Tolerance of different grass species to repeated application of NEU1173H – 2011 trial.

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MATERIALS/METHODS

This is the second year of a trial begun in spring 2010. Plots were located in turf research area at the Guelph Turfgrass Institute, Guelph, ON. The sites were areas of established turf: several years old in the case of Kentucky bluegrass (Figure 1) and fine fescue (Figure 2); established in 2010 in the case of perennial ryegrass (Figure 3). Turf was maintained with typical high maintenance turf regime: 1.5 kg actual N 100 m^{-2} per year in 3 applications (spring, summer, dormant); P and K in a 4:1:4 ratio with N; irrigated to prevent stress prior to treatment application and to prevent dormancy thereafter; mowed at 3 inches.

The treatments were combinations of different rates and volumes of post-emergent herbicide, as well as controls for a total of 7 treatments (see Table 1). Each treatment was replicated four times in 1 x 2 m plots arranged in a randomized complete block design. Treatments were applied in according to the schedule in Table 1. Treatments were applied with a compressed air sprayer (100 ml m^{-2} spray

Figure 1. Kentucky bluegrass plot area August 24, 2011.

Figure 2. Fine fescue plot area August 24, 2011.

Figure 3. Perennial ryegrass plot area July 27, 2011.

volume; Teejet 8001VS flat fan nozzles - 5 ml/sec/nozzle at 20 psi). First treatments were applied June 15, 2011.

An anecdotal photographic record of the experiment was kept.

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

Data Collection: Plots were rated pre- and post-treatment for turf color and quality, using visual assessments and canopy reflectance (normalized-difference vegetation index). Weed presence was assessed pre- and post-treatment with visual ratings.

Phytotoxicity of treatments to plots (turfgrass and weeds) was assessed by visual ratings and NDVI.

RESULTS

Environmental data. Daily air and soil temperatures for June – October 2011 are presented in Figures 4 and 5.

Visual ratings of turf performance. There were few visual differences observed in any of the performance characterisitics (quality, density, uniformity) in the three species in 2011. Density differences which had been observed in 2010 in Kentucky bluegrass and perennial ryegrass had mostly disappeared (Table 2). In the case of perennial ryegrass, some of the Fiesta treated plots had denser turf than the untreated control. Generally there was little broadleaf weed encroachment, except in the untreated control and Par III plots.

There was an outbreak of disease in each of the three species (Table 3): rust occurred in late August in the perennial ryegrass plots, dollarspot in the Kentucky bluegrass plots (Figure 6), and a patch disease tentatively identified as summer patch in late July in the fine fescues (Figure 7). In all three cases there was an effect of the Fiesta treatments. In thc case of and dollarspot, the Fiesta treatments reduced the disease presence, while in the patch disease in fine fescue, the Fiesta treatments increased the disease symptoms.

Table 1. Treatments

Treatment		Rate	Nominal application schedule
1	Control	—	—
2	PAR III	(0.55 ml m^{-2})	Once (June 15)
3	4x3		4 times, 3 week interval
4	8x2	NEU1173H	8 times, 2 week interval
5	S2F2	(1 g a.i. m^{-2})	2 times spring, 2 times fall, 2 week interval
6	S3F3	400 ml m^{-2}	3 times spring, 3 times fall, 2 week interval
7	S4F4		4 times spring, 3 times fall, 2 week interval

Application	— 4x3 —			— 8x2 —			— S2F2 —			— S3F3 —			— S4F4 —		
date (actual)	KB	FF	PR	KB	FF	PR	KB	FF	PR	KB	FF	PR	KB	FF	PR
06/15	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★
06/28				★	★	★									
07/05	★	★	★				★	★	★	★	★	★	★	★	★
07/12				★	★	★									
08/03	★	★		★	★		★	★		★	★		★	★	
08/12			★	★	★	★			★			★			★
08/19	★	★	★							★	★	★	★	★	★
08/25				★	★	★									
09/09				★	★	★							★	★	★

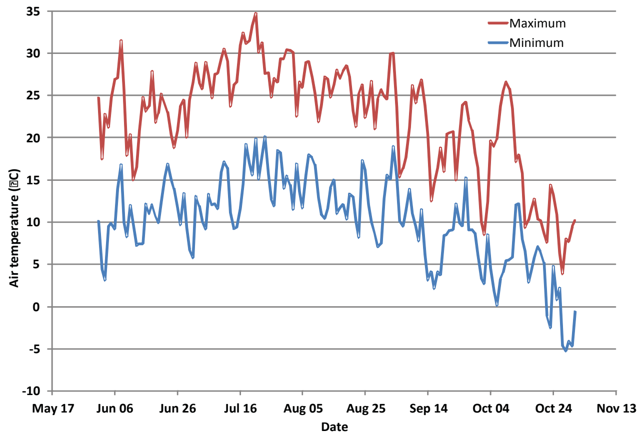

Figure 4. Daily air temperatures at GTI, summer 2011.

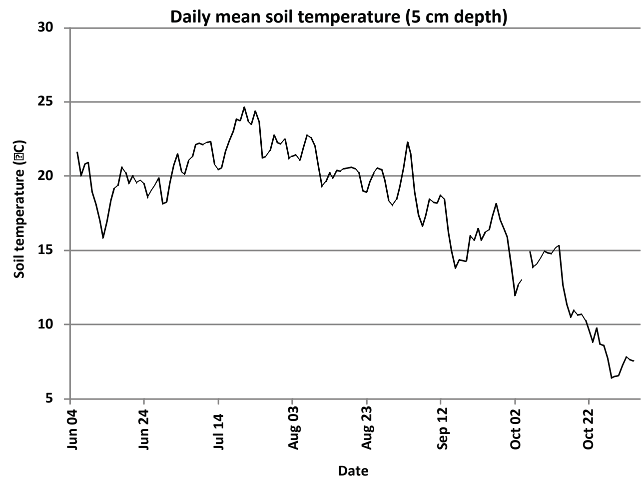

Figure 5. Daily soil temperatures at GTI, summer 2011.

Table 2. Visual ratings of turf performance characteristics.

Treatment	—— Kentucky bluegrass ——		—— Perennial ryegrass ——	
	weeds	density	weeds	density
	06/04	06/04	06/21	06/21
Par III	1.8 ab[1]	7.3	0.5 ab	8.3 ab
S2F2	0.3 b	7.0	0.0 b	8.3 ab
S3F3	1.5 ab	6.8	0.0 b	8.8 a
S4F4	0.0 b	7.8	0.0 b	7.5 b
4X3	0.0 b	7.5	0.0 b	7.5 b
8X2	0.0 b	7.5	0.0 b	7.5 b
Control	3.3 a	7.8	1.0 a	7.5 b
msd p=0.05	2.9	NS	0.5	0.9

[1] Visual ratings 0 - 10, 10 = best density, 10 = most weed presence. Means of 4 replicates. Means within columns followed by the same letter are not significantly different (Tukey's HSD test, p=0.05).

Table 3. Effects of treatments on spontaneous disease development in treated plots.

Treatment	— Fine fescue —	—— Kentucky bluegrass ——		Perennial ryegrass
	"Summer patch"	Dollarspot rating	Dollarspot centres	Rust
	08/24	08/24		08/30
Par III	0.0 b[1]	1.1[1]	13.3[2]	5.5 a[1]
S2F2	0.8 ab	0.0	0.0	2.8 b
S3F3	0.8 ab	0.0	0.0	1.3 b
S4F4	0.6 ab	0.0	0.0	1.3 b
4X3	2.0 a	0.0	0.5	2.0 b
8X2	1.6 ab	0.0	0.3	1.0 b
Control	0.0 b	0.6	12.3	5.5 a
msd p=0.05	1.9	NS	NS	2.2
Fiesta treatment				
No[3]	0.00 b	0.71 a	11.33 a	4.89 a
Yes	1.09 a	0.01 b	0.15 b	1.65 b
msd p=0.05	0.92	0.58	7.18	1.14

[1] Visual ratings 0 - 10, 10 = most disease presence.
[2] Count of dollarspot lesion centres per plot. Means of 4 replicates. Means within columns followed by the same letter are not significantly different (Tukey's HSD test, p=0.05).
[3] No Fiesta treatments were untreated control and Par III plots, Yes treatments were all other treatments.

Figure 6. Dollarspot infection on Kentucky bluegrass plots not treated with Fiesta – August 24, 2011 (block 1 of 4 pictured).

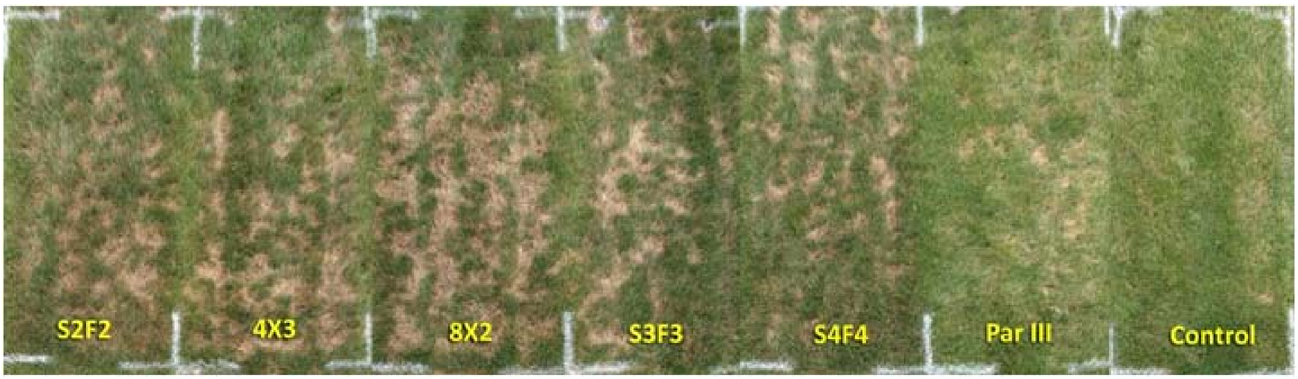

Figure 7. Patch disease (summer patch?) on fine leaved fescue – July 27, 2011 (block 1 of 4 pictured).

Crop tolerance – canopy reflectance. Canopy reflectance, which can be correlated with photosynthetic activity and plant health, was reduced by all treatments relative to the control in Kentucky bluegrass and fine fescue (Tables 4 and 5), but the same effect was not seen in the perennial ryegrass plots (Table 6). There was recovery toward control levels between treatment applications but this was reduced by more frequent application programs (Figures 8-10). The declines in canopy reflectance in treated plots, while statistically significant, were not associated with significant declines in visual turf quality associated with treatments, and by the end of the season the NDVI ratings were close to the levels in the untreated control plots.

DISCUSSION AND CONCLUSIONS

Kentucky bluegrass and fine fescue had reductions in canopy reflectance with applications of 400 ml m^{-2} of Fiesta, but with the exception of the higher frequencies (8x2 and S4F4) the decline diminished by the end of the trial. Perennial ryegrass did not show the same decline in canopy reflectance as the other species, which is quite different from the previous season. The perennial ryegrass plots treated in 2010 were young turf (6 wks after seeding); the same plots in 2011 were one year old turf. The declines were slight in absolute terms, and not accompanied by any visual decline in turf quality. Fiesta treatments lead to a darker green color, whereas normally a decline in turf canopy reflectance, for example caused by N deficiency, drought stress, or phytotoxicity, is accompanied by yellowing or chlorosis. In all treatments the turf had fully recovered to untreated control levels of canopy reflectance by the end of the season.

The reduction of turf density noted in 2010 at higher frequencies in the Kentucky bluegrass and perennial ryegrass plots had largely disappeared at the beginning of the trial in 2011,

Table 4. Canopy reflectance (NDVI) and change in canopy reflectance relative to untreated control (ΔNDVI) in treated plots – Fine fescue.

Treatment	05/05	06/07 pre	06/07 post	06/13	06/17	06/27	06/29	07/06	07/08
					NDVI				
Par III	0.524[1] bcd	0.546	0.483	0.566	0.592	0.591 ab	0.583 ab	0.562 a	0.618 a
S2F2	0.496 d	0.504	0.437	0.531	0.548	0.510 b	0.518 ab	0.498 ab	0.575 ab
S3F3	0.561 abc	0.518	0.455	0.534	0.549	0.500 b	0.498 b	0.483 b	0.573 ab
S4F4	0.577 ab	0.532	0.484	0.561	0.572	0.503 b	0.505 b	0.491 b	0.596 a
4X3	0.580 a	0.535	0.467	0.552	0.560	0.491 b	0.490 b	0.467 b	0.565 ab
8X2	0.591 a	0.569	0.507	0.580	0.598	0.534 ab	0.534 ab	0.432 b	0.516 b
Control	0.510 cd	0.538	0.480	0.559	0.593	0.625 a	0.611 a	0.563 a	0.637 a
					ΔNDVI				
Par III	0.014[2] bcd	0.008	0.002	0.006	-0.001	-0.034 ab	-0.028 ab	0.000 a	-0.020 a
S2F2	-0.014 d	-0.034	-0.044	-0.029	-0.045	-0.115 b	-0.093 ab	-0.064 ab	-0.062 ab
S3F3	0.051 abc	-0.020	-0.026	-0.026	-0.044	-0.126 b	-0.113 b	-0.079 b	-0.064 ab
S4F4	0.067 abc	-0.006	0.004	0.001	-0.021	-0.122 b	-0.105 b	-0.071 b	-0.042 a
4X3	0.070 a	-0.003	-0.014	-0.008	-0.032	-0.135 b	-0.121 b	-0.095 b	-0.072 ab
8X2	0.082 a	0.031	0.026	0.020	0.006	-0.092 ab	-0.076 ab	-0.130 b	-0.121 b
msd p=0.05	0.056	NS	NS	NS	NS	0.105	0.097	0.068	0.075
	07/11	07/13	07/22	07/27	08/05	08/15	08/22	08/26	09/14
					NDVI				
Par III	0.579 ab	0.547 a	0.456 a	0.432 ab	0.516 ab	0.579 ab	0.619	0.646 a	0.578 a
S2F2	0.487 c	0.411 b	0.306 b	0.298 c	0.388 c	0.476 b	0.561	0.610 ab	0.544 ab
S3F3	0.501 bc	0.425 b	0.326 b	0.313 c	0.421 abc	0.504 ab	0.559	0.566 abc	0.558 a
S4F4	0.501 bc	0.445 b	0.338 b	0.337 bc	0.444 abc	0.535 ab	0.583	0.610 ab	0.519 ab
4X3	0.470 c	0.396 b	0.284 b	0.281 c	0.373 c	0.480 ab	0.527	0.532 bc	0.553 a
8X2	0.485 c	0.454 b	0.328 b	0.313 c	0.410 bc	0.477 b	0.533	0.513 c	0.465 b
Control	0.598 a	0.555 a	0.480 a	0.462 a	0.528 a	0.589 a	0.639	0.648 a	0.562 a
					ΔNDVI				
Par III	-0.019 ab	-0.007 a	-0.024 a	-0.031 ab	-0.011 ab	-0.010 ab	-0.019	0.000 a	0.015 a
S2F2	-0.111 c	-0.143 b	-0.174 b	-0.165 c	-0.139 c	-0.113 b	-0.078	-0.036 ab	-0.018 ab
S3F3	-0.097 bc	-0.130 b	-0.155 b	-0.150 c	-0.106 abc	-0.085 ab	-0.079	-0.080 abc	-0.005 a
S4F4	-0.098 bc	-0.109 b	-0.142 b	-0.126 bc	-0.082 abc	-0.053 ab	-0.056	-0.036 ab	-0.044 ab
4X3	-0.128 c	-0.159 b	-0.196 b	-0.181 c	-0.154 c	-0.108 ab	-0.112	-0.114 bc	-0.009 a
8X2	-0.113 c	-0.101 b	-0.152 b	-0.150 c	-0.116 bc	-0.111 b	-0.105	-0.133 c	-0.098 b
msd p=0.05	0.087	0.067	0.091	0.099	0.109	0.112	NS	0.094	0.084

[1] Normalized-difference vegetation index; means of 40-50 readings x 4 replicates.
[2] Change in NDVI relative to control plot means; means of 40-50 readings x 4 replicates.
Means within columns followed by the same letter are not significantly different (Tukey's HSD, p=0.05).

and we did not see further changes in density associated with Fiesta treatmens.

All rates of Fiesta controlled an outbreak of leaf rust in the perennial ryegrass plots, and of dollarspot in Kentucky bluegrass. An outbreak of a patch disease, tentatively diagnosed as summer patch, in the fine fescue plots seemed to only in the Fiesta treated plots and not in the control or Par III plots. The effects on foliar diseases (rust, dollarspot) are likely to be a different mechanism from the effects on rootzone diseases (summer patch). The latter may be a function of the effects of the chelated iron on soil chemistry or nutrients, or perhaps direct effects on soil microorganisms. These disease effects need to be studied further.

Sponsor: Neudorff North America

Table 5. Canopy reflectance (NDVI) and change in canopy reflectance relative to untreated control (ΔNDVI) in treated plots – Kentucky bluegrass.

Treatment	05/05	06/07	06/13	06/15	06/17	06/27	06/29	07/06	07/08
					NDVI				
Par III	0.285 c[1]	0.473 bc	0.567	0.599	0.582 ab	0.588 ab	0.592 ab	0.584 ab	0.637 ab
S2F2	0.299 c	0.450 c	0.569	0.598	0.510 c	0.465 c	0.485 c	0.507 cd	0.575 bc
S3F3	0.357 bc	0.439 c	0.573	0.601	0.496 c	0.451 c	0.477 c	0.519 bcd	0.585 abc
S4F4	0.433 ab	0.507 ab	0.604	0.627	0.533 c	0.480 c	0.505 c	0.546 abc	0.601 ab
4X3	0.327 c	0.484 bc	0.591	0.620	0.535 bc	0.499 c	0.520 bc	0.566 abc	0.620 ab
8X2	0.469 a	0.540 a	0.607	0.635	0.542 bc	0.507 bc	0.509 c	0.455 d	0.526 c
Control	0.320 c	0.506 ab	0.593	0.613	0.600 a	0.609 a	0.605 a	0.598 a	0.648 a
					ΔNDVI				
Par III	-0.033 c[2]	-0.033 bc	-0.027	-0.014	-0.017 ab	-0.023 ab	-0.015 ab	-0.013 ab	-0.012 ab
S2F2	-0.018 c	-0.057 c	-0.025	-0.015	-0.088 c	-0.146 c	-0.123 c	-0.090 cd	-0.074 bc
S3F3	0.039 bc	-0.067 c	-0.021	-0.012	-0.103 c	-0.160 c	-0.130 c	-0.079 bcd	-0.064 abc
S4F4	0.115 ab	0.000 ab	0.010	0.014	-0.066 c	-0.131 c	-0.102 c	-0.052 abc	-0.049 ab
4X3	0.010 c	-0.022 bc	-0.003	0.007	-0.064 bc	-0.112 c	-0.088 bc	-0.031 abc	-0.029 ab
8X2	0.151 a	0.034 a	0.014	0.022	-0.056 bc	-0.104 bc	-0.098 c	-0.142 d	-0.123 c
msd p=0.05	0.080	0.048	NS	NS	0.052	0.086	0.074	0.073	0.065
	07/11	07/13	07/22	07/27	08/05	08/15	08/22	08/26	09/14
					NDVI				
Par III	0.613 ab	0.600 a	0.533 ab	0.541 a	0.600	0.607 a	0.620	0.660	0.578 abc
S2F2	0.495 d	0.433 c	0.424 cd	0.493 ab	0.570	0.598 a	0.639	0.689	0.618 a
S3F3	0.502 cd	0.452 c	0.453 bcd	0.529 ab	0.596	0.609 a	0.604	0.624	0.593 ab
S4F4	0.529 cd	0.479 bc	0.491 abc	0.546 a	0.594	0.608 a	0.604	0.622	0.519 bc
4X3	0.546 cd	0.467 c	0.475 abc	0.536 ab	0.602	0.609 a	0.608	0.618	0.598 ab
8X2	0.557 bc	0.551 ab	0.388 d	0.458 b	0.557	0.546 b	0.619	0.632	0.502 c
Control	0.629 a	0.616 a	0.540 a	0.564 a	0.611	0.620 a	0.647	0.692	0.595 ab
					ΔNDVI				
Par III	-0.018 ab	-0.015 a	-0.008 ab	-0.022 a	-0.008	-0.014 a	-0.028	-0.031	-0.017 abc
S2F2	-0.136 d	-0.182 c	-0.117 cd	-0.071 ab	-0.038	-0.023 a	-0.008	-0.002	0.023 a
S3F3	-0.129 cd	-0.163 c	-0.088 bcd	-0.034 ab	-0.012	-0.011 a	-0.044	-0.067	-0.002 ab
S4F4	-0.102 cd	-0.136 bc	-0.050 abc	-0.018 a	-0.014	-0.012 a	-0.043	-0.069	-0.076 bc
4X3	-0.085 cd	-0.148 c	-0.066 abc	-0.028 ab	-0.006	-0.011 a	-0.039	-0.073	0.003 ab
8X2	-0.074 bc	-0.064 ab	-0.153 d	-0.106 b	-0.051	-0.074 b	-0.028	-0.059	-0.093 c
msd p=0.05	0.061	0.073	0.085	0.079	NS	0.040	NS	NS	0.079

[1] Normalized-difference vegetation index; means of 40-50 readings x 4 replicates.
[2] Change in NDVI relative to control plot means; means of 40-50 readings x 4 replicates.
Means within columns followed by the same letter are not significantly different (Tukey's HSD, p=0.05).

Table 6. Canopy reflectance (NDVI) and change in canopy reflectance relative to untreated control (ΔNDVI) in treated plots – Perennial ryegrass

Treatment	05/05	06/07	06/13	06/15	06/17	06/27	06/29	07/06	07/8	07/11
						NDVI				
Par III	0.365[1]	0.526	0.511	0.482	0.443	0.427	0.413	0.361	0.401	0.328
S2F2	0.321	0.500	0.496	0.464	0.418	0.442	0.430	0.377	0.428	0.314
S3F3	0.475	0.567	0.523	0.468	0.403	0.425	0.414	0.367	0.431	0.335
S4F4	0.404	0.569	0.537	0.479	0.427	0.428	0.423	0.350	0.417	0.362
4X3	0.311	0.515	0.502	0.470	0.423	0.409	0.401	0.350	0.409	0.323
8X2	0.328	0.538	0.520	0.479	0.432	0.430	0.422	0.377	0.443	0.327
Control	0.312	0.544	0.537	0.496	0.448	0.447	0.435	0.372	0.423	0.343
						ΔNDVI				
Par III	0.052[2]	-0.017	-0.025	-0.015	-0.006	-0.020	-0.022	-0.011	-0.024	-0.015
S2F2	0.008	-0.044	-0.040	-0.032	-0.031	-0.005	-0.005	0.005	0.004	-0.029
S3F3	0.162	0.023	-0.013	-0.029	-0.047	-0.022	-0.021	-0.005	0.006	-0.008
S4F4	0.091	0.025	0.001	-0.018	-0.022	-0.019	-0.012	-0.022	-0.008	0.019
4X3	-0.002	-0.029	-0.035	-0.027	-0.026	-0.038	-0.033	-0.022	-0.016	-0.020
8X2	0.015	-0.005	-0.017	-0.018	-0.017	-0.017	-0.013	0.005	0.018	-0.016
msd p=0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	07/13	07/22	07/27	08/05	08/15	08/22	08/26	08/29	09/14	
						NDVI				
Par III	0.340	0.338	0.348	0.363	0.381	0.433	0.456	0.450	0.345	
S2F2	0.329	0.363	0.389	0.399	0.426	0.490	0.503	0.508	0.398	
S3F3	0.357	0.371	0.408	0.415	0.434	0.500	0.523	0.506	0.463	
S4F4	0.389	0.347	0.383	0.422	0.446	0.494	0.476	0.426	0.379	
4X3	0.350	0.330	0.352	0.368	0.392	0.442	0.451	0.445	0.373	
8X2	0.342	0.368	0.384	0.396	0.429	0.477	0.472	0.498	0.411	
Control	0.350	0.349	0.361	0.371	0.433	0.472	0.463	0.466	0.362	
						ΔNDVI				
Par III	-0.010	-0.011	-0.012	-0.007	-0.053	-0.040	-0.005	-0.015	-0.016	
S2F2	-0.021	0.014	0.028	0.028	-0.008	0.017	0.042	0.043	0.037	
S3F3	0.007	0.022	0.047	0.045	0.000	0.027	0.062	0.041	0.102	
S4F4	0.040	-0.002	0.023	0.051	0.012	0.021	0.015	-0.039	0.018	
4X3	0.000	-0.019	-0.009	-0.003	-0.042	-0.030	-0.010	-0.020	0.012	
8X2	-0.008	0.019	0.024	0.025	-0.005	0.005	0.012	0.033	0.050	
msd p=0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	

[1] Normalized-difference vegetation index; means of 40-50 readings x 4 replicates.
[2] Change in NDVI relative to control plot means; means of 40-50 readings x 4 replicates.
Means within columns followed by the same letter are not significantly different (Tukey's HSD, p=0.05).

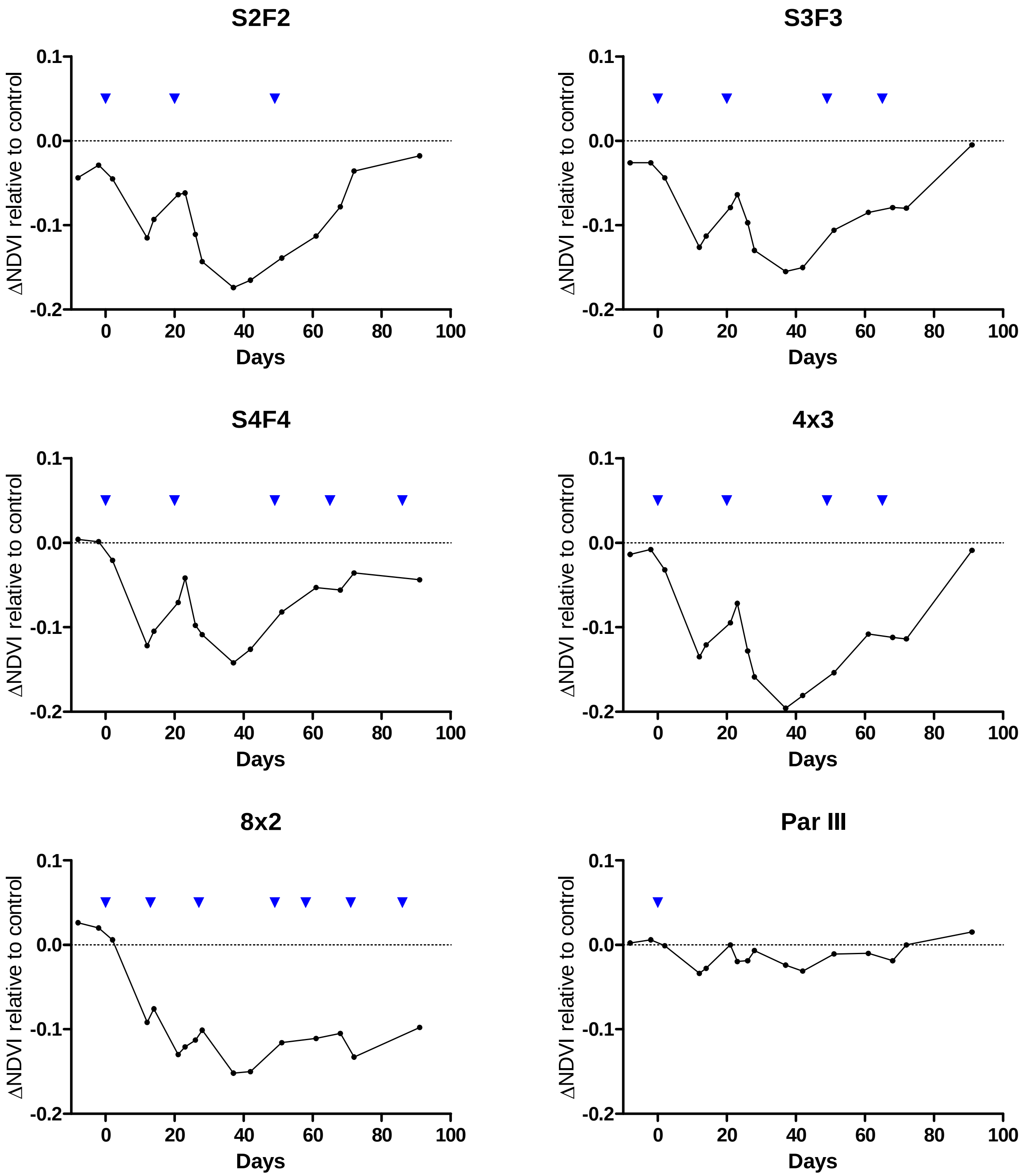

Figure 8. Changes in canopy reflectance in treated plots of fine fescue relative to untreated check. Application dates are indicated by blue arrows.

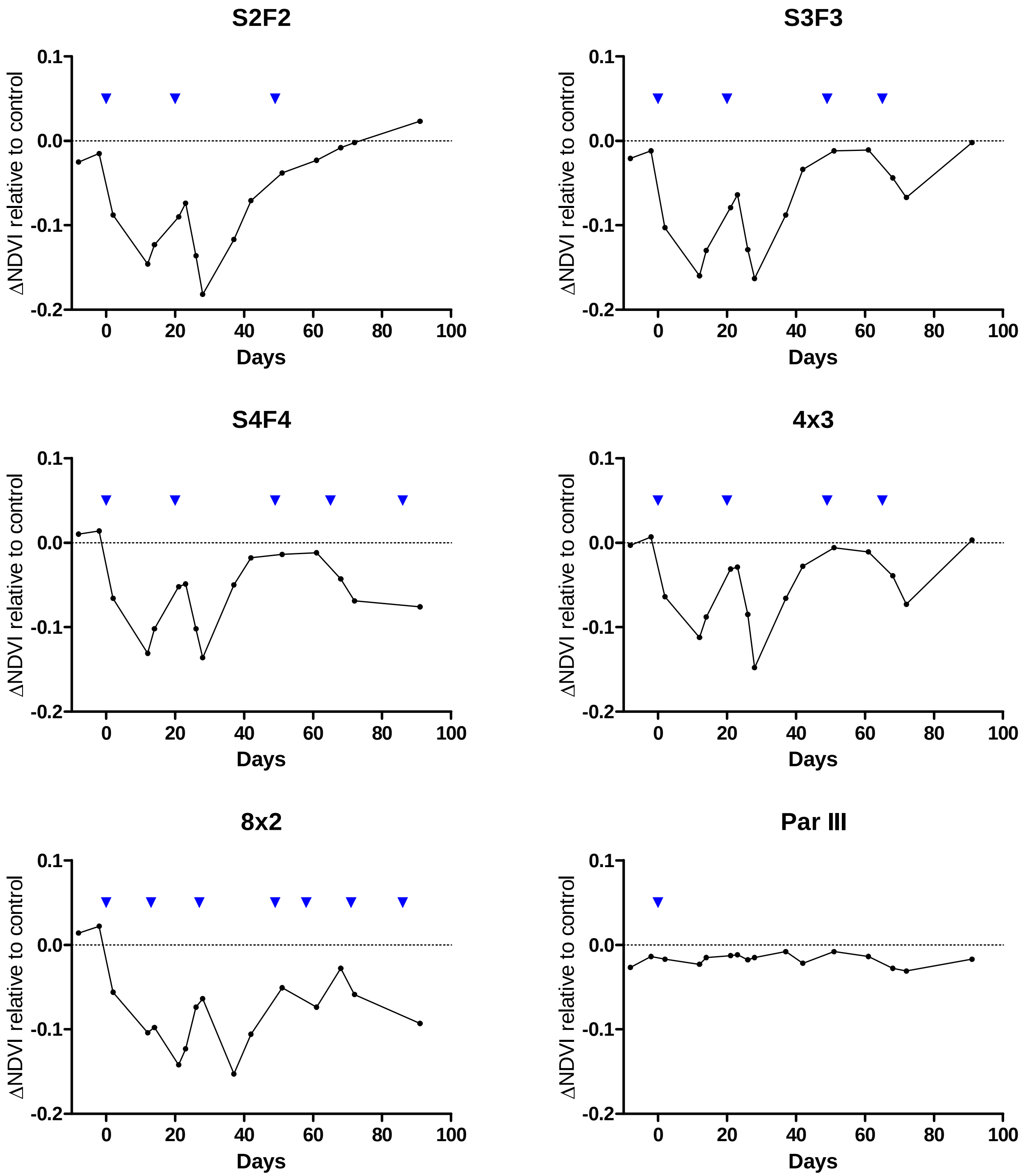

Figure 9. Changes in canopy reflectance in treated plots of Kentucky bluegrass relative to untreated check. Application dates are indicated by blue arrows.

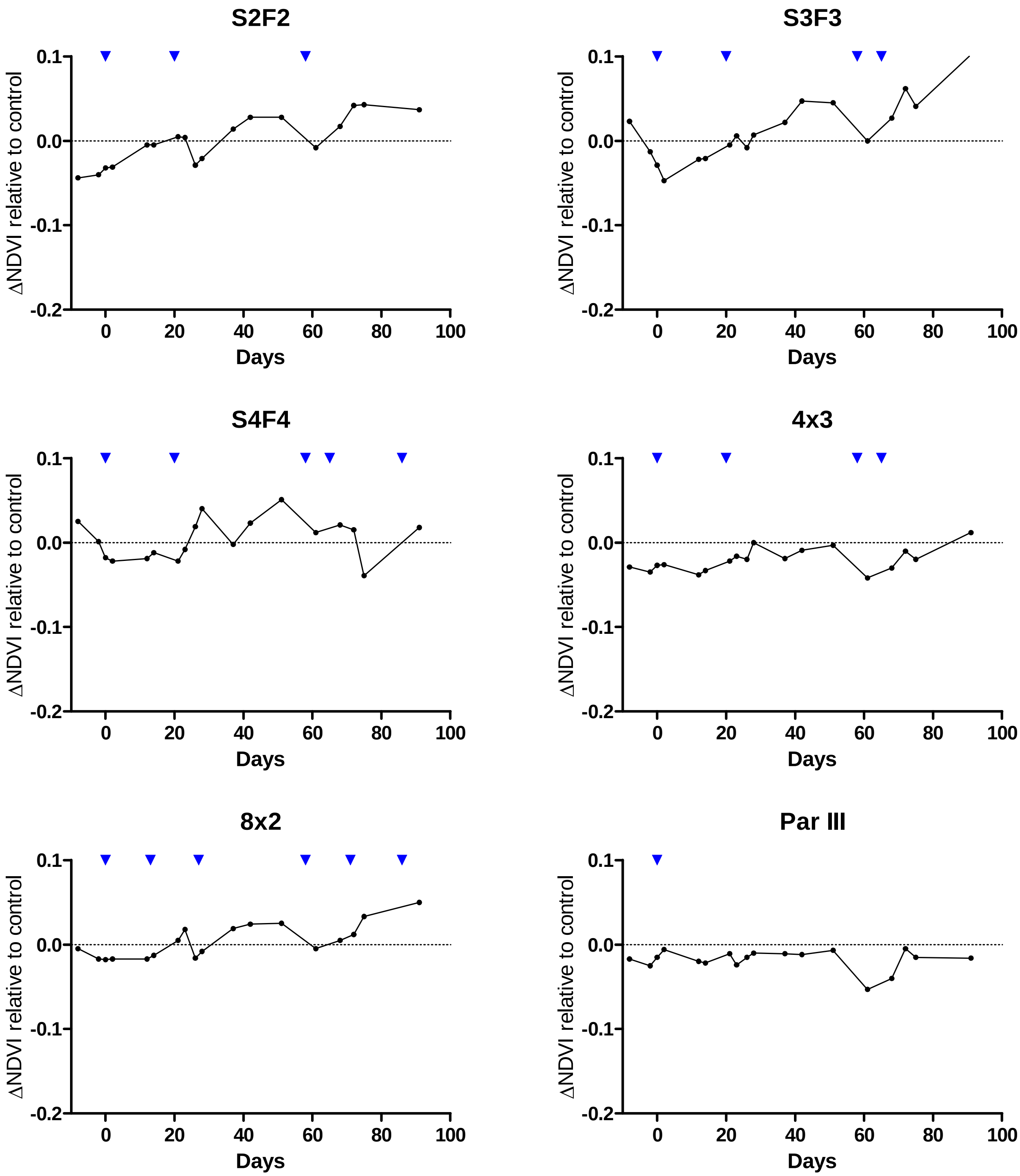

Figure 10. Changes in canopy reflectance in treated plots of perennial ryegrass relative to untreated check. Application dates are indicated by blue arrows.