Anuew PGR Performance on Bentgrass Fairways

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Quick Glance

The objective of this research was to model the performance of Anuew PGR with respect to GDD on a creeping bentgrass fairway at three rate and to compare the performance to equivalent AI of trinexapac-ethyl. Both PGRs reduced clipping yield by 70 to 80%. Ideal re-application intervals ranged from 250 to 540 GDD. Higher rates of AI reduced the intensity and duration of the rebound phase while the lowest rate of AI resulted in a stronger and more symmetric rebound phase. The low rates also had weak secondary suppression & rebound growth phases. Visual quality was improved but high rates resulted in mild phytotoxicity as expected at maximum or above-label rates.

INTRODUCTION

Growing degree day models can successfully predict the performance of gibberellin-inhibiting plant growth regulators (PGRs) applied to cool-season golf putting greens. These models are effective because metabolism or degradation of PGRs was found to be directly related to air temperature. Relative clipping yield of turfgrasses treated with PGRs follow a sinewave model with a period of growth suppression followed by a period of growth enhancement, hereafter called rebound, with respect to non-treated cool-season putting greens. Prior research found growth suppression is magnified on higher mower creeping bentgrass, such as golf course fairways. Recently, a new Class A PGR, late-GA inhibitor, called prohexadione-Ca (PC) became registered for use on turfgrass as Anuew (Nufarm). The performance of this new PGR on creeping bentgrass fairways is relatively unknown.

The objectives of this research were to i) develop GDD models for PC applied to creeping bentgrass fairways, ii) evaluate the impact of application rate on growth and visual quality response, and iii) compare the performance of PC to another Class A PGR, trinexapac-ethyl (TE), at equivalent rates of active ingredient.

METHODS

This research was conducted on an ‘L-93’ creeping bentgrass fairway at the JSA Turf Research Facility in Mead, NE during 2015. The fairway was constructed to USGA recommendations for putting green construction, mowed 2 d wk^{-1} at 0.380”, irrigated to 80% of pET, and fertilized weekly with 0.1 lbs N/1000 ft^2 from urea fertilizer. Topdressing and cultivation was avoided during the growing season to avoid impacting on data collection. Diseases were controlled curatively with fungicides; DMI fungicides were not used. A wetting agent (Revolution, Aquatrols) was applied monthly to ensure uniform water distribution.

The experimental design was a RCBD with three replicate blocks. Plots measured 5’x5.’ Treatments included Anuew at three rates, Primo Maxx at equivalent amounts of active ingredient (AI) per acre and a non-treated control (Table 1). All PGR treatments were re-applied approximately 1200 GDD Celsius after the first application (base temperature of 0°C). Temperature data was obtained from an on-site weather station and the GDD model was reset to 0 GDD when the PGRs were re-applied. Applications were made with a CO_2-powered backpack sprayer equipped with three TeeJet XR8006 flat fan nozzles. The sprayer output volume was calibrated to 2.0 gal/1000 ft^2 at 40 psi. The first application occurred on 19 June 2015 and the second application occurred on 11 August 2015.

Clippings were collected every time the fairway was mowed, approximately two times a week, by mowing one pass down the center of each pass with a Toro GM1000 walking greensmower. Clippings were then dried for 48 h at 70°C and weighed. To calculate relative clipping production, mean dry clipping weights for each PGR treatment was divided by the mean dry clipping weight of the non-treated control for each collection date. The final clipping collection occurred on 15 September 2015.

Relative clipping yield was modeled relative to GDDs following PGR application with waveform regression in SigmaPlot 13. The model was a three parameter sinewave model:

$$Relative\ yield = A*e(-GDD/C)*sin\ (2\pi*GDD/B+\pi) + y_{int}$$

Briefly explained, relative yield (g g^{-1}) is a function of the amplitude of growth suppression/rebound (*A*) times the sine of 2π times GDDs accumulated from the most recent PGR application divide by period (*B).* The period is the duration of time, in GDDs, required for the suppression and rebound response to occur. The intercept term (y_{int}) was the average of all the data points within each particular model. The *C* term was included in the model because some of the treatments lacked a symmetric suppression and rebound phase. The *C* term dampens the waveform as GDDs are accumulated. Student's *t-tests* were used to compare the amplitude, period, and dampening terms for the six PGR models with α=0.05. The ideal GDD interval for each PGR was determined by dividing the period by 3. This corresponds with a point 33% between the point of maximum growth suppression and the suppression/rebound transition point.

Turfgrass visual quality rating and phytotoxicity were rated every two weeks. Visual quality was rated on a 1 to 9 scale with 1 representing dead, 6 representing minimally acceptable, and 9 representing perfect fairway visual quality. This visual quality rating is affected by turfgrass color, density, stand uniformity, leaf texture, etc. Phytotoxicity was rated on a 1 to 9 scale where 1 represented no phytotoxicity and 9 represented severely impacted turf with complete discoloration. Repeated measures analysis was conducted in JMP12 Pro with means separated by Fisher's protected LSD.

RESULTS AND DISCUSSION

Both PGRs substantially reduced clipping production regardless of application rate. Peak suppression generally occurred 200-300 GDD after application. It was common to achieve 70 to 80% growth suppression relative to the non-treated control. Sinewave regression analysis indicated that clipping yield was highly correlated to GDD accumulation (Table 2). Model adjusted r^2 values ranged from 0.605 to 0.818 with all models statistically significant at $p<0.001$ (Figures 1-6). All model coefficients were significant at $p<0.100$ with the exception of the amplitude coeffient for the high-rate Primo Maxx ($p=0.175$). The models were having a difficult time fitting the amount of peak suppression. This resulted because of a lack of data points between 0 and 200 GDD. More applications are needed in 2016 to increase model robustness.

Duration of PGR Impact

The model period coefficient represents the time that is takes, in GDDs, for the suppression and rebound growth phases to occur. The period for Anuew ranged from 784 to 1067 GDD and ranged from 745 to 1607 GDD for Primo Maxx (Table 3). The period was not different between the low and medium AI rates of Anuew and Primo Maxx. However, Primo Maxx at the 6.0 oz/acre rate lasted longer than Anuew at the same AI rate. The ideal GDD re-application interval for the 2.0 and 4.4 oz AI/acre rates was 260 and 360 GDD, respectively (Table 4). The interval for Anuew at 6.0 oz AI did not increase the compared to the 4.4 oz AI application rate. Increasing the Primo Maxx rate from 4.4 to 6.0 oz/acre increased model period and lengthen the ideal re-application interval from 340 GDD to 540 GDD (Table 4).

The ideal GDD intervals for the low rate of Anuew and Primo Maxx were similar to the intervals for those PGRs on bentgrass putting greens. During that prior putting green research, Anuew was applied at 2.0 oz AI/acre (0.184 oz product/1000 ft^2) and had an ideal re-application interval of 280 GDD. The ideal Primo Maxx re-application interval was also found to be 230 GDD applied at 0.7 or 1.4 oz AI/acre (0.125 and 0.250 fl oz product/1000 ft^2). Increasing application rate to 2.0 fl oz AI/acre (0.370 fl oz product/1000 ft^2) only slightly increased the ideal re-application interval for Primo Maxx (250 GDD). The 4.4 and 6.0 oz AI/acre rates of Primo Maxx did extend control but these rates are greater than the rates allowed by the product label for creeping bentgrass greens and fairway (2.7 oz AI/acre or 0.50 fl oz product/1000 ft^2). This supports our prior findings that adjusting Primo Maxx application rate will have a minimal impact on the duration of effective control.

There is limited rate response research for Anuew, but this research indicates that the high labeled rate (Figure 2) for creeping bentgrass fairways (4.4 oz AI/acre or 0.370 fl oz product/1000 ft^2) provided better control than the low-labeled rate (Figure 1; 2.0 oz AI/acre of 0.170 fl oz product/1000 ft^2). Further increasing application rate did not increase the duration of control (Figure 3). More research needs to be completed to build confidence in these results. They are the outcome of only two application dates in 2015 and data collection was less frequent on fairway turf than putting green turf (it is mowed less frequently).

Clipping Yield Suppression

The models reveled evidence of a secondary suppression and rebound phase following the initial suppression and rebound growth phases (Figure 1-6). These secondary phases justify the inclusion of amplitude dampening coefficient in the regression models (Table 1). It’s likely that secondary, and possibility tertiary, suppression and rebound growth phases are the result of feedback mechanisms within the gibberellic acid pathway. Larger dampening coefficients (Figures 1 and 4) result in a more symmetric suppression and rebound growth phase while smaller coefficients cause the amplitude to decay more rapidly (Figures 2, 3, 5, and 6). This rapid decay results in a shallower and shorter rebound phase. Interestingly, the lower active ingredient treatments for both PGRs had statistically similar dampening coefficients, around 750. The medium and high rates of AI for both PGRs had dampening coefficients in the lower 300s; resulting in a shallower and shorter rebound.

The amplitude term cannot be used by itself to estimate the maximum amount of clipping yield suppression. Relative clipping yield is a function of both the amplitude and dampening coefficients. Past PGR GDD research has been conducted on putting greens with minimal evidence of amplitude decay in the primary suppression and rebound growth phases. This meant the amplitude coefficient corresponded with maximum yield suppression and rebound. In this research, the amplitude dampening, ¼ model period, and amplitude coefficients are required to calculate the maximum amount of growth suppression (Table 4). Even so, the models struggled to accurately fit the amount of peak suppression because of a lack of data points between 0 and 200 GDD (Figures 1-6). These points are particularly important when fitting the amplitude and dampening coefficients. More experimental runs will strengthen the model estimates. For now, it is clear that both PGRs will provide exceptional clipping yield suppression (greater than 50%) from roughly 200 to 300 GDD after application.

Quality and Phytotoxicity

The creeping bentgrass had very good turfgrass visual quality during the experiment. However, turfgrass visual quality did decline for all treatments after the first application of PGR treatments (Figure 7). The higher PGR rates resulted in higher levels of phytotoxicity (Figure 8). The turfgrass had a blue-brown coloration and the leaf tips were brown. It is likely that some of the discoloration was the result of substantial growth suppression that limited the plant's ability to growth through damage. Managers are encouraged to mow to the 1/3rd rule to avoid over-mowing when the growth rate is very low. All the PGRs had the same or slightly better turfgrass quality during July (rebound growth phase). There was limited phytotoxicity following the second application of PGR treatments in August (Figure 8). Visual quality was then enhanced during mid- to late-August (suppression phase; Figure 7). This has been thoroughly documented in the past with Primo Maxx and also appears with Anuew.

The amount of phytotoxicity with Primo Maxx may be surprising, but it is important to emphasize that the Primo Maxx medium and high rates are in excess of the labeled rate of 0.14 oz AI/acre (0.25 fl oz product/1000 ft^2). It was expected to observe some level of phytotoxicity at such high rates. This small dataset suggests that prohexadione-Ca may be slightly safer than trinexapac-ethyl at equivalent amounts of active ingredient, but the risk of phytotoxicity is likely minimal at labeled applications rates for both products.

CONCLUSIONS

Both Anuew and Primo Maxx substantially reduced clipping yield of a creeping bentgrass fairway. This work provides more evidence that higher mown turfgrass is more impacted by Class A PGRs than putting green height turfgrass. The duration of the growth phases (primary suppression and rebound) is similar to results on bentgrass putting greens at similar application rates. Increasing application rate increased the duration of control but also increased the risk of phytotoxicity and had minimal impact on the amount of growth suppression. A sinewave dampened model was most appropriate to model PGR response to GDDs. Interestingly, higher application rates reduced the intensity and duration of the primary rebound phase. There was also evidence of a secondary suppression and rebound phase at the low rates of Anuew and Primo Maxx. The results from this study are strengthening our hypothesis that PGR duration and degradation is affected by temperature, and can be predicted with GDDs, while the magnitude of growth suppression, presence/absence of a rebound phase, and secondary suppression/rebound is likely impacted by processes within the plant. This research has shown that labeled rates of Anuew can provide substantial growth suppression for 250 to 350 GDD on a creeping bentgrass fairway and that growth suppression is similar to Primo Maxx at equal amounts of active ingredient.

TABLES AND FIGURES

Table 1. The PGR treatments evaluated in 2015.

Plant growth regulator	Active ingredient (%)	Active Ingredient	Product Application Rate
		wt. oz./acre	oz/acre (oz/M)
Non-treated control	na	na	na
Anuew	Prohexadione-Ca (27.5%)	2.0	7.4 (0.17)
		4.4	16.1 (0.37)
		6.0	21.8 (0.50)
Primo Maxx	Trinexapac-ethyl (11.3%)	2.0	16.3 (0.37)
		4.4	35.5 (0.81)
		6.0	47.9 (1.10)

na   not applicable

Table 2. Sinewave regression model results and parameter estimates for the various PGR products and application rates.

Plant growth regulator	Active Ingredient	Adjusted r^2	Model Significance	Amplitude (*A*)	Period (*B*)	Dampen (*C*)	Intercept (y_{int})
	wt. oz./acre			$g\ g^{-1}$	GDD		$g\ g^{-1}$
Anuew	2.0	0.776	***	1.09**	784***	777*	1.13***
Anuew	4.4	0.704	***	1.61*	1067***	334*	1.09***
Anuew	6.0	0.757	***	2.01**	923***	329**	1.19***
Primo Maxx	2.0	0.723	***	1.41**	745***	705*	1.18***
Primo Maxx	4.4	0.605	**	1.34*	1025***	323*	1.05***
Primo Maxx	6.0	0.816	***	2.14†	1607**	356*	1.19***

*   Model coefficient significant at p<0.100

**   Model coefficient significant at p<0.010

***   Model coefficient significant at p<0.001

†   Coefficient p-value = 0.1746

Table 3. Impact of PGR product and application rate on the magnitude of the suppression and rebound growth phases.

Plant growth regulator	Active Ingredient	Amplitude	Dampening	Period
	wt. oz./acre	$g\ g^{-1}$		GDD
Anuew	2.0	1.09b	777a	784c
	4.4	1.61ab	334ab	1067ab
	6.0	2.01a	329b	923b
Primo Maxx	2.0	1.41ab	705ab	745c
	4.4	1.34ab	323ab	1025ab
	6.0	2.14ab	356ab	1607a

Table 4. Impact of PGR product and application rate on the duration of growth alteration and the ideal re-application interval to sustain season-long growth suppression.

Plant growth regulator	Active Ingredient	Relative Yield at Peak Suppression	Ideal GDD re-application interval
	wt. oz./acre	% of control	GDD
Anuew	2.0	28.4%	260
	4.4	36.8%	360
	6.0	18.9%	310
Primo Maxx	2.0	9.9%	250
	4.4	41.5%	340
	6.0	49.3%	540

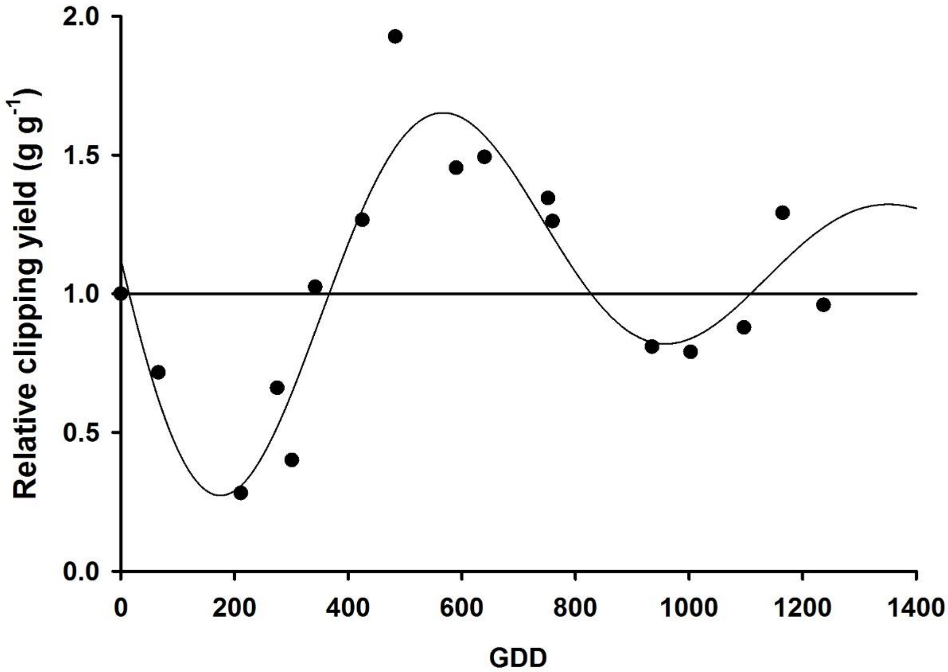

Figure 1. Clipping yield of a creeping bentgrass fairway treated with the low-labelled rate of Anuew PGR (2.0 wt. oz. AI/1000 ft^2).

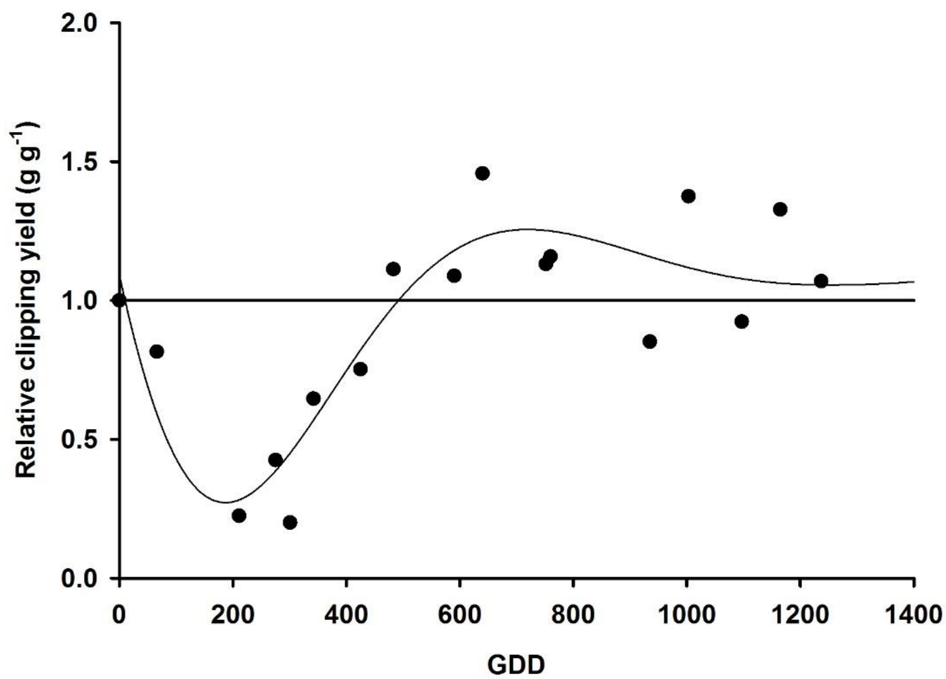

Figure 2. Clipping yield of a creeping bentgrass fairway treated with the medium-labelled rate of Anuew PGR (4.4 wt. oz. AI/1000 ft^2) for a creeping bentgrass fairway.

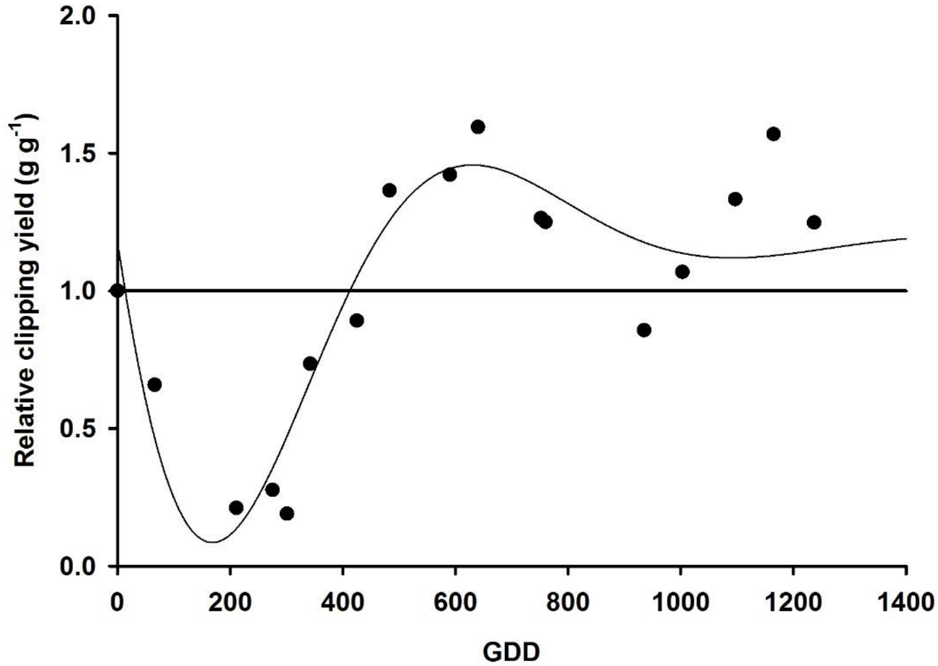

Figure 3. Clipping yield of a creeping bentgrass fairway treated with the high-labelled rate of Anuew PGR (6.0 wt. oz. AI/1000 ft^2).

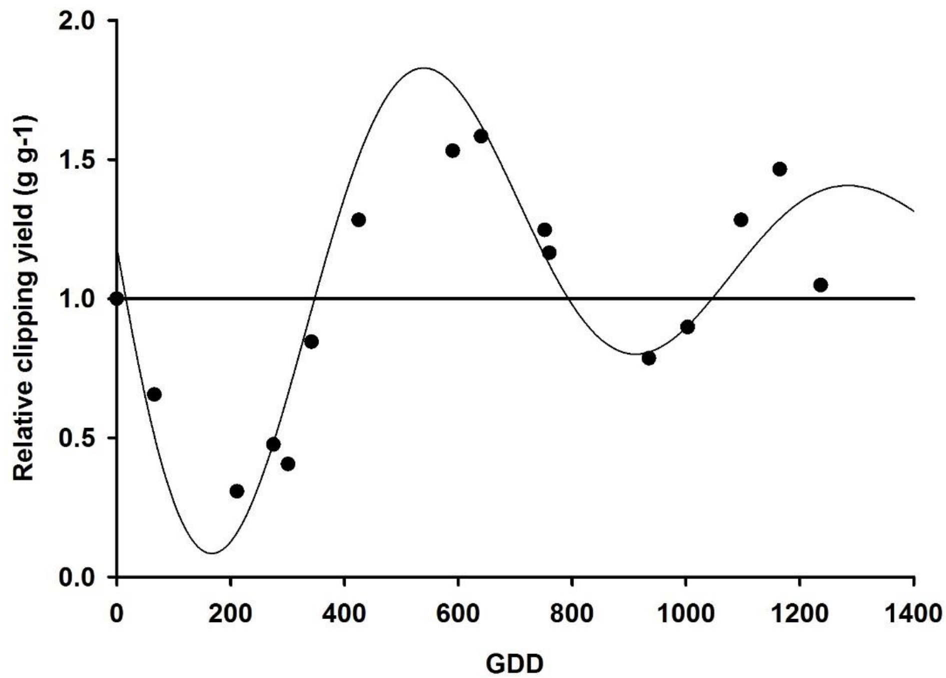

Figure 4. Clipping yield of a creeping bentgrass fairway treated with Primo Maxx applied at equivalent levels of active ingredient as the low-labelled rate of Anuew (2.0 wt. oz. AI/acre).

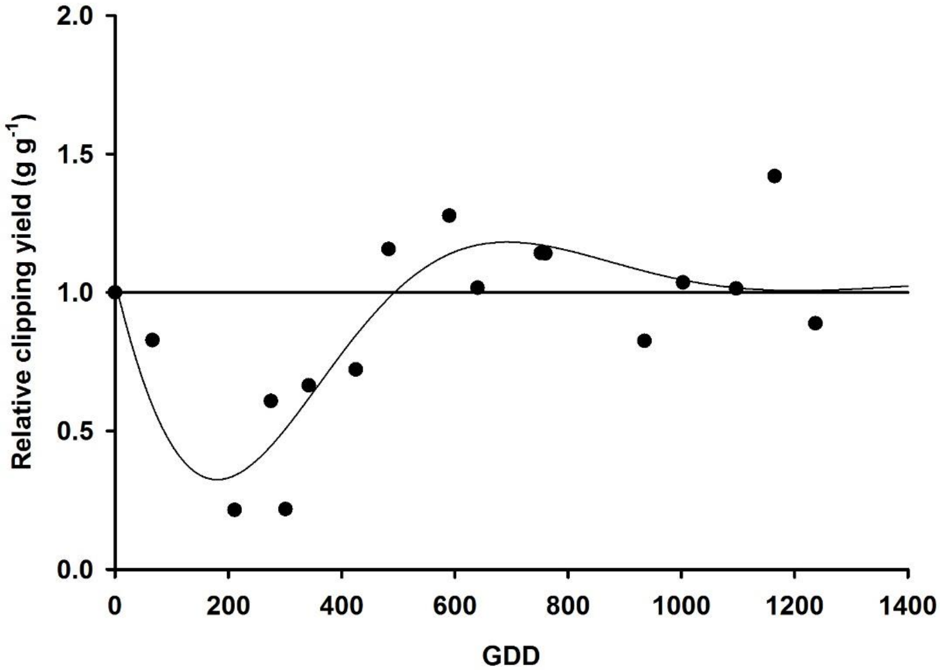

Figure 5. Clipping yield of a bentgrass fairway treated with Primo Maxx applied at equivalent levels of active ingredient as the medium-labelled rate of Anuew (4.4 wt. oz. AI/acre).

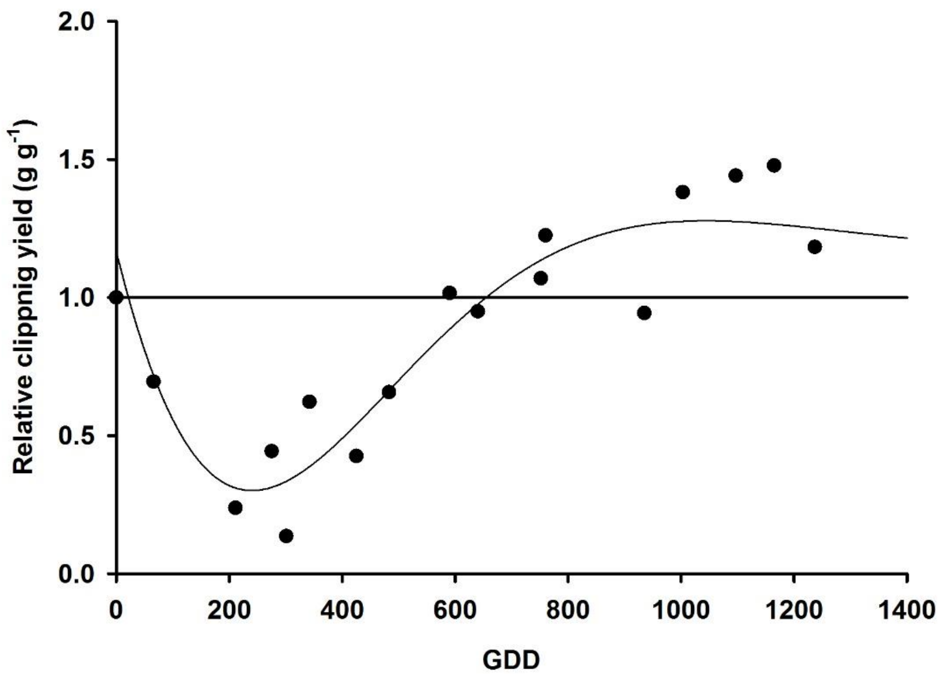

Figure 6. Clipping yield of a creeping bentgrass fairway treated with Primo Maxx applied at equivalent levels of active ingredient as the high-labelled rate of Anuew (6.0 wt. oz. AI/acre).

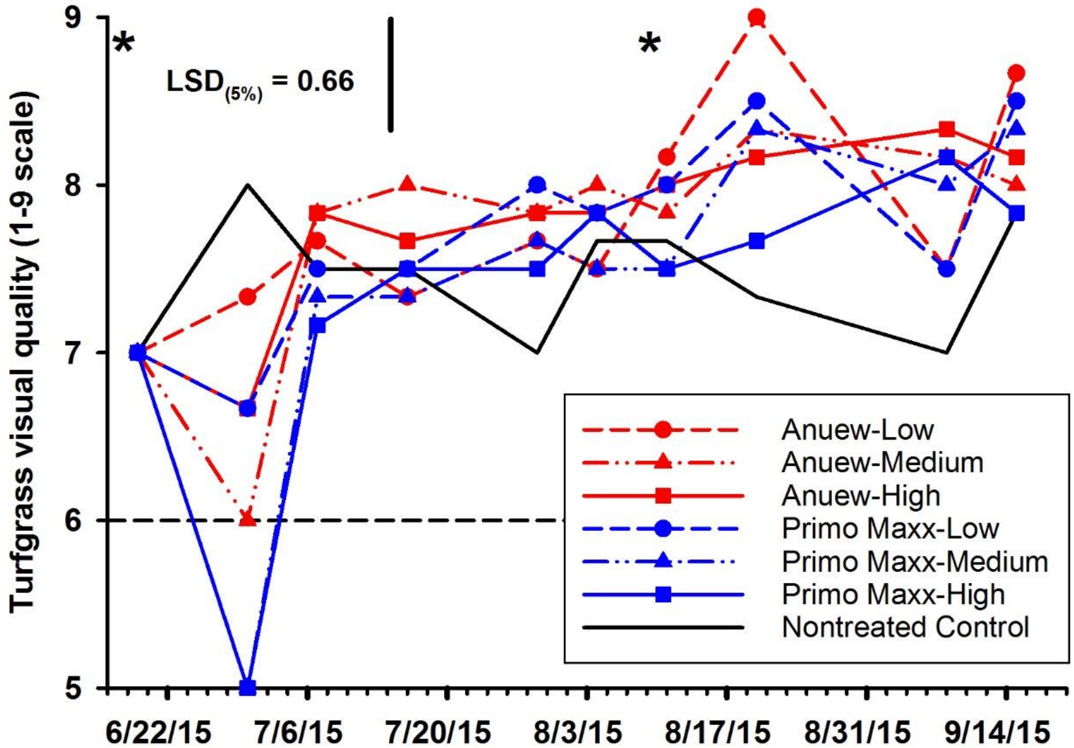

Figure 7. The impact of various rates of Anuew PGR and equivalent rates of Primo Maxx PGR on visual quality rating of a creeping bentgrass fairway. Visual quality was rated on a 1 to 9 scale where a rating of one represented dead, six represented minimally acceptable (dashed horizontal line), and nine represented perfect visual quality. The asterisk indicates when the PGR treatments were applied.

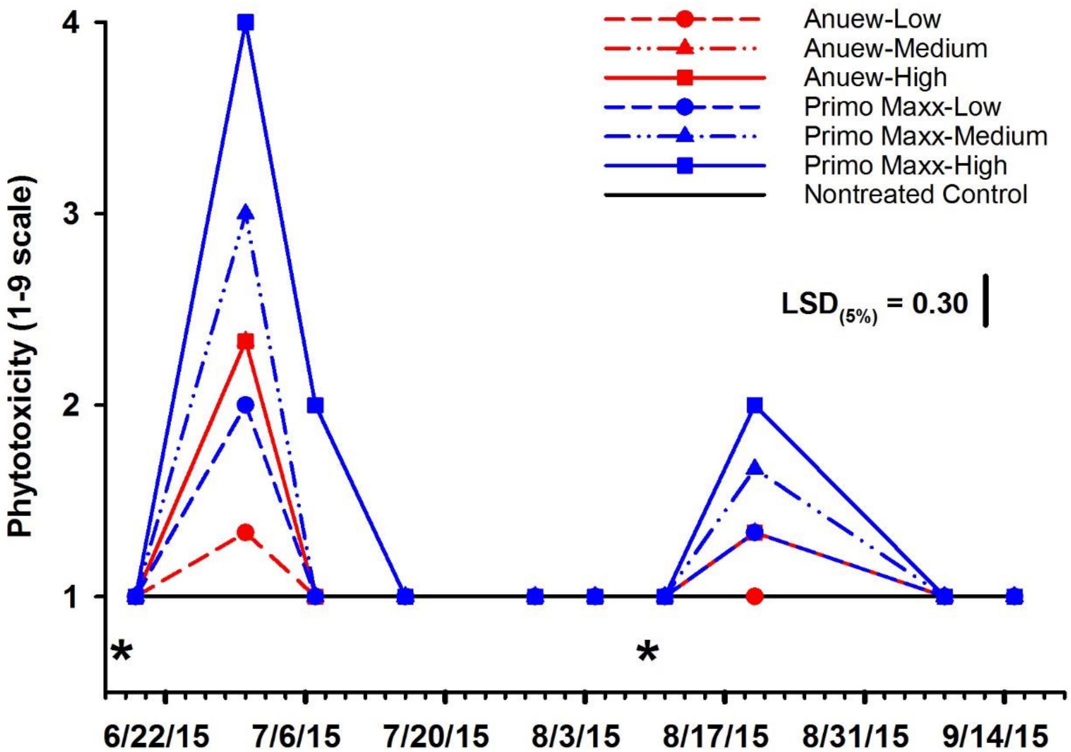

Figure 8. Visual phytotoxicity rating of the PGR treatments on a creeping bentgrass fairway turf. Phytotoxicity was rated on a 1 to 9 scale where a rating of one represented no observable phytotoxicity and nine represented severe discoloration/chlorosis of the turf. The asterisk indicates when the PGR treatments were applied.