Efficacy of experimental plant growth regulator on biomass growth reduction in creeping bentgrass fairway type turf

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The objectives of this research project were 1. to evaluate Experimental PGR for reduction grass biomass reduction and compare with Primo MAXX in golf course turf and 2. to determine appropriate rate for Experimental PGR competitive to Primo MAXX rate and evaluate crop safety on turf

Data collected included measurements of phytotoxicity 7 and 21 DAT, shoot dry matter accumulation to estimate grass biomass reduction (7, 14, 21, and 28 DAT), turf quality, uniformity, and density, and resistance of the turf to disease and other stresses.

MATERIALS/METHODS

The treatments consisted of the sponsor's products as well as an industry standard at several rates (Table 1) applied at day 0 and day 21. An untreated check was also included. Treatments were applied to 1 x 3 m plots of creeping bentgrass turf maintained as a golf course fairway on the sandy loam soil research ranges at the Guelph Turfgrass Institute (mowing at 10 mm (0.4"), regular fertility, irrigation to prevent stress, periodic coring and topdressing for thatch control) (Figure 1). Treatments were replicated four times in a randomized complete block design. Treatments were applied in two applications: August 26, 2008 and again 3 weeks later (September 18, 2008). Treatments were applied with a compressed air sprayer Treatments were applied with a compressed air sprayer (20 psi; 50 ml m^{-2} spray volume; TeeJet 8001VS flat fan nozzles).

Color response and general vigour of the turf was assessed, both visually and using canopy reflectance (Greenseeker NDVI), daily for the first week after application and then weekly. Uniformity of the color response was assessed visually. Plots were also rated for turf quality, density and uniformity. Clippings were collected from a fixed area of each plot from regular mowings to determine shoot growth rates. An anecdotal photographic record of the experiment was kept.

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

RESULTS

Visual ratings of turf performance. There was a significant decline in turf quality and uniformity associated with the growth regulator treatments (Table 2). By two weeks after the first application all but the lowest two levels of experimental PGR, and both Primo Maxx treatments were significantly poorer quality than the control (though still above the acceptable cutoff). Uniformity patterns were similar, but not significant 14 DAT. The decline in quality and uniformity was largely the result of the mixed creeping bentgrass/*Poa annua* turf, in which the response to the PGR treatments accentuated color

Table 1. Treatments

Treatment		Formulation	Product rate	ai rate	Application volume
1	Check				
2	PGR (A01)	27.5 % WG	1.27 g 100 m^{-2}	0.035 kg ai ha^{-1}	500 L ha^{-1}
3	PGR (A02)	27.5 % WG	2.55 g 100 m^{-2}	0.07 kg ai ha^{-1}	500 L ha^{-1}
4	PGR (A04)	27.5 % WG	5.1 g 100 m^{-2}	0.14 kg ai ha^{-1}	500 L ha^{-1}
5	PGR (A08)	27.5 % WG	10.2 g 100 m^{-2}	0.28 kg ai ha^{-1}	500 L ha^{-1}
6	PGR (A16)	27.5 % WG	20.4 g 100 m^{-2}	0.56 kg ai ha^{-1}	500 L ha^{-1}
7	Primo (P1)	120 g ai/L SC	8 ml 100 m^{-2}	0.096 kg ai ha^{-1}	500 L ha^{-1}
8	Primo (P2)	120 g ai/L SC	16 ml 100 m^{-2}	0.192 kg ai ha^{-1}	500 L ha^{-1}

All products applied at day 0 and again at day 21.

Figure 1. Plot area October 3, 2008 (38 days after first treatment application).

Table 2. Visual ratings of treated turf.

Treatment	8 DAT			14 DAT		24 DAT		44 DAT
	Qual.[1]	Unif.	Color	Qual.	Unif.	Qual.	Unif.	Qual.
A01	7.8[2]	7.3	8.3	7.8 ab	6.8	7.5 abc	7.5 a	7.0 bc
A02	8.0	7.3	8.5	7.8 ab	6.5	8.3 a	7.5 a	7.5 ab
A04	7.8	7.3	8.5	7.0 bc	6.3	8.3 a	7.5 a	7.0 bc
A08	7.0	7.0	8.3	6.3 c	5.5	7.0 bc	6.5 ab	7.0 bc
A16	7.5	6.8	8.5	6.3 c	5.8	6.5 c	5.8 b	6.3 d
P1	7.8	7.0	8.0	7.5 bc	6.3	8.0 ab	7.5 a	7.3 b
P2	7.3	7.3	8.3	7.0 bc	6.3	7.3 abc	6.8 ab	6.5 cd
Control	7.8	7.3	9.0	8.5 a	7.0	8.0 ab	7.5 a	8.0 a
lsd p=0.05	NS	NS	NS	0.89	NS	1.04	1.09	0.56

[1] Visual ratings on a scale of 0-10, 10=best, 6=acceptable.

[2] Mean of 4 replicates; means within columns followed by the same letter are not significantly different (Fisher's protected LSD; p=0.05).

differences between the species. Within both the experimental PGR and the Primo Maxx treatment groups, there was a rate effect, with the higher rates generally producing larger declines in quality and uniformity.

Canopy reflectance and turf performance. The canopy reflectance data followed a very similar pattern to the visual ratings, and in fact there was a significant association between normalized-difference vegetation indices and visual quality ratings. (Figure 2). There significant treatment effects on canopy reflectance, statistically significant on all measurement dates (Table 3). There was a clear rate effect of both experimental PGRs and Primo on canopy reflectance, with higher rates reducing the NDVIs significantly

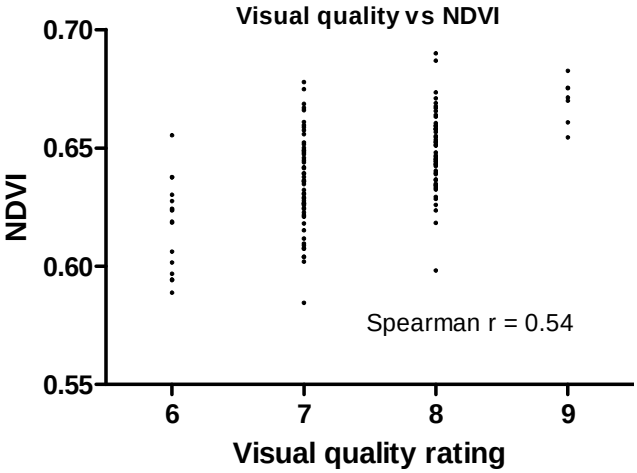

Figure 2. Association between visual quality ratings and canopy reflectance (NDVI). The Spearman correlation coefficient (r=0.54) is significant (alpha = 0.05).

Table 3. Canopy reflectance of treated plots (Normalized-difference vegetation index). Higher values indicate more absorbance at chlorophyll wavelength (i.e. increased photosynthetic activity, N status, quality, etc.)

	Date/DAT							
	8/22	8/26a[2]	8/26b	8/27	8/28a	8/28b	8/29	8/30
Treatment	-4	0	0.5	1	2	2.5	3	4
A01	0.625[1] dc	0.611 a	0.665 b	0.655 b	0.656 b	0.650 c	0.642 b	0.657 b
A02	0.620 dc	0.606 b	0.664 b	0.651 b	0.658 b	0.642 ef	0.637 c	0.647 cd
A04	0.630 abc	0.613 a	0.671 a	0.660 a	0.657 b	0.656 b	0.642 b	0.655 b
A08	0.629 abc	0.610 a	0.665 b	0.652 b	0.649 c	0.649 c	0.636 c	0.646 d
A16	0.631 ab	0.610 a	0.667 ab	0.655 b	0.656 b	0.644 de	0.637 c	0.646 d
Control	0.633 a	0.611 a	0.669 a	0.662 a	0.669 a	0.664 a	0.651 a	0.668 a
P1	0.628 bc	0.610 a	0.664 b	0.655 b	0.656 b	0.647 cd	0.636 c	0.650 c
P2	0.627 bc	0.606 b	0.659 c	0.651 b	0.647 c	0.640 f	0.628 d	0.638 e
lsd p=0.05	0.0055	0.0028	0.0037	0.0039	0.0051	0.0041	0.0035	0.0039
	8/31	9/02a	9/02b	9/3	9/4	9/5	9/06a	9/06b
Treatment	5	7	7.5	8	9	10	11	11.5
A01	0.658 b	0.655 b	0.646 b	0.648 b	0.652 b	0.660 b	0.661 b	0.641 c
A02	0.650 c	0.647 c	0.640 c	0.644 cd	0.641 cd	0.647 c	0.654 c	0.648 b
A04	0.653 c	0.647 c	0.641 c	0.646 bc	0.642 c	0.647 c	0.652 cd	0.649 b
A08	0.641 de	0.632 d	0.629 e	0.631 e	0.628 e	0.637 d	0.636 e	0.623 e
A16	0.638 ef	0.628 d	0.622 f	0.629 e	0.622 f	0.628 e	0.628 f	0.621 e
Control	0.670 a	0.672 a	0.659 a	0.666 a	0.670 a	0.679 a	0.682 a	0.666 a
P1	0.645 d	0.644 c	0.635 d	0.641 d	0.637 d	0.648 c	0.649 d	0.640 c
P2	0.636 f	0.630 d	0.628 e	0.630 e	0.628 e	0.635 d	0.636 e	0.631 d
lsd p=0.05	0.0041	0.0047	0.0045	0.004	0.0047	0.0044	0.0044	0.0049
	9/8	9/09a	9/09b	9/10	9/11	9/12	9/15	9/16a
Treatment	13	14	14.5	15	16	17	20	21
A01	0.646 b	0.659 b	0.660 b	0.654 b	0.632 b	0.662 b	0.678 b	0.676 b
A02	0.631 d	0.653 c	0.651 c	0.649 c	0.625 c	0.658 c	0.667 c	0.670 c
A04	0.634 d	0.647 d	0.649 c	0.645 cd	0.625 c	0.659 bc	0.669 c	0.670 c
A08	0.625 e	0.629 f	0.627 e	0.627 e	0.614 d	0.651 de	0.647 e	0.645 e
A16	0.622 e	0.621 g	0.624 e	0.618 f	0.609 e	0.644 f	0.634 f	0.631 f
Control	0.653 a	0.680 a	0.672 a	0.665 a	0.636 a	0.666 a	0.685 a	0.687 a
P1	0.640 c	0.650 cd	0.649 c	0.644 d	0.625 c	0.653 d	0.670 c	0.667 c
P2	0.626 e	0.634 e	0.634 d	0.626 e	0.613 d	0.648 e	0.652 d	0.650 d
lsd p=0.05	0.0047	0.0044	0.0044	0.0043	0.0033	0.0032	0.0045	0.0046
	9/16b	9/17	9/18	9/19a	9/19b	9/22	9/23a	9/23b
Treatment	21.5	22	23	24	24.5	27	28	28.5
A01	0.667 a	0.656 b	0.674 b	0.659 b	0.657 b	0.656 b	0.655 b	0.653 b
A02	0.657 b	0.661 b	0.671 bc	0.658 bc	0.655 b	0.656 b	0.651 b	0.650 b
A04	0.658 b	0.657 b	0.673 b	0.659 b	0.657 b	0.652 b	0.655 b	0.650 b
A08	0.639 c	0.638 d	0.645 e	0.630 e	0.633 d	0.625 e	0.626 e	0.624 d
A16	0.630 d	0.620 e	0.634 f	0.622 f	0.621 e	0.613 f	0.611 f	0.604 e
Control	0.670 a	0.673 a	0.684 a	0.668 a	0.667 a	0.668 a	0.670 a	0.667 a
P1	0.660 b	0.659 b	0.667 c	0.654 c	0.654 b	0.645 c	0.641 c	0.638 c
P2	0.642 c	0.646 c	0.652 d	0.641 d	0.638 c	0.633 d	0.633 d	0.624 d
lsd p=0.05	0.0047	0.0047	0.0045	0.0048	0.0051	0.0051	0.0054	0.0056
	9/24	9/25	9/26a	9/26b	9/29	10/1	10/3	10/06a
Treatment	29	30	31	31.5	34	36	38	41
A01	0.651 b	0.639 b	0.654 b	0.649 b	0.651 b	0.644 b	0.644 c	0.637 b
A02	0.647 b	0.638 b	0.651 b	0.647 b	0.652 b	0.646 b	0.650 b	0.638 b
A04	0.648 b	0.636 b	0.651 b	0.647 b	0.654 b	0.644 b	0.649 bc	0.635 b
A08	0.621 e	0.608 e	0.622 d	0.621 d	0.621 e	0.615 e	0.625 f	0.610 d
A16	0.605 f	0.598 f	0.604 e	0.596 e	0.596 f	0.595 f	0.603 g	0.588 e
Control	0.662 a	0.654 a	0.671 a	0.665 a	0.673 a	0.663 a	0.662 a	0.652 a
P1	0.637 c	0.628 c	0.633 c	0.636 c	0.640 c	0.634 c	0.637 d	0.626 c
P2	0.630 d	0.622 d	0.627 d	0.623 d	0.628 d	0.624 d	0.631 e	0.611 d
lsd p=0.05	0.0055	0.0058	0.0061	0.0056	0.0057	0.0052	0.0051	0.0057
	10/06b	10/9	10/10	10/14a	10/14b	10/15	10/16	10/23
Treatment	41.5	44	45	49	49.5	50	51	58
A01	0.631 b	0.628 cd	0.604 d	0.606 d	0.609 c	0.605 c	0.606 c	0.575 cd
A02	0.636 b	0.633 bc	0.610 bc	0.613 c	0.616 b	0.608 c	0.617 b	0.586 ab
A04	0.633 b	0.635 b	0.613 b	0.620 b	0.621 b	0.615 b	0.620 b	0.589 a
A08	0.609 d	0.612 f	0.585 f	0.585 f	0.587 e	0.586 e	0.589 e	0.561 e
A16	0.581 e	0.594 g	0.562 g	0.564 g	0.567 f	0.567 f	0.569 f	0.542 f
Control	0.652 a	0.642 a	0.629 a	0.636 a	0.633 a	0.626 a	0.630 a	0.590 a
P1	0.617 c	0.625 d	0.605 cd	0.606 d	0.603 d	0.604 c	0.602 c	0.580 bc
P2	0.612 d	0.618 e	0.594 e	0.593 e	0.599 d	0.593 d	0.596 d	0.573 d
lsd p=0.05	0.0054	0.0046	0.0051	0.0058	0.0065	0.0058	0.0056	0.0064

[1] Mean of 50-60 readings x 4 replicates. Means within columns followed by the same letter are not significantly different (Fisher's protected LSD, p=0.05).

[2] On dates when plots were mowed, canopy reflectance was measured before (a) and after (b) mowing.

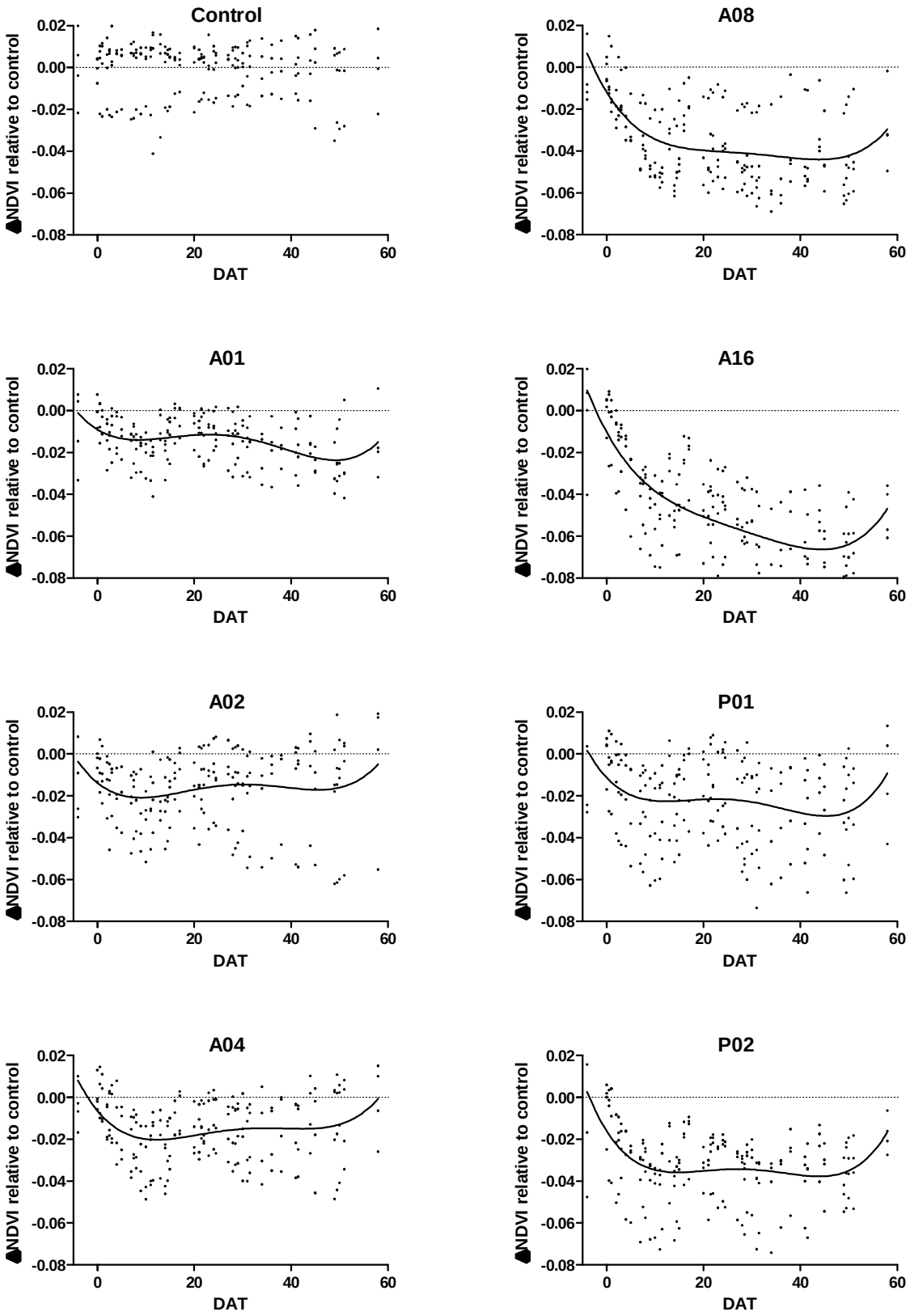

Figure 3. Reduction in canopy reflection by treatments (Control = 0). Curves are fourth order polynomials fitted by non-linear regression methods.

Table 4. Shoot tissue dry matter accumulation

Treatment	Days after first treatment										
	2	7	11	14	17	21	24	28	31	41	49
						g m^{-2} d^{-1}					
A01	1.26[1]	0.72 b	0.93 b	0.59 b	0.63 b	1.25 a	0.59 b	0.53 b	0.55 b	0.30 b	0.39 b
A02	0.89	0.48 bc	0.55 c	0.35 c	0.43 bc	0.71 bc	0.48 bc	0.37 c	0.37 c	0.20 c	0.28 bc
A04	1.18	0.52 bc	0.66 bc	0.43 bc	0.40 cd	0.61 bcd	0.49 bc	0.34 c	0.26 cd	0.17 cd	0.18 cd
A08	0.93	0.35 c	0.41 c	0.24 c	0.15 e	0.35 de	0.24 de	0.19 de	0.15 d	0.10 d	0.08 d
A16	1.13	0.37 c	0.47 c	0.28 c	0.18 de	0.27 e	0.17 e	0.14 e	0.14 d	0.09 d	0.08 d
Control	1.34	1.12 a	1.52 a	0.93 a	0.98 a	1.46 a	0.90 a	0.85 a	0.82 a	0.45 a	0.54 a
P1	0.94	0.52 bc	0.64 bc	0.45 b	0.48 bc	0.84 b	0.47 bcd	0.35 c	0.31 c	0.13 cd	0.15 d
P2	0.95	0.43 bc	0.43 c	0.32 c	0.32 cde	0.55 cde	0.34 cde	0.28 cd	0.26 cd	0.16 cd	0.16 cd
lsd p=0.05	NS	0.32	0.36	0.22	0.23	0.28	0.23	0.13	0.14	0.09	0.11

[1]Mean of 4 replicates. Means within columns followed by the same letter are not significantly different (Fisher's protected LSD, p=0.05).

Table 5. Shoot fresh tissue accumulation

Treatment	Days after first treatment									
	2	7	11	14	17	21	24	28	41	49
						g m^{-2} d^{-1}				
A01	2.62[1]	2.19 b	3.16 b	1.87 b	2.13 b	4.37 b	2.05 b	1.64 b	0.87 b	1.15 b
A02	1.53	1.41 bc	1.65 c	1.05 c	1.39 c	2.35 c	1.54 bc	1.11 c	0.57 bc	0.83 bc
A04	2.22	1.26 bc	1.80 c	1.04 c	1.16 cd	2.02 cd	1.35 bcd	1.02 c	0.47 cd	0.54 cd
A08	1.48	0.93 c	1.19 c	0.75 c	0.53 d	1.12 de	0.72 de	0.50 d	0.30 cd	0.24 d
A16	2.13	0.95 c	1.32 c	0.74 c	0.56 d	0.86 e	0.49 e	0.40 d	0.26 d	0.23 d
Control	2.90	3.67 a	5.50 a	3.19 a	3.64 a	5.54 a	3.04 a	2.95 a	1.49 a	1.78 a
P1	1.66	1.46 bc	1.98 bc	1.40 bc	1.48 bc	2.71 c	1.41 bcd	1.04 c	0.37 cd	0.41 d
P2	1.65	1.25 bc	1.24	0.88 c	0.96 cd	1.83 cde	1.03 cde	0.83 cd	0.43 cd	0.47 d
lsd p=0.05	NS	1.08	1.27	0.72	0.72	1.09	0.75	0.49	0.30	0.35

[1]Mean of 4 replicates. Means within columns followed by the same letter are not significantly different (Fisher's protected LSD, p=0.05).

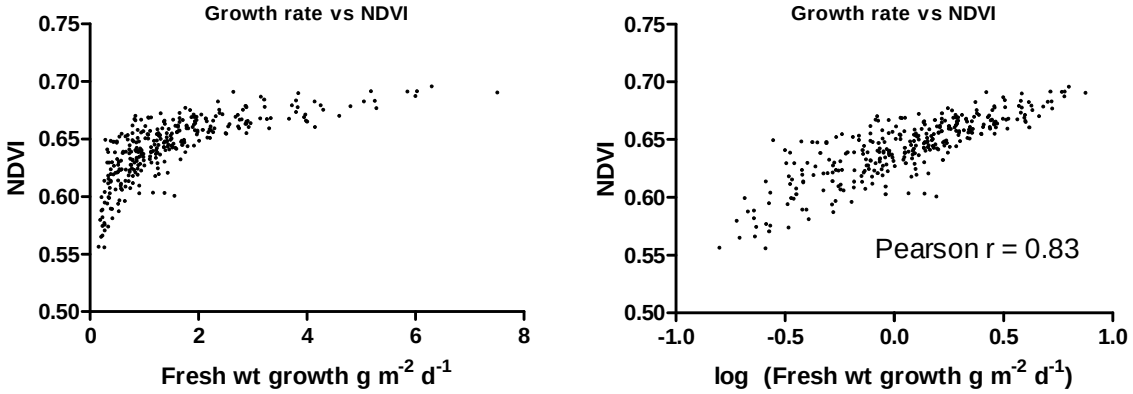

Figure 4. Relationship between canopy reflectance (NDVI) and growth rate as estimated by shoot fresh tissue growth. Decline in growth rate and canopy reflectance are more noticeable at lower values.

more than the lower rates. The effects of the treatments can be visualized by fitting non-linear regression curves to the mean NDVI values over time (Figure 3).

Growth rate. Both fresh weight (Table 4) and dry weight (Table 5) measurements of shoot dry matter accumulation showed a very similar pattern to quality and canopy reflectance data. As with quality, growth was strongly associated with canopy reflectance (Figure 4), though the relationship is not a linear one. The same rate effects that were seen in quality and canopy reflectance were also seen in growth rate. The graphical representation of the growth rate response to treatments over time shows the rate effect (Figure 5). The second treatment did not have the same clear effect on growth rate that it did on canopy reflectance, largely because the second treatment was applied in mid September, when the growth rate of the turf, including the control plots, was beginning to slow.

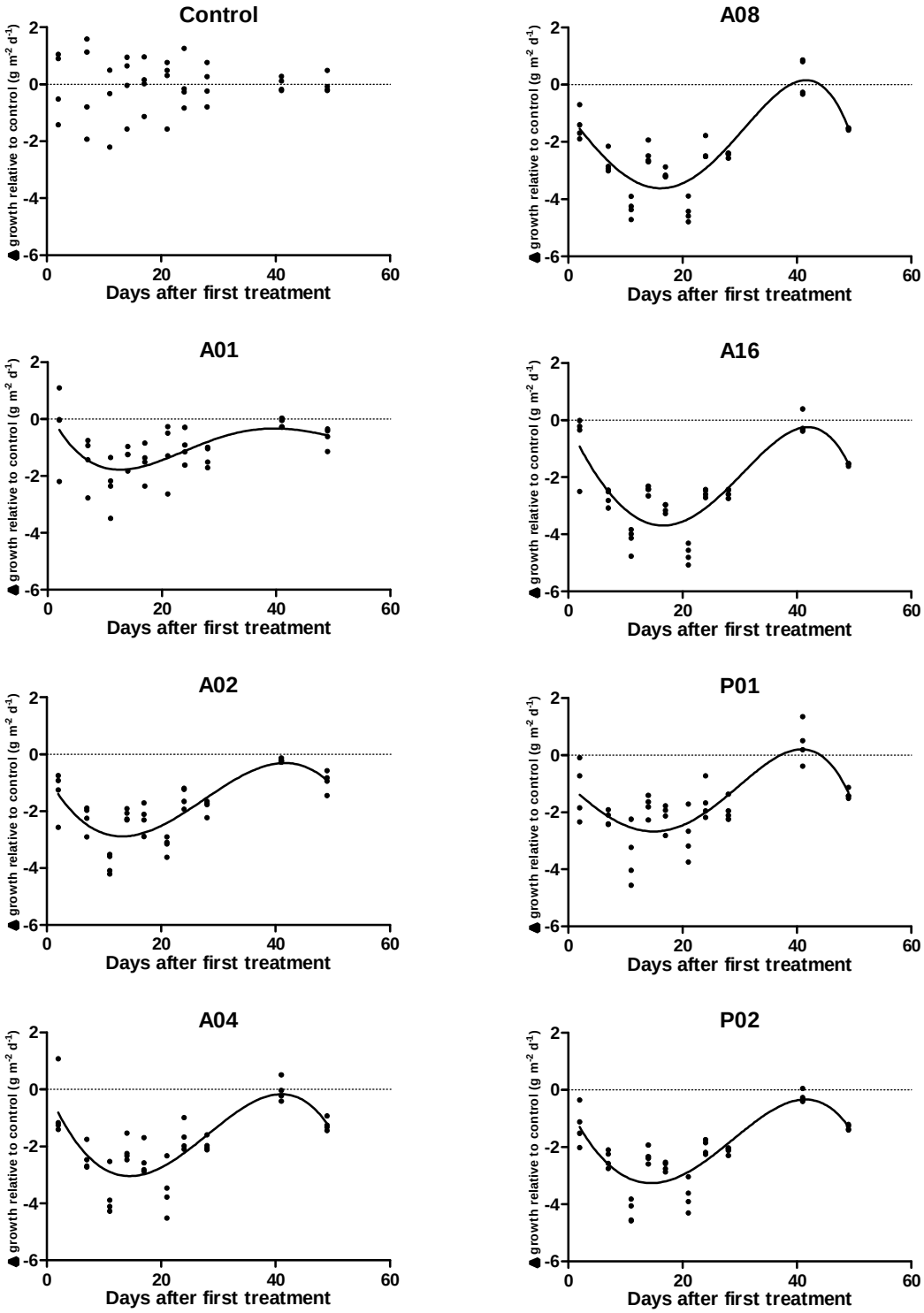

Figure 5. Reduction in shoot tissue growth rate by treatments (Control = 0). Curves are fourth order polynomials fitted by non-linear regression methods.

DISCUSSION AND CONCLUSIONS

All growth regulator treatments produced significant reductions in shoot tissue growth relative to the untreated check. There was a significant rate effect , with the higher rates (PGR at 0.28 and 0.56 kg ai ha^{-1}, and Primo MAXX at 0.192 kg ai ha^{-1}) reducing shoot growth by 68 to 76% over the period of the trial. The experimental PGR at 0.07 kg ai ha^{-1} performed roughly equivalent to Primo MAXX at 0.096 kg ai ha^{-1}, reducing overall shoot growth by about 60%, but did not have the negative effect on turf quality (assessed visually). Generally, the reduction in turf quality associated with all PGRs, compared to the control, was a result of differential effect (color and growth) on the bentgrass and annual bluegrass of which the turf was composed. The experimental PGR at the lowest rate (0.035 kg ai ha^{-1}) only reduced growth by about 34%, but also had a greater negative impact on quality than the next highest rate.

Sponsor: BASF Corporation