Avoid the Rebound: Use of Growing Degree Days to Re-apply Growth Regulators

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The most poorly understood products applied to turfgrass are plant growth regulators (PGRs) because 1) it is difficult tell when they are working and 2) their labels can be vague. This is especially true when PGRs are applied to golf course putting greens. Despite best efforts, it is nearly impossible to tell how well a PGR is suppressing putting green clipping yield. As a result, many golf course superintendents use vastly different application rates and frequencies for each PGR in their arsenal. This ambiguity leads to one of the most common questions superintendents tend to ask, "What rate should I use on my greens?"

Before we tackle that question let's get back to the basics. The most commonly applied PGRs used on putting greens are Primo Maxx (trinexapac-ethyl), Trimmit (paclobutrazol), and Cutless (flurprimidal). These products alter growth rate in two distinct phases. Following PGR application clipping yield becomes suppressed relative to non-treated turfgrass; the suppression phase. After a period of time the suppression phase ends and clipping yield increases to a level greater than non-treated turfgrass; the rebound phase. Researchers have found that the duration of the suppression phase is dependent upon air temperature (Lickfeldt et al. 2001; Beasley et al. 2007). As air temperatures increase into the summer the length of the suppression phase decreases. This occurs because turfgrass plants breakdown PGRs, such as Primo Maxx, faster as air temperatures increase (Beasley and Branham, 2005). This means that calendar based PGR re-application intervals are not efficient at maintaining yield suppression because the ideal re-application interval changes during the

course of a growing season.

During my Masters degree with Dr. Soldat at the University of Wisconsin-Madison we studied how PGR re-application frequency and rate affected yield suppression on creeping bentgrass golf putting greens; primarily with Primo Maxx. Instead of evaluating inefficient calendar-based intervals (i.e. weekly or biweekly applications), we used a growing degree day (GDD) model to estimate the duration of the yield suppression phase and aid in scheduling Primo Maxx applications. The goal was to sustain season-long yield suppression and avoid the rebound. Growing degree day models are used extensively in traditional agriculture to estimate crop growth and development in relation to air temperature and recently have been used to estimate weed growth and development in turfgrass, i.e. Poa annua seed head formation (GDDTracker.net). To calculate GDD the high and low air temperature are averaged together, subtracted from a base temperature where metabolism is minimal, and added to values from the previous days.

In a 2008 study, we measured daily relative clipping yield from a creeping bentgrass putting green treated with Primo Maxx every 100, 200, 400, and 800 GDD as well as every four weeks. ***The GDD was calculated in degrees Celsius with a base temperature of 0°C and began after the previous Primo Maxx application. After the GDD threshold had been surpassed (i.e. 200 GDD after Primo Maxx application), Primo was re-applied and the model was reset to zero.*** We realize that most Americans avoid using the Celsius scale, however, it is convenient in this case because there is no need to subtract a base temperature (the base is 0°C). Additionally, spreadsheet programs such as MS Excel can be used to track the progression of GDD after PGR application and convert temperatures to Celsius. Temperature °C=((Temp °F-32))/1.8

We found that the 400 GDD, 800 GDD, and four week re-application

frequency did not maintain season-long yield suppression (Fig. 1). We plotted relative clipping yields at different GDDs after Primo Maxx application to create a Primo Maxx response model (Fig. 2). This model showed that the suppression phase occurs during the first 300 GDD; after 300 GDD the turfgrass entered the rebound phase of increased yield relative to non-treated turf. The maximum amounts of both yield suppression and rebound was 18% of the non-treated turf.

We found that the 100 and 200 GDD re-application frequencies maintained season-long yield suppression (Fig. 1). The 100 GDD re-application interval resulted in a greater level of yield suppression than the other treatments. The 200 GDD re-application interval is the furthest Primo Maxx re-application interval to maintain yield suppression because the yield begins to transition into the rebound phase after 200 GDD. For some perspective, 200 GDD occurs in 14 days during an average May in Madison, WI (average day temp. 57°F) and as frequently as every 9 days during an average July (72°F). During a heat wave with high temperatures of 100°F and lows around 75°F (average day temp. 89°F) 200 GDD occurs in 7 days or less (Fig. 3). This illustrates how Primo Maxx re-application interval needs to be adjusted depending upon air temperatures to avoid the rebound phase. As temperatures warm into the summer, Primo needs to be re-applied more frequently than it does in spring and fall to avoid the rebound.

In 2009 and 2010 we wanted to verify that the 200 GDD model worked on a different creeping bentgrass putting green and see how it was affected by Primo Maxx application rate. There were two application rates (0.125 and 0.25 fl oz/M) applied either every 200 GDD or every four weeks. In both years the 200 GDD re-application interval maintained season-long yield suppression regardless of the time of year. Surprisingly, we found that the 0.25 fl oz/M application rate did not increase either the level or duration of yield suppression. ***Application rate did not matter.*** The only effective way to increase the amount

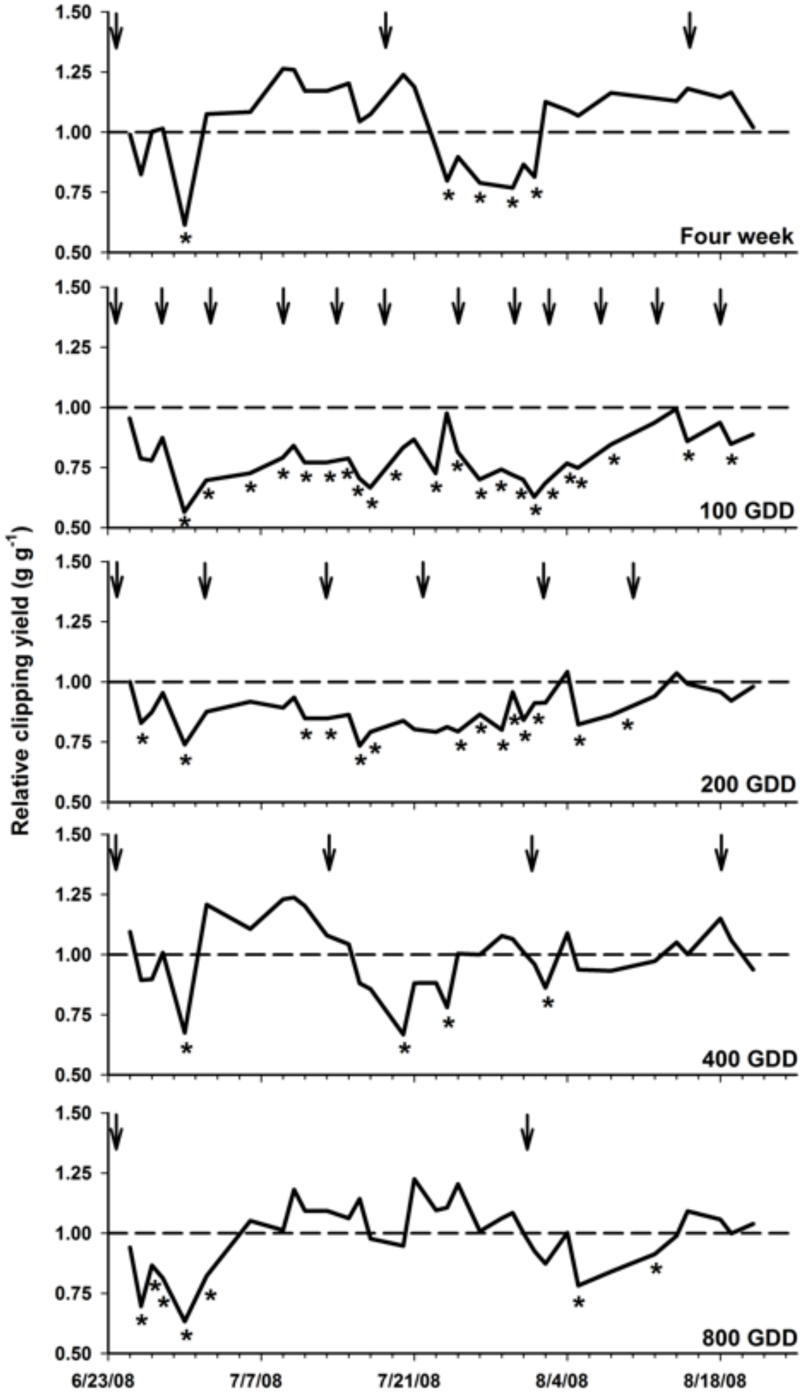

Figure 1. The effect of Primo Maxx re-application frequency on the relative yield of a creeping bentgrass putting green. Stars indicate days clipping yield was less than the non-treated control (dashed line) and arrows indicated Primo Maxx applications. Primo Maxx was applied at the labeled rate for golf course putting greens of 0.125 fl oz/M. Values below the 1.0 reference line indicate yield suppression while values above the line indicate the rebound phase.

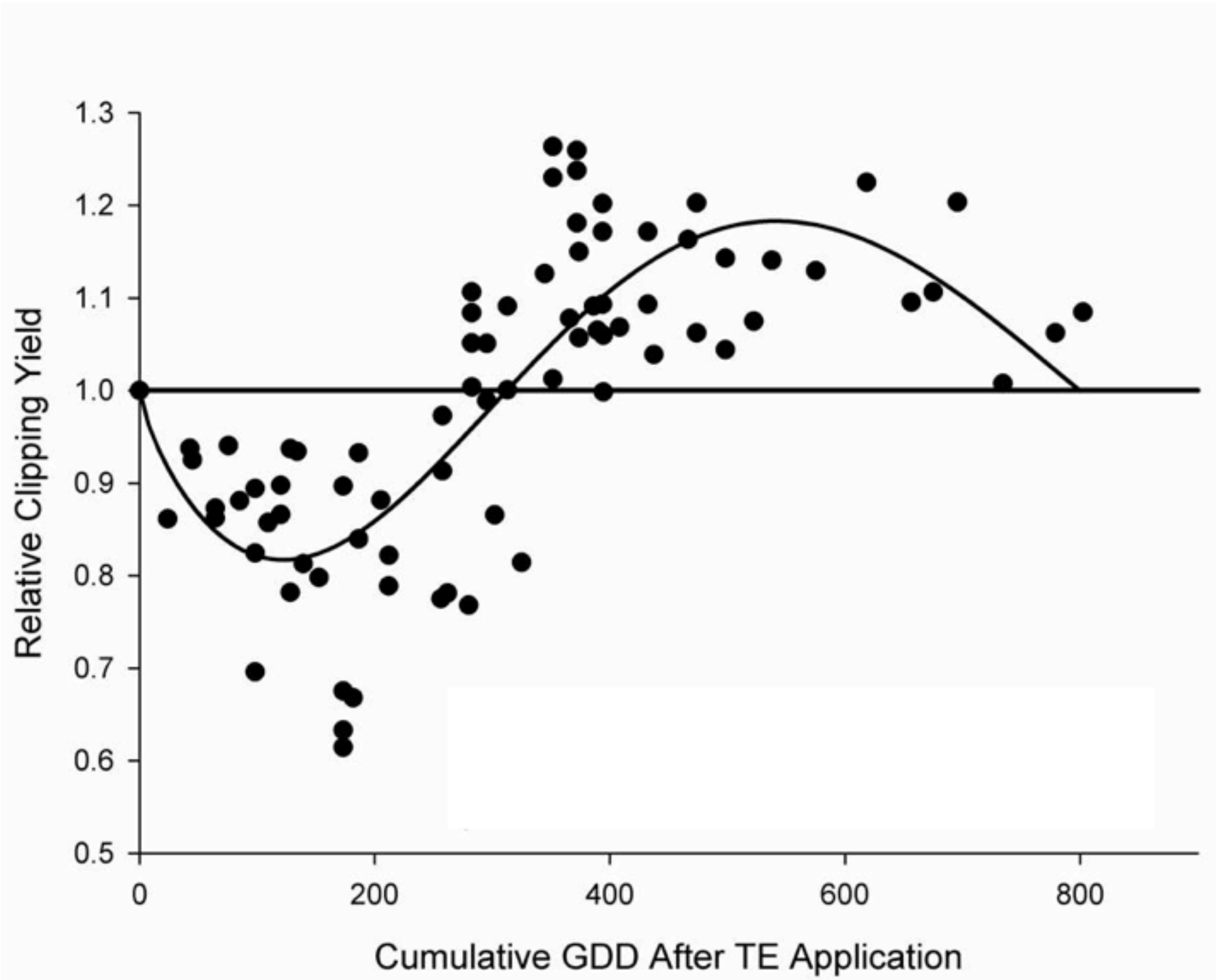

Figure 2. Relative clipping yield of a creeping bentgrass golf putting green at various growing degree days after Primo Maxx application. Cumulative GDD was calculated in degrees Celsius with a base temperature of 0°C from the time the previous Primo Maxx application. Primo Maxx was applied at the labeled rate for golf course putting greens of 0.125 fl oz/M. Values below the 1.0 reference line indicate yield suppression while values above the line indicate the rebound phase.

of yield suppression is to re-apply more frequently than 200 GDD (i.e. 100 GDD). The only benefit of the high application rate is that the bentgrass visual quality was greater compared to the labeled application rate of 0.125 fl oz/M.

It needs to be very clear that 200 GDD re-application interval is only meant for Primo Maxx applications to creeping bentgrass golf putting greens. Bermudagrass greens and taller mowed turfgrass such as Kentucky bluegrass athletic fields are more sensitive to Primo Maxx and would have a different Primo GDD threshold. Some preliminary research on Poa annua putting greens found that the 200 GDD re-application interval is effective at maintaining yield suppression of Poa. We also have found that 200 GDD applications to mixed bent/Poa green decreased the Poa annua population from 23% to 16% of the surface. However, golf course superintendents visually estimated that there was more Poa invasion on those same plots. This occurred because the bentgrass and Poa annua populations began to segregate as the grass density increased with repeat Primo Maxx applications. This gave the illusion of more Poa invasion while the actual amount of was diminished (verified with a grid count).

We also wanted to determine the GDD threshold for Trimmit application to creeping bentgrass and Poa annua golf putting greens. We used the same methods described above to determine Primo Maxx GDD. Trimmit was applied at the rate of 0.25 fl oz/M (11 fl oz/A) and was lightly watered in after application. We found that 300 GDD re-applications (base °C) maintained yield suppression during the growing season for both grass species. After approximately 350 GDD the turf entered the rebound phase (Fig 4). A word of caution however, the 300 GDD Trimmit treatment contributed to the collapse of the Poa annua stand during 2010 and was described in more detail in Dr. Soldat's January/February 2011 Grass Roots article (http://www.lib.msu.edu/cgi-bin/flink.pl?recno=175732). In conclusion, the use a GDD model to estimate

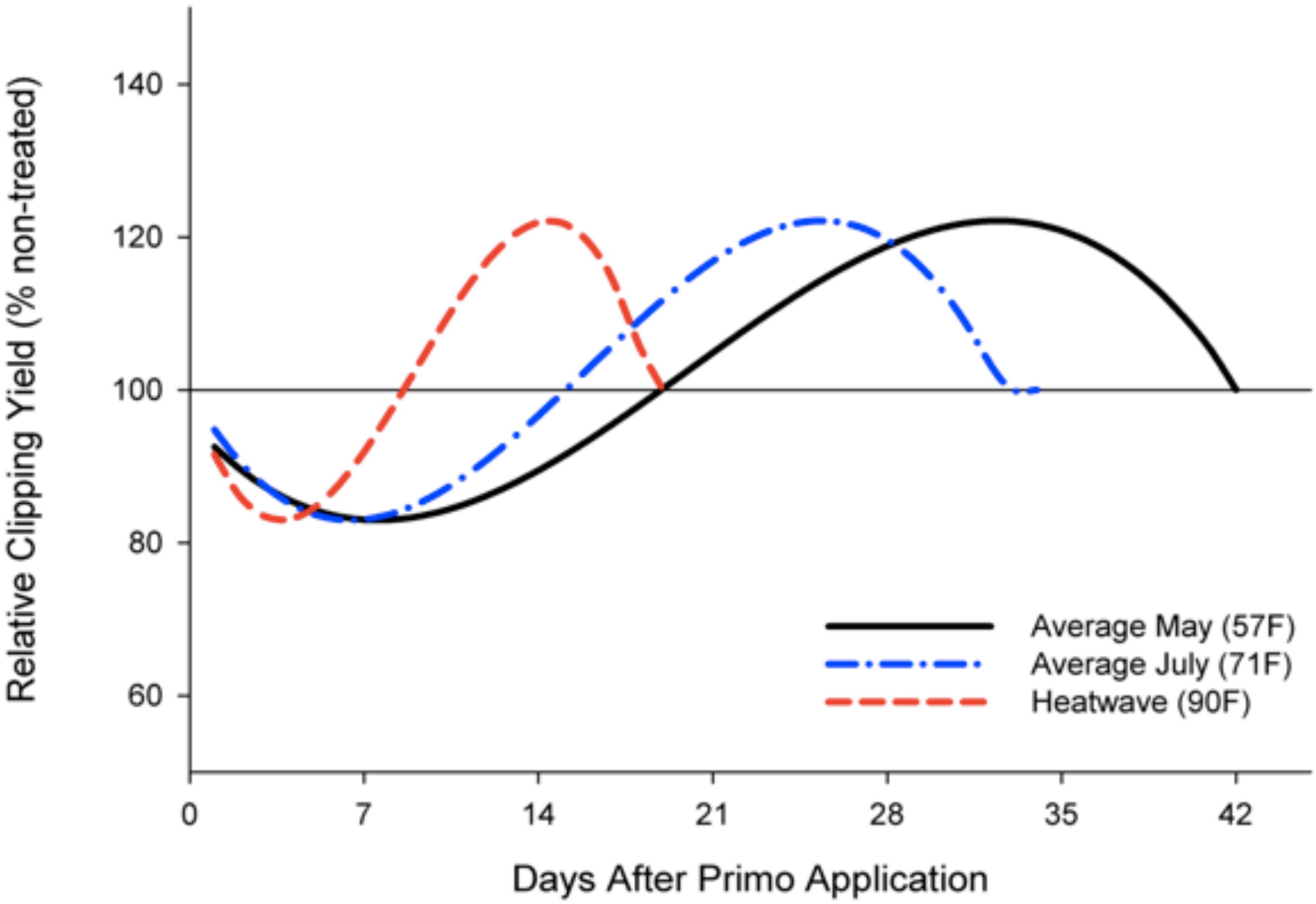

Figure 3. The influence of air temperature on the duration of the yield suppression and rebound phases in Madison, WI. Values below the 100% reference line indicate yield suppression while values above the line indicate the rebound phase.

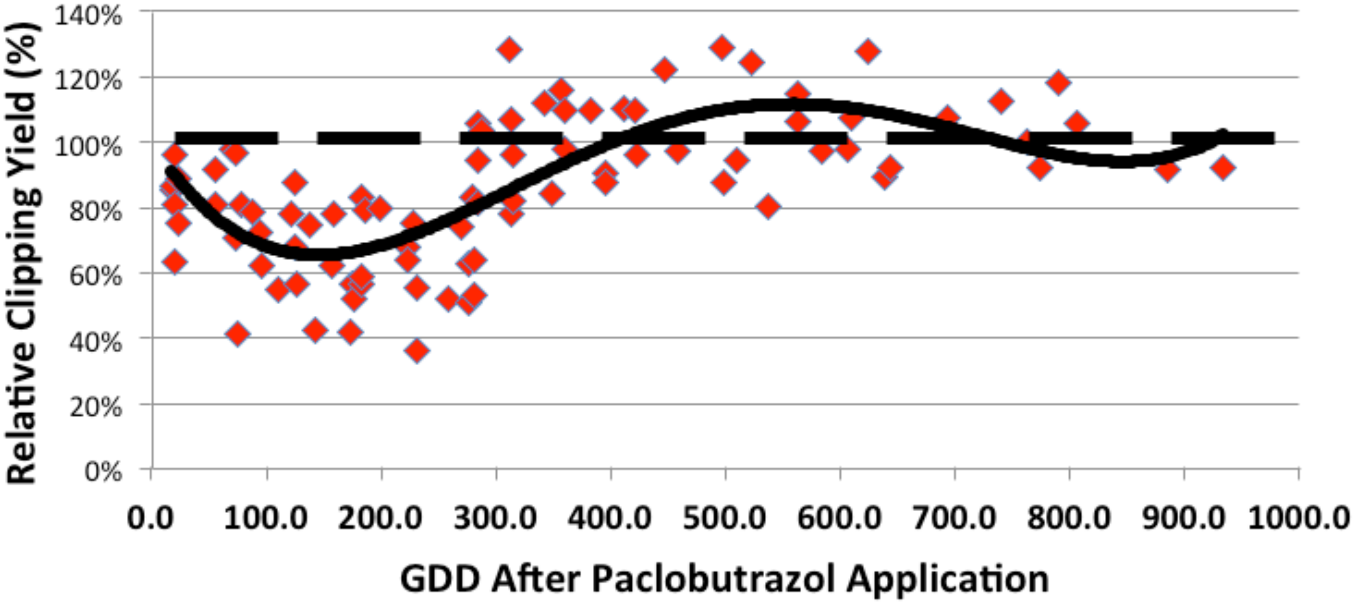

Figure 4. Relative clipping yield of a creeping bentgrass golf putting green at various growing degree days after Trimmit application. Cumulative GDD was calculated in degrees Celsius with a base temperature of 0°C from the time the previous Trimmit application. Trimmit was applied at the rate of 0.125 fl oz/M. Values below the 100% reference line indicate yield suppression while values above the line indicate the rebound phase.

PGR metabolism and schedule re-applications increases application precision and removes some of the mystery and misconceptions involved with these PGRs. If you have any questions or would like a copy of an Excel spreadsheet to track GDD accumulation please email me at wck38@cornell.edu or go to this link http://www.hort.cornell.edu/turf/ for the actual spreadsheet.

Summary Points

PGRs reduce clipping yield for a duration dependent upon air temperature.

GDD systems can be used to estimate the duration of the suppression growth phase.

Re-applying Primo Maxx to creeping bentgrass putting greens every 200 GDD (base 0°C) maintained season-long yield suppression regardless of season.

The 200 GDD re-application interval is specific only to creeping bentgrass (and likely Poa annua) golf putting greens. Other turf species have different GDD thresholds which need to be determined experimentally.

Increasing Primo Maxx application rate did not increase the level or duration of yield suppression, but the higher application rate resulted in greater visual quality enhancement.

Re-application of Trimmit to creeping bentgrass and Poa annua putting greens every 300 GDD (base 0°C) maintained yield suppression. However, that application frequency was stressful on the Poa annua and contributed to collapse of the turfgrass stand in 2010.

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