab	0.042	0.028	0.034 ab	0.031 ab	0.035	0.053 ab	0.047 ab	0.050 ab	0.049
XCU/Urea	0.037 ab	0.035	0.026	0.024 ab	0.033 ab	0.033	0.037 ab	0.038 ab	0.039 ab	0.033
msd p=0.05	0.048	NS	NS	0.036	0.042	NS	0.060	0.054	0.062	NS
	57	59	62	65	70	72	78	84	91	97
Control	0.000 b	0.000	0.000 b	0.000 b	0.000	-0.001 b	0.000	-0.001 b	0.000 b	-0.001 b
UFLEXX	0.064 a	0.059	0.041 ab	0.047 a	0.034	0.039 ab	0.031	0.035 a	0.035 a	0.052 a
UMAXX	0.065 a	0.054	0.055 a	0.048 a	0.039	0.044 a	0.036	0.033 a	0.035 a	0.052 a
Urea	0.068 a	0.061	0.054 a	0.044 a	0.035	0.044 a	0.029	0.029 a	0.028 ab	0.042 a
XCU	0.052 ab	0.044	0.037 ab	0.036 ab	0.026	0.028 ab	0.022	0.019 ab	0.023 ab	0.042 a
XCU/Urea	0.036 ab	0.035	0.030 ab	0.022 ab	0.023	0.030 ab	0.018	0.023 ab	0.023 ab	0.046 a
msd p=0.05	0.063	NS	0.049	0.043	NS	0.045	NS	0.026	0.035	0.023

<sup>1</sup> Change in normalized-difference vegetation index (compared to untreated control set to 0): mean of 4 replicates; means within columns followed by the same letter are not significantly different (Tukey's HSD test, p=0.05).

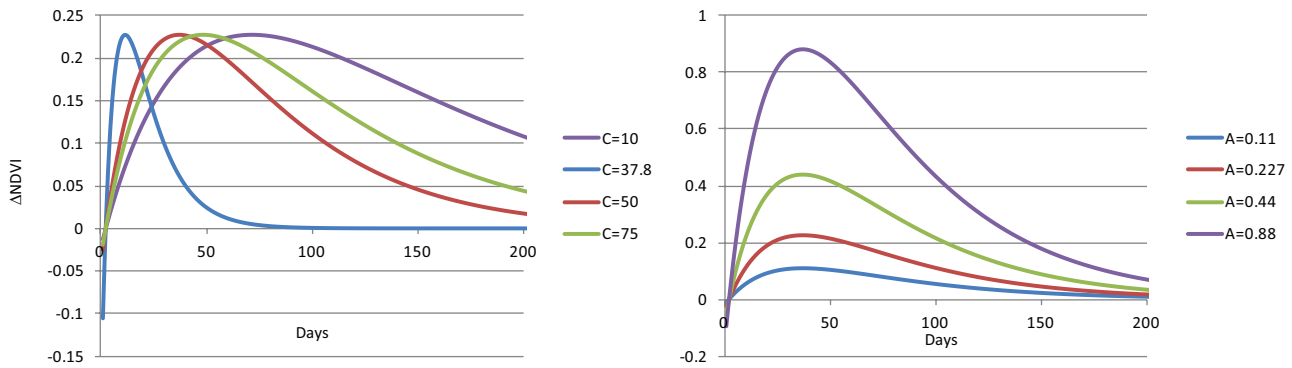


Figure 6. Families of curves of the function  $\Delta NDVI = 4 * A * e^{(-0.7 * DAT / C)} * (1 - e^{(-0.7 * DAT / C)})$  illustrating the effects of varying the parameters A and C.

NDVI values, while the two treatments with XCU did not. The urea treatment was sometimes significantly better than the control, and other times not.

The  $\Delta NDVI$  values, when plotted over time, allowed some differentiation among the fertilizer treatments in terms of release characteristics as detected by canopy reflectance. Replicate mean values of  $\Delta NDVI$  were tested against various curves to determine which functions had potential to adequately describe the responses. The online curve fitting and surface fitting web site at [www.zunzun.com](http://www.zunzun.com) was used to investigate families of curves. One of the best functions to fit the data was a compound exponential (pulse peak) function

$$\Delta NDVI = 4 * A * e^{(-0.7 * DAT / C)} * (1 - e^{(-0.7 * DAT / C)}),$$

in which there are two fitted parameters: A, which varies with maximum  $\Delta NDVI$ , and C, which varies with days to maximum  $\Delta NDVI$  (Figure 6 and 7). The suitability was judged based on the combination of goodness of fit, minimum number of parameters, and interpretability of the parameters.

The  $\Delta NDVI$  values for each treatment were fitted to these curves using GraphPad Prism, and the estimates of A and C for each treatment were compared using ANOVAs. The parameter estimates of the fitted curves are shown in Table 4 and Figure 8, and the fitted curves are shown in Figure 9.

#### Shoot growth

Clippings were collected periodically to estimate shoot dry matter accumulation. Plots were mowed to 7.5 mm and then 3-5 days later clippings were collected from a 0.5 m<sup>2</sup> strip. There were some trends

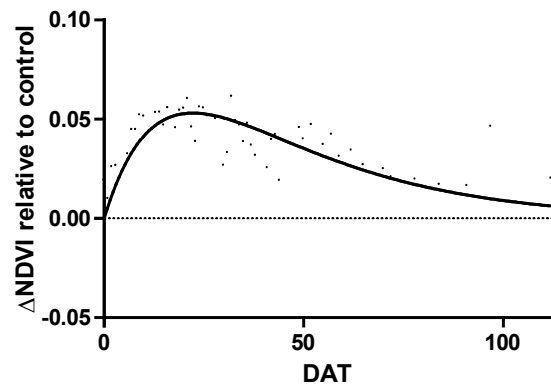


Figure 7. Typical curve fitted to data from one replicate of the XCU treatment; A = 0.053, C = 22.5 days, R<sup>2</sup> = 0.34.

to increased growth in the treated plots compared to the control, but the differences were not statistically significant (Table 5).

#### Leaf tissue analysis

Clippings were analysed for total nitrogen content prior to the treatment application, and then at 1, 6, and 11 weeks after treatment application (Table 6). By seven days after treatment all significantly higher N content than the control plots, with no significant differences among the treatments except for the XCU plots, which were lower. By six weeks after application differences among the treatments had disappeared, though the XCU treatment continued to be slightly lower than the other treatments.

## DISCUSSION AND CONCLUSIONS

All treatments gave a significant improvement in colour and growth compared to the untreated

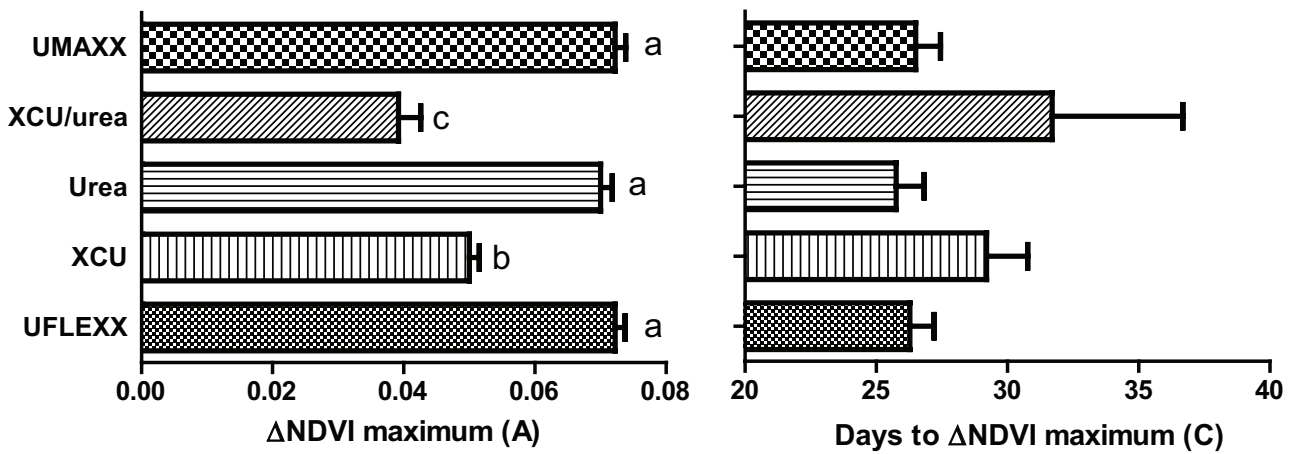


Figure 8. Parameters A and C for curves fitted to fertilizer response as estimated by  $\Delta$ NDVI. Parameter estimates are significantly different where a different letter is present on the bars (Tukey's multiple comparison test,  $p=0.05$ ).

control. Fertilizer effects were observable by 7 days after treatment in the canopy reflectance data, and persisted in significant amounts until data collection ceased for the season. The average gain of fertilized treatments over control was about 1.5 ranks on the visual colour rating scale (6.5 to 8), or about 0.08 units on the canopy reflectance index. The untreated control plots were at an acceptable colour and quality level ( $>5$ ) through most of the trial. Among the fertilizer treatments the UFLEXX and UMAXX treatments had the strongest and fastest response, with the two XCU treatments the weakest and the urea treatment intermediate. Nitrogen content levels as determined by analysis of leaf tissue showed patterns of variation that agreed well with other observations.

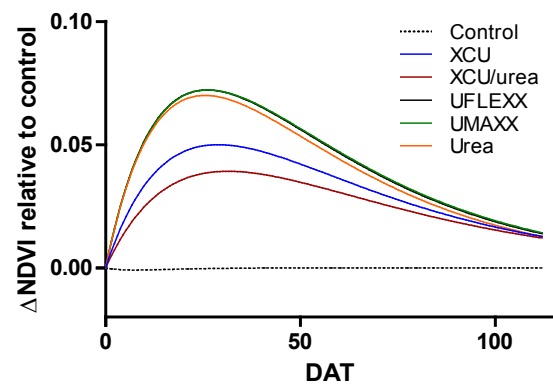


Figure 9. Curves fitted to fertilizer response as estimated by  $\Delta$ NDVI. See Table 4 for estimates of A (max  $\Delta$ NDVI) and C (days to max  $\Delta$ NDVI). Curves were fitted to data from all four replicates. The curves for UFLEXX and UMAXX essentially overlap.

Table 5. Dry matter accumulation.

Treatment	pretreatment	7 DAT	42 DAT	79 DAT
Control	3.8	2.7	3.4	4.8
UFLEXX	3.6	4.3	4.1	5.9
UMAXX	2.8	3.9	4.0	6.1
Urea	3.6	3.9	4.4	5.9
XCU	4.1	3.3	3.3	6.3
XCU/Urea	3.0	3.3	3.5	4.9
msd $p=0.05$	NS	NS	NS	NS

<sup>1</sup> Clippings collected from 0.53 x 0.94 m strip of each plot, mowed at 7.5 mm after 3-5 days of growth.