

Field trial of effects of TerraBioGen liquid organic fertilizer on performance of established creeping bentgrass/annual bluegrass putting green turf following a reduced fungicide application regime

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Sponsor: TerraBioGen

The objective of this research project was to compare the effects of the sponsor’s organic fertilizer products on performance, especially diseases tolerance, of established creeping bentgrass/annual bluegrass putting green turf on a sand rootzone with a reduced fungicide program.

Data collected included: 1. turf performance (color, quality, density, uniformity) estimated visually and by canopy reflectance (normalized-difference vegetation index) and 2. assessment of dollarspot disease development in inoculated and uninoculated turf

MATERIALS/METHODS

The experimental design included management treatments (sponsor’s product, urea in solution at 5 g actual N m⁻², and full and ½ rates of commonly used fungicides – see Table 1). Each treatment was replicated four times in 1 x 2 m plots on a creeping bentgrass/annual bluegrass putting green turf on a sand rootzone at the Guelph Turfgrass Institute (Figure 1). Treatments were arranged in a



Figure 1. Plot area on USGA green, July 19, 2013.

randomized complete block design. Half of each plot was randomly selected to be inoculated with dollarspot (*Sclerotinia homoeocarpa*) inoculum. Inoculum (*S. homoeocarpa* grown on autoclaved Kentucky bluegrass seed) was added at 3.5 g m⁻² on July 27, 2012. Fertilizer was added by compressed air sprayer: a solution of 54.34 g urea / L was sprayed at a nominal rate of 200 ml m⁻². The actual delivered rates for the fertilizer by application date were: July 19 - 3.3 g N m⁻², August 16 - 3.1 g N m⁻², September 13 - 3.7 g N m⁻², October 12 - 3.4 g N m⁻². Daconil treatments were applied on July 20, August 3, August 17,

Table 1. Treatment list

Treatment	Rate ai l ha ⁻¹	Volume l ha ⁻¹	Frequency	Fungicide	Fungicide Frequency	Fertilizer (kg N 100 m ⁻²)	Fertilizer Frequency
1 control	0-	0		none		0.5 kg N	28 D
2 none	0	0		Dac - Full	14 D	0.5 kg N	28 D
3 none	0	0		Banner - Full	28 D	0.5 kg N	28 D
4 none	0	0		Dac - Half	14 D	0.5 kg N	28 D
5 none	0	0		Banner - Half	28 D	0.5 kg N	28 D
6 F4	0.1	300	28 D	none		0.5 kg N	28 D
7 LC	2.5	300	28 D	none		0.5 kg N	28 D
8 LC	2.5	300	28 D	Dac - Half	14 D	0.5 kg N	28 D
9 LC	2.5	300	28 D	Banner - Half	28 D	0.5 kg N	28 D
10 F4	0.1	300	28 D	Dac - Half	14 D	0.5 kg N	28 D
11 F4	0.1	300	28 D	Banner - Half	28 D	0.5 kg N	28 D
12 F4	0.2	300	28 D	Banner - Half	28 D	0.5 kg N	28 D
13 F4	0.2	300	28 D	Dac - Half	14 D	0.5 kg N	28 D



August 31, September 17, and September 28, and Banner treatments on July 20, August 17, and September 17.

Canopy reflectance was measured with the Greenseeker NDVI meter. Other performance features (colour, quality, uniformity, density) were assessed visually. Dollarspot disease was assessed by visual ratings, lesion counts, point quadrat counts, and by digital image analysis.

Plots were maintained on a putting green maintenance program, with mowing at 4 mm and irrigation to prevent stress, except for drought stress test periods. No pesticides (with the exception of fungicide treatments) were applied.

An anecdotal photographic record of the experiment was kept.

Winter survival and spring greenup will be assessed in spring of 2013.

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

RESULTS

Environmental data

Daily air and soil temperatures for May - October 2012 are presented in Figures 2 and 3. Because of failures in weather station equipment at the GTI, we do not have on-site precipitation information, but Figure 4 shows the precipitation records at the Region of Waterloo International Airport (YKF), which is about 20 km from the GTI.

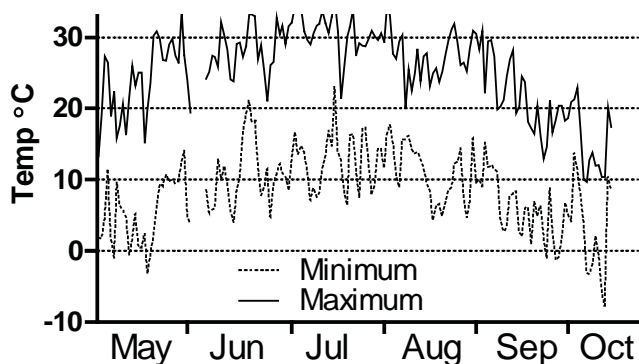


Figure 2. Daily air temperatures at GTI, summer 2012.

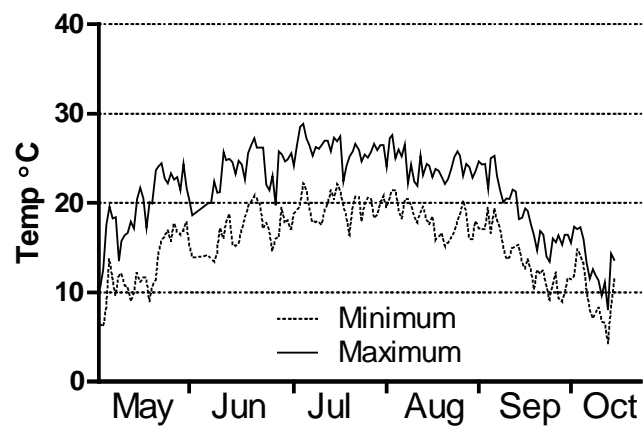


Figure 3. Daily soil temperatures at GTI, summer 2012.

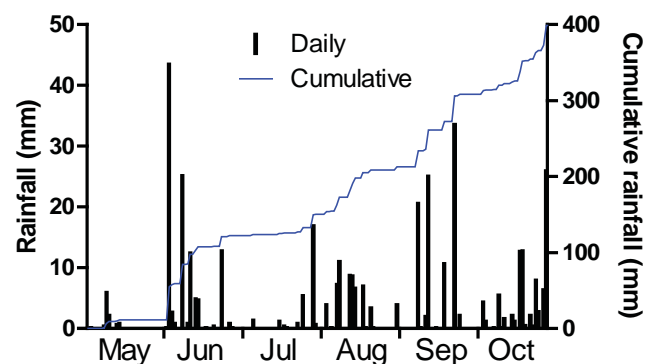


Figure 4. Daily rainfall at Region of Waterloo International Airport (YKF), summer 2012.

Waterloo International Airport (YKF), which is about 20 km from the GTI.

Turf quality

Apart from the effects of dollarspot infection (see below), there were no treatment effects on turf colour, quality, density, or uniformity. The dollarspot pressure at its peak was severe enough to mask any slight differences that might have been present.

Canopy reflectance

The canopy reflectance (NDVI) data from the plots indicated no differences among treatments until the dollarspot disease lesions began to develop on Aug. 13, about 2 weeks after application of disease inoculums (Table 2). The positive controls (Banner and Daconil at full rate) showed little change in canopy reflectance throughout the trial period, while the negative

Table 2. Canopy reflectance of treated plots

Treatment	0703	0719	0720	0723	0725	0727	0730	0731	0801	0803	0807						
Banner 1/2x	0.505 ¹	0.506	0.478	0.529	0.508	0.517	0.513	0.520	0.542	0.514	0.517						
Banner 1x	0.507	0.469	0.435	0.484	0.469	0.510	0.534	0.528	0.541	0.523	0.525						
Control	0.521	0.477	0.441	0.499	0.478	0.502	0.521	0.508	0.512	0.485	0.490						
Daconil 1/2x	0.529	0.481	0.450	0.504	0.478	0.540	0.560	0.535	0.539	0.498	0.505						
Daconil 1x	0.540	0.504	0.465	0.527	0.501	0.542	0.547	0.556	0.562	0.524	0.526						
F4	0.519	0.484	0.449	0.515	0.483	0.508	0.525	0.513	0.521	0.500	0.503						
F4 1x + Banner	0.538	0.503	0.453	0.507	0.508	0.553	0.559	0.553	0.568	0.545	0.537						
F4 1x + Daconil	0.529	0.496	0.449	0.515	0.491	0.534	0.530	0.537	0.542	0.529	0.514						
F4 2x + Banner	0.524	0.496	0.467	0.514	0.499	0.544	0.541	0.544	0.559	0.532	0.540						
F4 2x + Daconil	0.521	0.492	0.446	0.507	0.487	0.532	0.525	0.536	0.546	0.501	0.486						
LC	0.537	0.503	0.471	0.522	0.495	0.507	0.539	0.519	0.522	0.500	0.491						
LC + Banner	0.524	0.483	0.456	0.503	0.476	0.517	0.516	0.556	0.571	0.527	0.542						
LC + Daconil	0.538	0.506	0.470	0.523	0.503	0.555	0.531	0.557	0.561	0.521	0.505						
	0809	0813	0816	0820	0824	0828	0831	0905	0907								
Banner 1/2x	0.539	0.532	0.533 a-d	0.489 a-d	0.535 abc	0.455 def	0.539 ab	0.458 c-g	0.572 abc	0.507 c-f	0.589 abc	0.546 b-g	0.517 a-e	0.504 a-g	0.560 abc	0.512 def	0.538 ab
Banner 1x	0.552	0.560	0.531 a-d	0.530 a-d	0.537 abc	0.515 a-d	0.532 abc	0.504 a-f	0.564 a-d	0.553 a-e	0.586 a-d	0.584 a-e	0.554 a	0.552 a	0.567 ab	0.565 ab	0.554 a
Control	0.524	0.515	0.486 bcd	0.469 d	0.486 b-f	0.448 def	0.478 b-g	0.437 fg	0.531 a-f	0.497 ef	0.538 d-g	0.502 gh	0.496 a-g	0.446 gh	0.506 def	0.445 fg	0.478 cde
Daconil 1/2x	0.542	0.545	0.505 a-d	0.506 a-d	0.507 a-e	0.468 c-f	0.495 a-g	0.445 fg	0.537 a-f	0.493 ef	0.568 a-f	0.529 fgh	0.515 a-e	0.466 fgh	0.546 a-c	0.486 fg	0.525 abc
Daconil 1x	0.561	0.558	0.538 abc	0.530 a-d	0.545 abc	0.517 a-d	0.522 a-d	0.501 a-g	0.572 abc	0.551 a-e	0.593 abc	0.578 a-f	0.538 abc	0.498 a-g	0.570 a	0.532 a-e	0.555 a
F4	0.530	0.523	0.502 a-d	0.468 d	0.501 a-f	0.434 f	0.506 a-f	0.432 fg	0.551 a-e	0.500 def	0.559 a-f	0.503 gh	0.513 a-e	0.449 fgh	0.523 b-f	0.435 h	0.494 b-e
F4 1x + Banner	0.565	0.556	0.548 ab	0.516 a-d	0.548 ab	0.490 b-f	0.539 ab	0.480 a-g	0.576 ab	0.530 a-f	0.592 abc	0.567 a-f	0.548 ab	0.519 a-e	0.566 ab	0.526 a-f	0.543 ab
F4 1x + Daconil	0.543	0.540	0.512 a-d	0.492 a-d	0.513 a-d	0.469 c-f	0.492 a-g	0.454 d-g	0.544 a-e	0.512 b-f	0.568 a-f	0.548 a-g	0.521 a-e	0.479 c-g	0.544 a-d	0.505 def	0.528 abc
F4 2x + Banner	0.557	0.554	0.545 ab	0.498 a-d	0.547 ab	0.472 c-f	0.545 ab	0.463 c-g	0.579 a	0.513 b-f	0.594 ab	0.553 a-g	0.553 a	0.517 a-e	0.566 ab	0.518 c-f	0.547 ab
F4 2x + Daconil	0.539	0.534	0.509 a-d	0.491 a-d	0.504 a-f	0.464 def	0.482 a-g	0.437 fg	0.536 a-f	0.505 def	0.560 a-f	0.543 c-f	0.505 a-f	0.477 d-g	0.541 a-d	0.504 def	0.513 a-d
LC	0.528	0.527	0.496 a-d	0.473 cd	0.495 a-f	0.437 ef	0.480 a-g	0.426 g	0.529 a-f	0.476 f	0.537 d-g	0.479 h	0.491 b-g	0.412 h	0.513 def	0.411 h	0.479 cde
LC + Banner	0.564	0.538	0.554 a	0.497 a-d	0.561 a	0.464 def	0.555 a	0.456 d-g	0.587 a	0.508 c-f	0.598 a	0.548 a-g	0.518 a-e	0.501 a-g	0.570 a	0.515 def	0.546 ab
LC + Daconil	0.566	0.543	0.537 abc	0.497 a-d	0.537 abc	0.470 c-f	0.519 a-e	0.449 d-g	0.562 a-d	0.511 c-f	0.577 a-f	0.535 efg	0.534 a-d	0.478 d-g	0.548 a-d	0.494 ef	0.528 abc
	0907	0910	0917	0921	0924	0928	1002	1010	1019								
Banner 1/2x	0.462 def	0.542 abc	0.466 fg	0.559 abc	0.500 d-i	0.590 ab	0.538 c-f	0.580 abc	0.536 b-f	0.585 a	0.543 a-e	0.602 ab	0.563 a-d	0.555 a-d	0.526 a-f	0.557 ab	0.539 a-e
Banner 1x	0.545 ab	0.560 a	0.547 ab	0.575 a	0.570 ab	0.593 ab	0.593 ab	0.582 ab	0.584 ab	0.580 ab	0.582 a	0.597 abc	0.602 ab	0.560 abc	0.563 abc	0.559 ab	0.570 a
Control	0.381 gh	0.486 def	0.404 hij	0.517 b-h	0.448 ijk	0.552 a-e	0.489 fgh	0.541 b-f	0.486 gh	0.537 b-e	0.490 fg	0.560 a-e	0.518 ef	0.511 efg	0.472 gh	0.520 b-e	0.493 de
Daconil 1/2x	0.421 fg	0.526 a-e	0.432 ghi	0.539 a-f	0.465 h-k	0.582 abc	0.514 efg	0.572 a-d	0.518 fg	0.577 ab	0.525 ef	0.579 a-d	0.539 def	0.564 ab	0.537 a-e	0.559 ab	0.545 abc
Daconil 1x	0.497 b-e	0.559 a	0.495 c-f	0.563 abc	0.547 b-h	0.595 a	0.558 a-e	0.590 a	0.560 a-f	0.583 a	0.558 a-e	0.578 a-d	0.555 cde	0.566 a	0.552 a-e	0.559 ab	0.553 ab
F4	0.367 gh	0.498 b-f	0.388 ij	0.532 a-f	0.444 jk	0.562 a-e	0.484 gh	0.554 a-f	0.486 gh	0.557 a-e	0.477 g	0.572 a-d	0.517 ef	0.522 b-f	0.487 fgh	0.531 a-e	0.505 cde
F4 1x + Banner	0.480 cde	0.544 abc	0.486 def	0.552 a-e	0.513 c-h	0.579 a-d	0.551 a-e	0.570 a-e	0.548 a-f	0.569 abc	0.547 a-e	0.590 abc	0.572 a-d	0.548 a-e	0.535 a-e	0.548 abc	0.541 abc
F4 1x + Daconil	0.459 def	0.530 a-d	0.467 fg	0.541 a-f	0.491 f-j	0.576 a-d	0.536 c-f	0.568 a-e	0.540 b-f	0.568 a-e	0.546 a-e	0.574 a-d	0.559 a-e	0.558 a-d	0.553 a-e	0.559 ab	0.550 abc
F4 2x + Banner	0.465 def	0.549 ab	0.474 efg	0.555 a-d	0.494 f-j	0.583 abc	0.529 d-g	0.575 a-d	0.529 d-g	0.570 abc	0.530 c-f	0.593 abc	0.556 cde	0.554 a-e	0.520 c-f	0.548 abc	0.530 a-e
F4 2x + Daconil	0.459 def	0.520 a-e	0.467 fg	0.529 a-g	0.492 f-j	0.576 a-d	0.539 c-f	0.569 a-e	0.540 b-f	0.572 abc	0.550 a-e	0.576 a-d	0.558 b-e	0.561 abc	0.544 a-e	0.560 ab	0.548 abc
LC	0.340 h	0.489 def	0.359 j	0.511 c-h	0.416 k	0.543 b-e	0.457 h	0.540 b-f	0.465 h	0.537 b-e	0.473 g	0.558 a-e	0.504 f	0.516 def	0.467 h	0.522 b-e	0.487 e
LC + Banner	0.472 c-f	0.552 a	0.467 fg	0.571 ab	0.498 e-j	0.593 ab	0.533 c-g	0.584 ab	0.532 c-g	0.585 a	0.537 b-e	0.603 a	0.564 a-d	0.564 ab	0.521 c-f	0.557 ab	0.527 a-e
LC + Daconil	0.452 ef	0.533 a-d	0.448 fgh	0.535 a-f	0.474 g-j	0.575 a-d	0.520 efg	0.570 a-e	0.521 efg	0.569 abc	0.526 def	0.584 a-d	0.544 def	0.561 abc	0.531 a-e	0.560 ab	0.534 a-d

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).
²- plots not inoculated with dollarspot organism; + plots inoculated with dollarspot.



Table 4. Visual assessment of dollarspot disease pressure.

Treatment	07/18	08/03		08/08	
		lesion counts		ratings	
		- ¹	+ ¹	-	+
Banner 1/2x	9.8 ²	8.0	8.0	1.0 ab ³	2.8 bc
Banner 1x	4.8	2.3	1.3	0.5 ab	2.5 bcd
Control	7.8	6.3	5.8	1.0 ab	3.3 ab
Daconil 1/2x	13.5	8.8	11.0	0.8 ab	0.8 e
Daconil 1x	4.3	2.0	2.3	0.0 b	1.5 cde
F4	6.8	8.5	8.8	1.0 ab	4.5 a
F4 1x + Banner	8.0	5.0	6.3	1.8 a	3.3 ab
F4 1x + Daconil	7.0	3.8	5.5	0.5 ab	1.0 de
F4 2x + Banner	8.0	5.3	10.8	1.3 ab	3.3 ab
F4 2x + Daconil	11.8	9.0	7.0	0.8 ab	1.0 de
LC	8.8	7.8	6.5	0.8 ab	3.3 ab
LC + Banner	9.3	8.3	5.0	1.3 ab	3.3 ab
LC + Daconil	5.3	5.5	2.3	0.3 b	1.0 de

¹ - plots not inoculated with dollarspot organism; + plots inoculated with dollarspot.

² Number of lesions per 2 m² plot. Means of 4 replicates.

³ Rating of disease pressure 0 - 10, 0 = no disease, 10 = ~50% of plot affected. Means of 4 replicates.

Means within columns followed by the same letter are not significantly different (Tukey's HSD test, p=0.05).

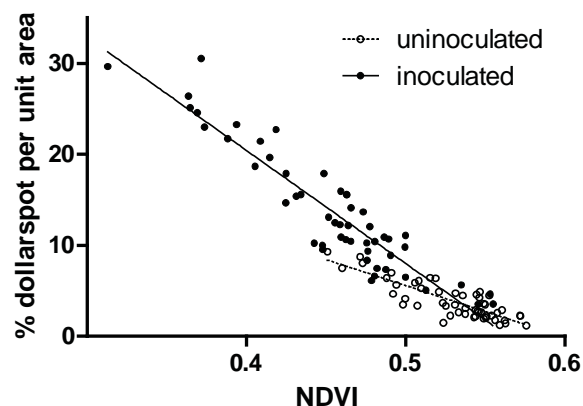


Figure 5. Association between dollarspot infection (digital image analysis) and canopy reflectance. Data shown are plots of all treatments on Sept. 10, 2013, which was the date of most severe infection.

(untreated) control and F4 and LC treatments without fungicide showed a significant decline in canopy reflectance, proportional to the disease development (Figure 5).

Dollarspot disease

There was some natural dollarspot infection present on the plots prior to inoculation with *S. homoeocarpa* spores (July 27, Table 3, Figure 6). Significant disease presence developed in the inoculated half of the plots by 3 weeks after inoculation (August 13). Visual estimates of disease pressure (Table 4) were only taken early in the disease development phase, and were consistent with the digital image data, in that

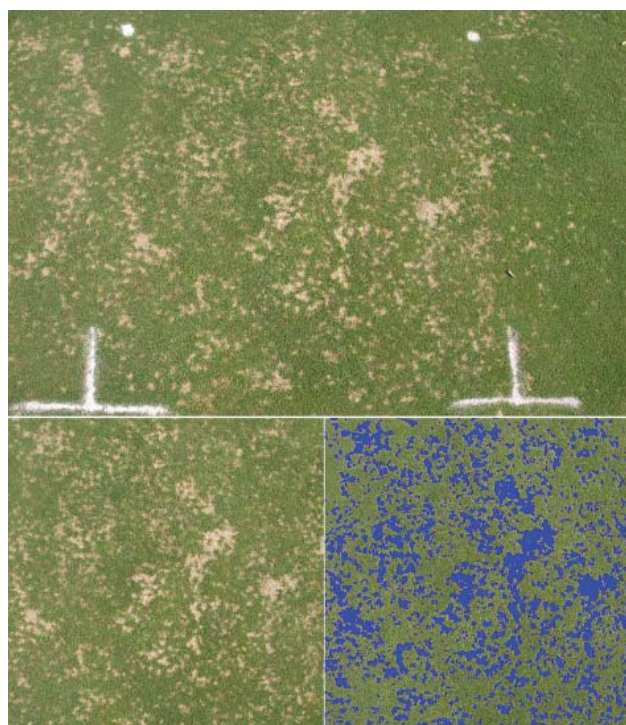


Figure 6. For digital image analyses, raw images of each 1x1 m subplot (top) were deskewed, cropped, and resized to 2000x2000 pixels in Adobe Photoshop (bottom left), and then analyzed with Sigma Scan software, which estimates dollar spot area based on color thresholds (bottom right). The actual estimate in the plot pictured was 25.3% area covered by dollar spot lesions.

there were no significant differences among treatments in early lesion counts, but when the pressure had increased to the point where counts were no longer possible, visual ratings gave significant treatment effects which were consistent with image analysis and canopy reflectance data.

DISCUSSION AND CONCLUSIONS

Both canopy reflectance data and dollarspot disease data showed the same pattern, namely that there were no treatment effects apart from the fungicide control of dollarspot. The treatments without fungicide (LC and F4) were not significantly different from the negative control, and the treatments with fungicide were not significantly different from the positive controls of fungicide at the same rate. There was a rate effect among treatments with fungicide, but no interactions with F4 and LC.

It was difficult to assess turf quality once the dollarspot disease became widespread, but there was no visible difference in quality in the unaffected area of the uninoculated treatments.

