

Performance of slow release fertilizers containing experimental compost material on Kentucky bluegrass turf

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The objective of this research project is to determine the performance of the sponsor's experimental compost/fertilizer products on Kentucky bluegrass turf on a soil rootzone.

Data collected included the duration and strength of the color response following application(s) of the tested products, turf quality, uniformity, and density, and resistance of the turf to disease and other stresses was noted. Shoot growth rate was also measured.

MATERIALS / METHODS

The treatments consisted of the sponsor's products compared to industry standards at one application rate (Table 1). An unfertilized check treatment was also included. Treatments were applied to 1 x 2 m plots of Kentucky bluegrass turf maintained as a low-cut turf on the research ranges at the Guelph Turfgrass Institute (mowing at 40 mm, irrigation to prevent stress) (Figure 1). Treatments were replicated four times in a randomized complete block design. Treatments will be applied June 15, 2011.

Color response of the turf to treatments were assessed regularly, both visually and using instrumental color (canopy reflectance: normalized difference vegetation index measured with the GreenSeeker meter). Uniformity of the color response was assessed visually. Plots were rated for turf quality, density

and uniformity. Clippings were collected regularly, dried and weighed to determine shoot dry matter accumulation per unit area. Other stresses were measured as they occur (disease, weed, drought).

An anecdotal photographic record of the experiment was kept.

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

RESULTS

Canopy reflectance – Normalized-difference vegetation index. The canopy reflectance (normalized-difference vegetation index) data collected with the GreenSeeker gave a very precise picture of the response to the treatments. Index values were calculated both as the raw NDVI values (Table 2) 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 (Table 3). Figure 2 shows the pattern of change of the raw NDVI values (averaged across all plots) and the Δ NDVI values (averaged across all non-control plots) during the experiment.

There were significant differences in canopy reflectance readings among the treatments on all

Table 1. Treatments and rates at application (June 15, 2011)

1	Pelletized product 1 – Homogenous Product (20-1-5)	500g N per 100m ²
2	Pelletized product 2 – Blended Product (20-1-5)	500g N per 100m ²
3	Pelletized Natural Compost (3-1-5)	500g N per 100m ²
4	Urea (46-0-0)	500g N per 100m ²
5	Polygon Blend (30-2-6)	500g N per 100m ²
6	Scotts Turf Builder (32-0-4) (NPK control)	500g N per 100m ²
7	Untreated check	—



Figure 1. Plot area two weeks after treatment application (July 2, 2011).

observation dates between 7 and 65 days after treatment application (Table 2.) The Greenseeker is very sensitive to NDVI variation, which reflects turf health (chlorophyll content, photosynthetic activity, growth rate), as well as stresses (phytotoxicity from treatments, drought stress, etc.). There was a strong response to the first application of most treatments with the exception of the natural compost material, with significant differences developing by one week. The maximum difference in NDVI of about 0.2 units corresponds to a visual colour difference of about 4 rating points (from 5 to 9). In general the canopy reflectance values were below typical healthy lawn type turf about .1 index units.

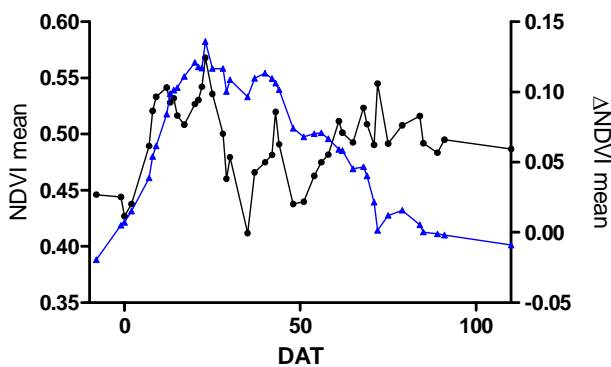


Figure 2. Changes in overall mean NDVI (black) and NDVI corrected to remove control value (blue) during the experiment.

The Δ 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 Δ 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 was used to investigate families of curves. One of the best functions to fit the data was a compound exponential function Δ NDVI = $4 \cdot A \cdot e^{(-DAT/C)} \cdot (1 - e^{(-DAT/C)})$, in which there are two fitted parameters: A, which varies with maximum Δ NDVI, and C, which varies with days to maximum Δ NDVI (Figure 3). The suitability was judged based on the combination of goodness of fit, minimum number of parameters, and interpretability of the parameters

The release curves as estimated from Δ NDVI values indicate that urea and the blended product had the fastest and strongest color response, and both maintained their colour longest. The homogeneous product, the Scotts positive control, and the Polyon blend all had intermediate performance, with a slower and weaker response and faster loss of colour. The natural compost had a very slow and small response, but the longest release period.

Table 2. Canopy reflectance (NDVI) in treated plots

Treatment	DAT							
	-8	-1	0	2	7	8	9	12
Pelletized Natural Compost (3-1-5)	0.447 ¹	0.430	0.420	0.435	0.476 ab	0.501 ab	0.502 bc	0.497 cd
Pelletized 1 – Homogenous (20-1-5)	0.452	0.457	0.445	0.456	0.511 a	0.546 a	0.553 a	0.562 ab
Pelletized 2 – Blended (20-1-5)	0.434	0.459	0.445	0.458	0.515 a	0.552 a	0.571 a	0.599 a
Polyon Blend (30-2-6)	0.425	0.437	0.419	0.434	0.493 ab	0.524 a	0.536 ab	0.553 ab
Scotts Turf Builder (32-0-4) (NPK control)	0.437	0.439	0.415	0.426	0.475 ab	0.508 ab	0.528 ab	0.542 bc
Untreated check	0.467	0.438	0.419	0.422	0.448 b	0.464 b	0.471 c	0.457 d
Urea (46-0-0)	0.461	0.448	0.426	0.434	0.508 a	0.550 a	0.572 a	0.581 ab
msd p=0.05	NS	NS	NS	NS	0.056	0.053	0.049	0.053
	13	14	15	17	20	21	22	23
Pelletized Natural Compost (3-1-5)	0.467 c	0.467 c	0.445 b	0.437 b	0.451 b	0.458 b	0.464 b	0.474 c
Pelletized 1 – Homogenous (20-1-5)	0.549 ab	0.549 ab	0.529 a	0.521 a	0.540 a	0.538 a	0.549 a	0.581 b
Pelletized 2 – Blended (20-1-5)	0.590 a	0.599 a	0.583 a	0.578 a	0.606 a	0.603 a	0.614 a	0.651 a
Polyon Blend (30-2-6)	0.545 ab	0.555 ab	0.540 a	0.531 a	0.557 a	0.562 a	0.568 a	0.602 ab
Scotts Turf Builder (32-0-4) (NPK control)	0.540 b	0.545 b	0.533 a	0.528 a	0.553 a	0.560 a	0.574 a	0.596 ab
Untreated check	0.429 c	0.429 c	0.412 b	0.397 b	0.406 b	0.411 b	0.425 b	0.431 c
Urea (46-0-0)	0.579 ab	0.580 ab	0.574 a	0.568 a	0.576 a	0.579 a	0.601 a	0.642 ab
msd p=0.05	0.049	0.050	0.056	0.058	0.072	0.069	0.066	0.067
	25	28	29	30	35	37	40	42
Pelletized Natural Compost (3-1-5)	0.463 c	0.430 b	0.406 cd	0.418 c	0.377 bc	0.420 bc	0.427 bc	0.453 b
Pelletized 1 – Homogenous (20-1-5)	0.541 b	0.508 a	0.462 bc	0.482 b	0.394 abc	0.458 ab	0.467 ab	0.479 ab
Pelletized 2 – Blended (20-1-5)	0.607 a	0.571 a	0.525 ab	0.550 a	0.477 ab	0.534 a	0.550 a	0.541 a
Polyon Blend (30-2-6)	0.558 ab	0.522 a	0.467 abc	0.491 ab	0.406 abc	0.470 ab	0.492 ab	0.491 ab
Scotts Turf Builder (32-0-4) (NPK control)	0.570 ab	0.525 a	0.476 ab	0.510 ab	0.423 ab	0.498 ab	0.501 ab	0.503 ab
Untreated check	0.418 c	0.383 b	0.360 d	0.370 c	0.316 c	0.357 c	0.361 c	0.372 c
Urea (46-0-0)	0.591 ab	0.563 a	0.527 a	0.535 ab	0.489 a	0.525 a	0.527 a	0.531 a
msd p=0.05	0.065	0.065	0.065	0.063	0.108	0.087	0.088	0.069
	43	44	48	51	54	56	58	61
Pelletized Natural Compost (3-1-5)	0.489 b	0.447 bc	0.419 abc	0.428 abc	0.453 abc	0.463 abc	0.469 abc	0.502 abc
Pelletized 1 – Homogenous (20-1-5)	0.520 ab	0.485 ab	0.408 bc	0.409 bc	0.422 bc	0.433 bc	0.443 bc	0.474 bc
Pelletized 2 – Blended (20-1-5)	0.574 a	0.551 a	0.477 ab	0.480 a	0.498 ab	0.510 ab	0.520 ab	0.546 ab
Polyon Blend (30-2-6)	0.529 ab	0.507 ab	0.462 ab	0.458 ab	0.482 ab	0.496 ab	0.499 ab	0.521 abc
Scotts Turf Builder (32-0-4) (NPK control)	0.541 ab	0.514 ab	0.444 ab	0.446 ab	0.472 abc	0.487 ab	0.493 abc	0.521 abc
Untreated check	0.415 c	0.389 c	0.364 c	0.372 c	0.393 c	0.405 c	0.414 c	0.451 c
Urea (46-0-0)	0.572 a	0.544 a	0.490 a	0.485 a	0.520 a	0.532 a	0.534 a	0.566 a
msd p=0.05	0.071	0.075	0.078	0.070	0.080	0.081	0.080	0.080
	62	65	68	69	71	72	75	79
Pelletized Natural Compost (3-1-5)	0.499 ab	0.493 ab	0.524	0.510	0.499	0.576	0.500	0.513
Pelletized 1 – Homogenous (20-1-5)	0.455 b	0.422 b	0.461	0.439	0.424	0.458	0.404	0.428
Pelletized 2 – Blended (20-1-5)	0.533 ab	0.520 ab	0.541	0.523	0.493	0.558	0.491	0.503
Polyon Blend (30-2-6)	0.511 ab	0.504 ab	0.533	0.518	0.491	0.522	0.493	0.514
Scotts Turf Builder (32-0-4) (NPK control)	0.504 ab	0.496 ab	0.530	0.517	0.492	0.530	0.499	0.518
Untreated check	0.442 b	0.448 ab	0.476	0.469	0.468	0.540	0.481	0.493
Urea (46-0-0)	0.565 a	0.565 a	0.598	0.586	0.565	0.632	0.574	0.586
msd p=0.05	0.100	0.131	NS	NS	NS	NS	NS	NS
	84	85	89	91	110			
Pelletized Natural Compost (3-1-5)	0.519	0.498	0.492	0.502	0.454			
Pelletized 1 – Homogenous (20-1-5)	0.423	0.410	0.403	0.414	0.428			
Pelletized 2 – Blended (20-1-5)	0.504	0.478	0.468	0.478	0.465			
Polyon Blend (30-2-6)	0.519	0.493	0.480	0.490	0.494			
Scotts Turf Builder (32-0-4) (NPK control)	0.532	0.508	0.502	0.523	0.543			
Untreated check	0.511	0.489	0.484	0.497	0.495			
Urea (46-0-0)	0.605	0.567	0.554	0.562	0.528			
msd p=0.05	NS	NS	NS	NS	NS			

¹Normalized-difference vegetation index: mean of 4 replicates. Means within columns followed by the same letter are not significantly different (Tukey's HSD test, p=0.05).

Table 3. Change in canopy reflectance (NDVI) relative to control

Treatment	DAT							
	-8	-1	0	2	7	8	9	12
Pelletized Natural Compost (3-1-5)	-0.019 ¹	-0.008	0.000	0.012	0.026 ab	0.035 ab	0.030 bc	0.040 cd
Pelletized 1 – Homogenous (20-1-5)	-0.014	0.018	0.025	0.034	0.061 a	0.080 a	0.081 a	0.105 ab
Pelletized 2 – Blended (20-1-5)	-0.032	0.020	0.025	0.036	0.065 a	0.086 a	0.100 a	0.141 a
Polyon Blend (30-2-6)	-0.040	-0.002	-0.001	0.011	0.042 ab	0.057 a	0.064 ab	0.096 ab
Scotts Turf Builder (32-0-4) (NPK control)	-0.028	0.000	-0.004	0.003	0.024 ab	0.041 ab	0.056 ab	0.085 bc
Untreated check	0.001	-0.001	-0.001	0.000	-0.003 b	-0.003 b	-0.001 c	-0.001 d
Urea (46-0-0)	-0.004	0.009	0.006	0.011	0.057 a	0.084 a	0.100 a	0.124 ab
msd p=0.05	NS	NS	NS	NS	0.056	0.053	0.049	0.053
	13	14	15	17	20	21	22	23
Pelletized Natural Compost (3-1-5)	0.037 c	0.036 c	0.032 b	0.039 b	0.045 b	0.046 b	0.039 b	0.042 c
Pelletized 1 – Homogenous (20-1-5)	0.119 ab	0.118 ab	0.116 a	0.124 a	0.134 a	0.126 a	0.124 a	0.149 b
Pelletized 2 – Blended (20-1-5)	0.161 a	0.168 a	0.169 a	0.180 a	0.200 a	0.191 a	0.189 a	0.219 a
Polyon Blend (30-2-6)	0.115 ab	0.125 ab	0.127 a	0.133 a	0.152 a	0.149 a	0.143 a	0.170 ab
Scotts Turf Builder (32-0-4) (NPK control)	0.111 b	0.114 b	0.120 a	0.131 a	0.147 a	0.148 a	0.149 a	0.164 ab
Untreated check	-0.001 c	-0.002 c	-0.002 b	-0.001 b	0.000 b	-0.001 b	0.000 b	-0.001 c
Urea (46-0-0)	0.149 ab	0.150 ab	0.160 a	0.171 a	0.170 a	0.166 a	0.175 a	0.210 ab
msd p=0.05	0.049	0.050	0.056	0.058	0.072	0.069	0.066	0.067
	25	28	29	30	35	37	40	42
Pelletized Natural Compost (3-1-5)	0.044 c	0.046 b	0.046 cd	0.048 c	0.062 bc	0.063 bc	0.065 bc	0.081 c
Pelletized 1 – Homogenous (20-1-5)	0.122 b	0.124 a	0.102 bc	0.112 b	0.078 abc	0.102 ab	0.105 ab	0.107 bc
Pelletized 2 – Blended (20-1-5)	0.188 a	0.187 a	0.165 ab	0.179 a	0.162 ab	0.178 a	0.189 a	0.169 a
Polyon Blend (30-2-6)	0.139 ab	0.139 a	0.107 abc	0.120 ab	0.091 abc	0.114 ab	0.130 ab	0.119 abc
Scotts Turf Builder (32-0-4) (NPK control)	0.151 ab	0.142 a	0.116 ab	0.140 ab	0.108 ab	0.142 ab	0.140 ab	0.131 abc
Untreated check	-0.001 c	0.000 b	0.000 d	-0.001 c	0.000 c	0.001 c	-0.001 c	0.000 d
Urea (46-0-0)	0.173 ab	0.179 a	0.167 a	0.165 ab	0.174 a	0.169 a	0.166 a	0.159 abc
msd p=0.05	0.065	0.065	0.065	0.063	0.108	0.087	0.088	0.061
	43	44	48	51	54	56	58	61
Pelletized Natural Compost (3-1-5)	0.075 b	0.057 bc	0.056 abc	0.056 abc	0.060 abc	0.059 abc	0.054 abc	0.050 abc
Pelletized 1 – Homogenous (20-1-5)	0.106 ab	0.096 ab	0.044 bc	0.037 bc	0.030 bc	0.029 bc	0.028 bc	0.021 bc
Pelletized 2 – Blended (20-1-5)	0.161 a	0.162 a	0.114 ab	0.109 a	0.105 ab	0.106 ab	0.105 ab	0.094 ab
Polyon Blend (30-2-6)	0.115 ab	0.118 ab	0.098 ab	0.087 ab	0.089 ab	0.092 ab	0.084 ab	0.069 abc
Scotts Turf Builder (32-0-4) (NPK control)	0.128 ab	0.125 ab	0.081 ab	0.074 ab	0.080 abc	0.083 ab	0.079 abc	0.068 abc
Untreated check	0.001 c	0.000 c	0.001 c	0.000 c	0.000 c	0.001 c	-0.001 c	-0.001 c
Urea (46-0-0)	0.159 a	0.154 a	0.127 a	0.113 a	0.127 a	0.128 a	0.119 a	0.113 a
msd p=0.05	0.071	0.075	0.078	0.070	0.080	0.081	0.080	0.080
	62	65	68	69	71	72	75	79
Pelletized Natural Compost (3-1-5)	0.056 ab	0.046 ab	0.048	0.041	0.030	0.032	0.020	0.021
Pelletized 1 – Homogenous (20-1-5)	0.012 b	-0.025 b	-0.015	-0.03	-0.045	-0.085	-0.076	-0.064
Pelletized 2 – Blended (20-1-5)	0.090 ab	0.073 ab	0.065	0.055	0.025	0.014	0.011	0.011
Polyon Blend (30-2-6)	0.068 ab	0.056 ab	0.056	0.049	0.022	-0.021	0.014	0.022
Scotts Turf Builder (32-0-4) (NPK control)	0.061 ab	0.048 ab	0.054	0.049	0.023	-0.014	0.019	0.026
Untreated check	-0.001 b	0.001 ab	-0.001	0.000	0.000	-0.004	0.002	0.001
Urea (46-0-0)	0.122 a	0.118 a	0.121	0.117	0.097	0.088	0.094	0.094
msd p=0.05	0.100	0.131	NS	NS	NS	NS	NS	NS
	84	85	89	91	110			
Pelletized Natural Compost (3-1-5)	0.009	0.006	0.008	0.005	-0.042			
Pelletized 1 – Homogenous (20-1-5)	-0.088	-0.081	-0.081	-0.083	-0.068			
Pelletized 2 – Blended (20-1-5)	-0.006	-0.014	-0.016	-0.019	-0.031			
Polyon Blend (30-2-6)	0.008	0.002	-0.004	-0.007	-0.002			
Scotts Turf Builder (32-0-4) (NPK control)	0.021	0.016	0.018	0.026	0.047			
Untreated check	0.000	-0.003	-0.001	0.000	-0.001			
Urea (46-0-0)	0.094	0.075	0.069	0.065	0.033			
msd p=0.05	NS	NS	NS	NS	NS			

¹Normalized-difference vegetation index corrected against control mean: mean of 4 replicates; means within columns followed by the same letter are not significantly different (Tukey's HSD test, p=0.05).



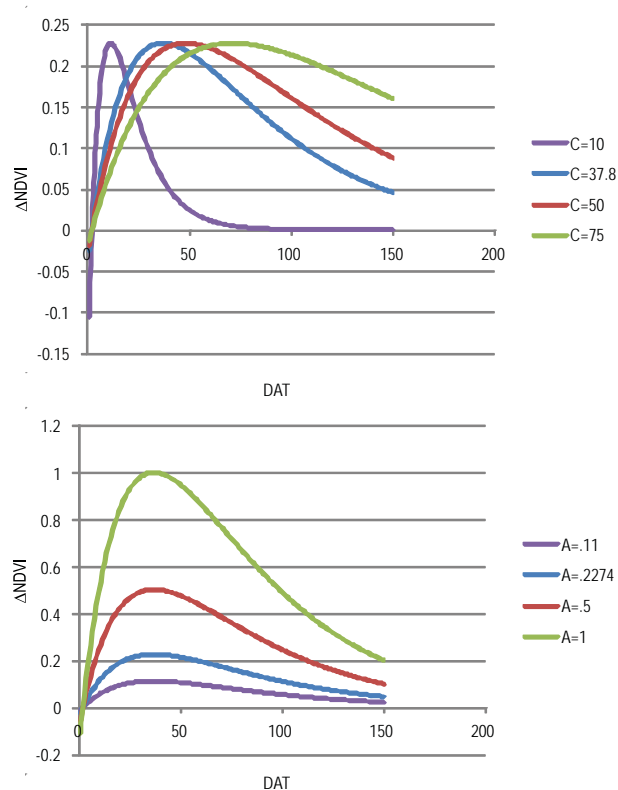


Figure 3. Families of curves of the function $\Delta NDVI = 4 * A * e^{(-DAT/C)} * (1 - e^{(-DAT/C)})$ illustrating the effects of varying the parameters A and C.

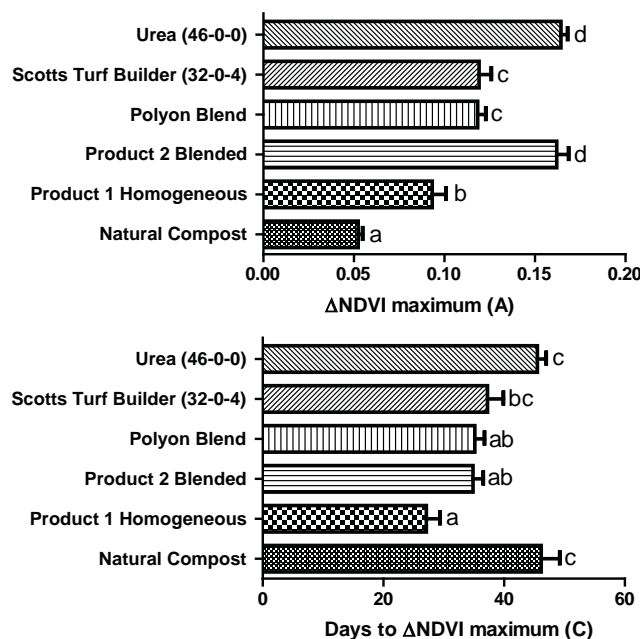


Figure 4. Parameters A and C for curves fitted to fertilizer response as estimated by “NDVI. Parameter estimates are all significantly different except where a common letter is present on the bars (Tukey’s multiple comparison test, p=0.05).

Table 4. Multiple comparisons of estimated parameters for fitted curves of ΔNDVI.

Treatment	A	C
Natural Compost	0.052 a	46.2 c
Polyon Blend	0.118 c	35.2 ab
Product 1 Homogeneous	0.093 b	27.1 a
Product 2 Blended	0.162 d	34.8 ab
Scotts Turf Builder (32-0-4)	0.119 c	37.3 bc
Urea (46-0-0)	0.164 d	45.5 c

¹Parameters followed by the same letter are not significantly different (Tukey’s Multiple Comparison Test, p=0.05)

The ΔNDVI 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 4, and the fitted curves are shown in Figure 5.

Visual ratings. In general visual ratings for the plots were quite low (barely acceptable for colour), and not statistically significant (Table 5). Dollar spot disease developed in the plots

about 8 weeks into the trial, which affected visual ratings and general canopy reflectance (Figure 6), but showed no pattern affected by treatments.

Dry matter accumulation. There were significant differences among the treatments for shoot growth, with the pattern of increased growth closely following the pattern of release indicated by the ΔNDVI values (Table 6). As the release of the fertilizer declined after about 10 weeks, the relationship between growth and ΔNDVI disappeared (Figure 7).

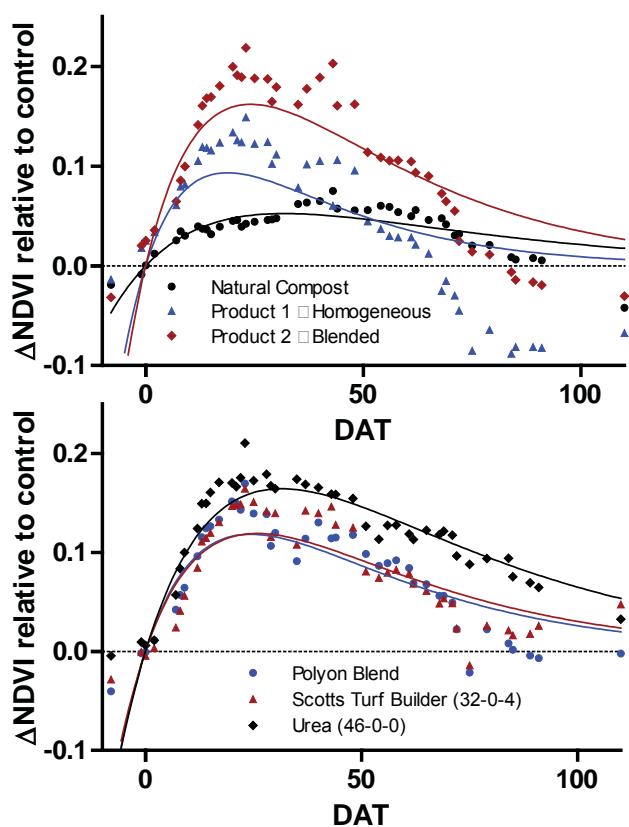


Figure 5. Release curves of fertilizer treatments as estimated by change in canopy reflectance relative to untreated control treatments. Points are means of 4 replicates and curves are fitted to the equation in Figure 3 (GraphPad).

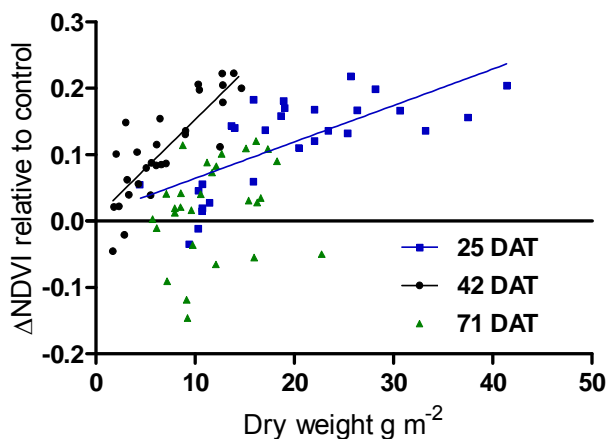


Figure 6. Relationship between dry matter accumulation and canopy reflectance.

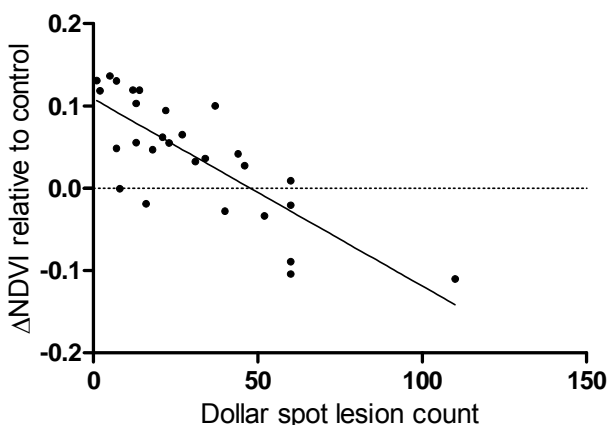


Figure 7. Relationship between dollar spot infection and canopy reflectance.

Table 5. Visual ratings of treated plots.

Treatment	6 DAT			70 DAT	
	Colour	Quality	Weed	Dollar spot rating	lesion count
Pelletized Natural Compost (3-1-5)	6.50 ¹	4.75	3.25	2.0	27.8
Pelletized product 1 – Homogenous Product (20-1-5)	6.25	5.75	1.75	3.5	48.8
Pelletized product 2 – Blended Product (20-1-5)	6.50	5.50	2.25	2.8	39.5
Poyon Blend (30-2-6)	6.50	5.75	2.75	2.5	28.3
Scotts Turf Builder (32-0-4) (NPK control)	6.25	5.00	2.25	2.3	35.5
Untreated check	5.75	5.25	3.25	1.1	17.8
Urea (46-0-0)	7.25	5.00	3.50	1.0	13.3

¹ Mean of 4 replicates. Visual ratings of colour and quality 0-10, 10=best, 6=acceptable. Dollar spot and weed rating 0-10, 10=100% of plot area affected.

Table 6. Shoot dry matter accumulation.

Treatment	26 DAT	42 DAT	71 DAT
		g m^{-2}	
Pelletized Natural Compost (3-1-5)	9.04 c ¹	2.82 c	8.55 b
Pelletized product 1 – Homogenous Product (20-1-5)	18.06 abc	5.18 bc	8.48 b
Pelletized product 2 – Blended Product (20-1-5)	26.62 a	13.19 a	16.75 a
Polyon Blend (30-2-6)	24.27 ab	7.08 bc	13.83 ab
Scotts Turf Builder (32-0-4) (NPK control)	19.18 abc	8.04 b	13.33 ab
Untreated check	10.45 bc	2.56 c	7.55 b
Urea (46-0-0)	29.14 a	9.99 ab	14.02 ab
msd p=0.05	14.13	5.04	6.94

¹ Mean of 4 replicates; means within columns followed by the same letter are not significantly different (Tukey's HSD test, p=0.05)

DISCUSSION AND CONCLUSIONS

All treatments gave a significant improvement in colour and growth compared to the untreated control. The fertilizer effects were observable by a week after treatment in the canopy reflectance data, and persisted in significant amounts until 10 weeks after treatment. The maximum gain of fertilized treatments over control was about 3 ranks on the visual colour rating scale (5 to 8), or about 0.16 units on the canopy reflectance index. The untreated control plots were below an acceptable colour and quality level (<) through most of the trial. There was a strong and consistent pattern in canopy reflectance distinguishing the fertilizer treatments from one another. Using the release curves fitted to the seasonal pattern of "NDVI shows that the ranking of the fertilizer treatments for strength of response (A) was Natural Compost < Product 1 Homogeneous < Polyon Blend,

Scotts Turf Builder (32-0-4) < Product 2 Blended, Urea (46-0-0). Similarly, the rank order of the treatments for days to maximum release (C) was Product 1 Homogeneous, Product 2 Blended, Polyon Blend, Scotts Turf Builder (32-0-4), Urea (46-0-0), Natural Compost. The differences in strength of response were more pronounced than the differences in speed/delay of response.

Differences in growth were most apparent when fertilizer response was near its maximum, about 4 weeks after treatment. At this point the treatments with the highest growth rate had about a 2.5 x increase over the untreated control. Later in the season when the overall growth rate declined, the differences between the untreated control and the best performing fertilizer treatment (Product 2 Blended) were more pronounced.

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