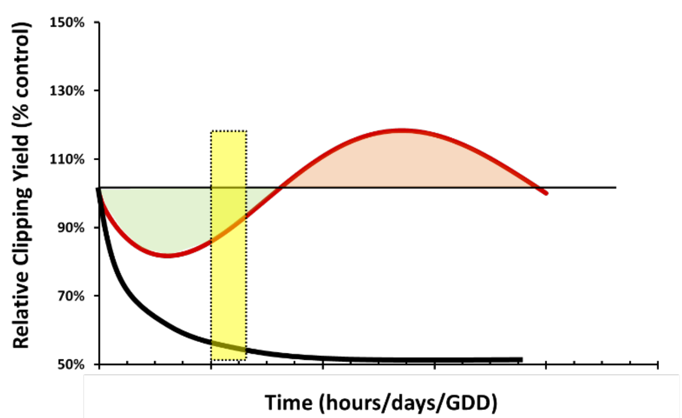
What I've learned about PGRs this year
11/29/16

Since 2010, I've been extremely fortunate to travel around the country to discuss my plant growth regulator (PGR) growing degree day (GDD) modeling research. One of the best parts of my job is making new discoveries and then sharing those with turfgrass managers. And, the learning process never stops because most research produces more questions than answers. Our GDD modelling research for PGRs has not been any different. We've doubled down on our PGR research the past two years and we've learned a lot, but have more questions, too. I'd be remiss if I didn't thank the other researchers helping with this research around the country. The labs of Dr. Soldat, Dr. Kerns, Dr. Brosnan, Dr. McElroy, Dr. Young, Dr. Richardson, and Dr. McCurdy have all furthered our knowledge of PGRs on golf and sports turf. I wanted to briefly summarize some of the current findings in this Turf iNfo. *Please keep in mind that these data are very preliminary and the research is still active. We'll have more specific information shortly.*

1) ***Performance of all Class A and B PGRs can be modeled with GDDs***

The initial GDD models were created for trinexapac-ethyl (Primo Maxx) on creeping bentgrass greens in Madison, WI. That research was conducted during the 2008-2010 growing seasons. Since that initial publication, PGR GDD models have been created for prohexadione-Ca (Anuew) – another foliar absorbed Class A PGR – and for the root absorbed Class B PGRs of flurprimidol (Cutless) and paclobutrazol (Trimmit). Models have also been created for combination products like Legacy and Musketeer (supplemental table). All PGRs have a similar impact on turfgrass clipping yield. First, clipping yield is reduced as synthesis of plant hormone gibberellin (GA) is inhibited following application of PGR (Figure 1). Maximum growth suppression develops over time (typically 150-250 GDD after application on cool-season greens). Relative clipping yield then increases following maximum suppression. Class B PGRs alone and combination products containing Class B PGRs generally have a longer suppression period and deeper maximum growth suppression than Class A PGRs alone.

Figure 1. The impact of GA inhibiting PGRs on turfgrass clipping yield. The red line represents clipping yield relative to non-treated turf and the black line represents the concentration of PGR within the plant. The green region represents growth suppression phase, the orange represents the rebound phase, and yellow the represents the ideal re-application interval.



2) ***Application rate impacts amount of suppression, not duration of suppression***

A common question is how does application rate impact PGR performance. It is becoming very clear than application rate has more of an impact on the amount of suppression than the duration of the suppression phase. For example, the low rate of paclobutrazol (5.5 fl oz/1000 ft^2) applied to 'V-8' creeping bentgrass putting greens reduced clipping yield by 31% at peak suppression and needed to be re-applied at roughly 270 GDD to sustain growth suppression. While the high rate (16 fl oz/1000 ft^2) suppressed clipping yield by 53% with an ideal re-application interval of 310 GDD. That difference of 40 GDD is less than two calendar days during summer (high temperatures near 80F with lows near 60F). Clearly tripling rate had little practical impact on the duration of control but had a very significant impact on the amount of suppression.

3) Know the base temperature

The base temperature for the GDD models is **0° Celsius for cool-season turf**. The benefit of the Celsius scale is the base temperature is zero, so it doesn't need to be subtracted from the daily mean air temperature. Still, too many managers try to use the Fahrenheit scale and base temperatures ranging from 32 to 50F for their calculations. To correctly use a Fahrenheit scale, turf managers need to subtract 32 from the daily mean air temperature and then multiply the ideal interval by 1.8 (to convert from C to F). This means with a re-application interval of 200 GDD (base 0C) the interval inflates to 360 GDD (base 32F).

This year we have studied GDD models for warm-season turf, mainly bermudagrass greens and fairways. While I'm reluctant to give exact GDD intervals at this point, it is clear that Primo Maxx and Anuew remain active in warm-season turf stands for a significantly longer time. The suppression phase can last for three or more weeks in the middle of a North Carolina summer. For these species, a base temperature of 0C is likely inappropriate. I've been fortunate to serve on the MS committee of Ethan Flourney at Mississippi State University. He is finding the base temperature of warm-season turf to be 10-12C. Apply a base of 10C to the GDD models being developed on ultradwarf greens by Wendell Hutchens and Jim Kerns at NC State University and the warm-season GDD models and intervals become very similar to the models and intervals for cool-season putting greens. More information is sure to come from this research.

4) PGR over-regulation is real

Over the past couple summers, we've seen more and more *over-regulation* from too frequent PGR applications. This seems to occur more and more as end users are making custom PGR mixes with different rates and chemistries. The symptoms of *over-regulated* turf are segregation of grass species, blue-brown discoloration, and the inability to recover from traffic or disease. Some pathologists even believe the severe growth suppression (ranging from 60 to 90%) may be related to the emergence of new diseases like anthracnose on bentgrass and mini ring on bermudagrass.

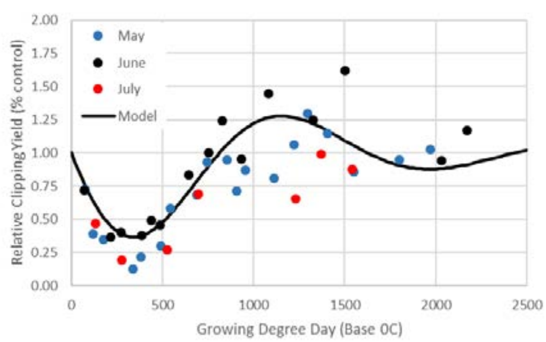
The familiar appearance of PGR over-regulation on a bent-poa putting green.

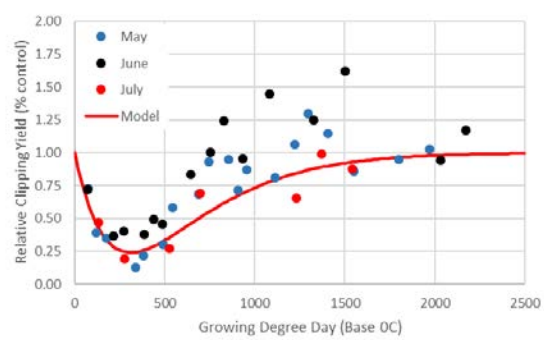
Over-regulation is not only a PGR application rate issue. Yes, higher application rates can intensify growth suppression, but low rates at very tight re-application intervals can also cause significant growth suppression. The important concept is PGR half-life within the turf. Beasley and Branham (2005) showed the half-life of Primo Maxx in creeping bentgrass was 6.4 days at 68F and 3.1 days at 86F. Convert that to GDD and the half-life of Primo Maxx in creeping bentgrass is roughly 100 GDD. The ideal re-application interval for Primo is roughly 200 GDD. That means roughly 75% of the last PGR application is gone when the next application is made. Re-application of PGR at one half-life, instead of two, causes the amount of PGR within the plant to build up. This increases the effective dose in the plant and further intensifies growth suppression.

Build-up of PGR in the plant is most likely when i) switching to or mixing a PGR that has a longer half-life (i.e. paclobutrazol), ii) when models for putting greens are used for other turf areas like fairways, or iii) when the wrong base temperature is used (i.e. warm-season turf species). For example, many turfgrass managers in the Southeastern US apply Primo Maxx every four to seven days on their ultradwarf putting greens. The rational is to apply very low rates (1 fl oz/1000 ft^2) very frequently for low and consistent suppression. The problem is that low rate can build up over time because the interval is much sooner than one half-life. In effect, the managers are applying Primo Maxx faster than the plant can break it down and growth suppression in intensified. Over time, it is common to observe 90% growth suppression on these stands.

5) ***Fairway height turf has more growth suppression.***
This last year, Dr. Soldat and I have been testing all commercially available GA inhibitors on creeping bentgrass fairway plots. Our results have been promising and somewhat unexpected. I'll write another Turf iNfo summarizing these experiments later this winter, but the take-home message is both amount of growth suppression and duration of suppression is roughly 50%-100% greater than it is on bentgrass greens. We are working to understand why this occurs. Potentially the turf is growing at a slower rate which makes it more responsive to the PGR. That would also mean that absolute clipping yield may also impact the duration of growth suppression because some of the PGR will be removed with clippings. This makes collars and approaches a prime target for over-regulation because a turf manager will schedule PGR applications for the putting green turf; turf that is less responsive to PGR applications.

6) ***The rebound phase doesn't always occur***
Up until this time last year, I thought the rebound phase always followed the suppression phase. In my seminars I talk about "avoiding the rebound" because numerous secondary benefits occur during the suppression phase. Those benefits, like stored carbohydrates and increased turf color, dissipate as growth surges in the rebound phase. However, data from Dr. Young at Texas Tech University showed creeping bentgrass greens did not have a rebound phase in Texas. We observed that same phenomenon when we applied PGRs to our fairway treatments in Nebraska this July. Instead of a large rebound phase that mirrored the suppression phase, the clipping yield slowly returned to the level of the non-treated turf. In some cases, there was only a very small rebound phase. This is most likely to occur in the months of July and occasionally in May. Interestingly, a strong rebound was observed in Texas, Nebraska, and WI when the PGRs were applied in June. There is even evidence of a secondary growth suppression and rebound phase following the first rebound phase and the growth response modulates or dampens away.





The figure on the left shows the GDD model for Anuew applied to a creeping bentgrass fairway in June (black). Notice the large rebound and subsequent secondary suppression phase. The figure on the right has the GDD model from the July (red) application. Notice the lack of rebound as growth effects dampen away. The point of max suppression is relatively the same. This suggests the ideal interval is also roughly the same despite the differences in rebound.

The time of year appears to have a big impact on PGR performance. We can speculate that production of GA may be greater in June than July. This would lead to a large "back-log" of GA precursors when a PGR is applied in June. This back-log of hormone precursors could then promote a large rebound phase once the PGR is broken down or mowed off. June is a time when cool-season grasses produce seed heads and GA production is important to that process, so the theory does make some sense. To dig deeper, we really need to understand how GA production changes over the course of the growing season. This information would have broad impacts on a range of turfgrass topics from PGR performance modeling, to growth potential models, to turf nutrient requirements. We've applied for a USGA grant to hopefully study this over the next three years.

How does the lack of rebound impact re-application intervals? It doesn't, fortunately. We still find that peak suppression occurs roughly the same GDD (150 to 250 GDD for cool-season turf depending on PGR a.i. and application rate). While we may not be 100% certain what will occur following suppression, the duration of the suppression phase is consistent because degradation of the PGR is determined by air temperature. The amount of suppression and the presence or absences of the rebound phase may vary with time of year and other factors, but timing PGR re-applications can be estimated with simple GDD models.

The body of knowledge behind PGR modeling is growing rapidly. It certainly is an exciting time to be a PGR researcher. The good news for turf managers is the latest PGR models are being built into our web-app, http://GreenKeeperApp.com. This site automatically determines the ideal GDD interval based on the PGR, rate, grass species, and management area. It then tracks PGR GDDs based on our location and provides estimates of growth suppression and rebound. I'd personally like to thank Nufarm and SePRO for their donations to my research program and Nufarm for sponsoring GreenKeeper. This research and the app improvements would not be possible without their support.

PGR Performance on Cool-Season Putting Greens:
http://turf.unl.edu/PGR%20Performance%20on%20Cool.pdf

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