

Title: Influence of nitrogen rate on growing degree day models for plant growth regulator reapplication interval on annual bluegrass putting greens

Project Leader: Chas Schmid

Co-leader: Alec Kowalewski

Affiliation: Department of Horticulture, Oregon State University

Objectives:

- 1) Develop a growing degree day model for PGR (trinexapac-ethyl and prohexadione-Ca) application intervals on annual bluegrass putting greens
- 2) Determine if nitrogen rate has an influence on a growing degree day model for annual bluegrass putting greens

Start Date:

June 2024

Project Duration:

2 years, June 2024 to Dec 2025 (1st year report)

Total Funding:

\$29,975 total

Summary Points:

- Predicted reapplication interval for trinexapac-ethyl (TE) on annual bluegrass ranged from 309 to 217 GDD for low and high N rates, respectively; TE combined with High N was similar to previous recommendations for bentgrass.
- Predicted reapplication interval for Prohexadione-Ca on annual bluegrass ranged from 243 to 212 GDD for low and high N rates, respectively; both were much lower than previous recommendations for bentgrass.
- Trends suggest reapplication intervals for PGR varied by month of application, with PGRs applied to annual bluegrass under stressful environmental conditions during July resulting in longer reapplication intervals, particularly when combined with low N rates which increased intervals by > 130 GDD.

INTRODUCTION

Plant growth regulators (PGR) are typically applied to golf course putting greens on a calendar-based schedule, but recently growing degree-day (GDD) models for PGR reapplication interval have been developed to provide season-long growth suppression; including models for applications of trinexapac-ethyl (TE; Primo Maxx 1ME, Syngenta) (Kreuser et al., 2011) and paclobutrazol (Trimmit 2SC, Syngenta) on creeping bentgrass (*Agrostis stolonifera* L.) putting greens (Kreuser et al., 2018), and TE and paclobutrazol on ultradwarf hybrid bermudagrass [*Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burt-Davy] putting greens (Reasor et al. 2017).

However, no previous research has attempted to develop a GDD model for PGRs on annual bluegrass (ABG) putting greens. Instead, superintendents managing ABG putting greens have relied on GDD models developed for creeping bentgrass as a baseline for reapplication intervals. Thus, development of GDD models for PGR reapplication interval on ABG turf is needed.

The effect of N rate on ABG putting green turf quality, disease susceptibility, and playability has been well documented (Hempfling et al., 2017; Inguagiato et al. 2008; Schmid et al. 2017), but little is known about the effect of N rate on PGRs applied to annual bluegrass. Specifically, if N rate influences PGR reapplication interval for ABG putting greens. It is possible that greater rates of N may require a more frequent (< GDD) reapplication interval compared to lower rates. Further research is needed to determine if GDD models for PGRs should be adjusted based on N rates.

MATERIALS AND METHODS

Site Description and Maintenance

This three-year field trial was initiated in June 2023. The trial is being conducted on a sand-based annual bluegrass research green constructed using the United States Golf Association rootzone specifications (USGA, 2018). The research green is managed to simulate conditions found on golf course putting greens in the Pacific Northwest. Pesticides (except DeMethylation Inhibitors) were applied preventatively to control common disease and insect pests. An onsite Campbell Scientific weather station was used to measure daily air temperatures, which were used to calculate cumulative GDD using methods described by McMaster and Wilhelm (1997), with a base temperature of 0°C and the stipulation that if the daily mean temperature is less than the base temperature, then the GDD for that day is set to zero.

Treatment Design

The treatment design for the trial was adapted from those described by Kreuser et al. (2017) and Reasor et al. (2018). The experiment was designed as 2 by 2 factorial in a randomized complete block design with four replications. Factors include PGR type, either a single application of TE at 0.125 fl oz 1000ft⁻² or prohexadione-Ca (PH; Anuew, Nufarm) at 0.05 fl oz 1000ft⁻², and N rate, either 0.075 or 0.15 lb N 1,000 ft⁻² every 7-d throughout the trial period (June through September). Multiple runs of the experiment were conducted within each year, with applications starting on June 13, July 13, and August 15, 2023; and June 18, July 11, August 15, 2024 to plots with no previous PGR application that season. Two sets of nontreated control plots were included per replication to improve the accuracy of calculating relative clipping yield based on recommendations from Kreuser et al. (2017). Plot size for the trial is 3 x 10 ft (30 ft²). Plant growth regulator treatments were applied with a CO₂-pressured backpack sprayer using a carrier volume of 2.0 gal 1,000 ft⁻².

Data Collection

Clipping collection methods were adapted from those described by Reasor et al. (2018), with clippings collected three times per week (Monday, Wednesday, and Friday) until ≈ 600 GDD; at which point, clippings were collected once per week until the effects of TE and PH are no longer detectable (≈ 1000 GDD). Clipping collection and general plot mowing were done using an electric walk-behind greens mower (eFlex 2120, Toro Company), with bench height set at 0.110 inches. The entire plot area was mowed six days per week (except Saturday), including on days when clippings had been collected from treated plots. Sand topdressing was withheld from the trial area to prevent contamination in clipping samples. Any debris was removed from collected clippings prior to weighing.

Statistical Analysis

Relative clipping yield was compared to GDD using an amplitude-dampened sine wave regression model (Kreuser et al. 2017). Data was combined across months (June, July, and August) and years (2023 and 2024) for each PGR and N rate combination and analyzed to determine their overall effect on relative growth suppression and reapplication interval. The nonlinear regression function in SigmaPlot 15 (Systat Software, 2023) was used to fit the amplitude-dampened sinewave model, which is defined by Eq. [1].

$$\text{Relative clipping yield (g g}^{-1}\text{)} = 1 + A * e^{\left(\frac{GDD}{D}\right)} * \sin\left(2\pi * \frac{GDD}{B} + \pi\right) \quad [1]$$

Where A is the magnitude of the suppression and rebound growth stages, D is the amplitude decay coefficient, GDD is the cumulative GDD since the last PGR application, and B is the period of the model in GDD. In addition, data from each month (June, July, and August) was averaged across years (2023 and 2024) for each PGR and N rate combination and analyzed to determine the effect of application timing on relative growth suppression and reapplication interval.

PRELIMINARY RESULTS

All combinations of PGRs (TE and PH) and N rate (0.075 and 0.15 lb N 1,000 ft⁻² wk⁻¹), averaged across months (June, July, and August) and years (2023 and 2024), indicated a significant relationship between relative clipping yield and GDD using a sine wave regression model with R² values ranging from 0.521 to 0.685 (Figure 1). Peak growth suppression for TE was observed at 238 and 167 GDD for the low and high rate of N, respectively, with predicted reapplication intervals of 309 and 217 GDD. Reapplication interval for TE in combination with high rates of N (217 GDD) is similar to previous reports of GDD reapplication interval for creeping bentgrass (230 GDD; Kreuser, 2016). However, when TE is combined with low rates of N (0.075 lb N/1,000 ft² per week), the reapplication interval appears for be much higher (309 GDD) than previous recommendations or TE combined with high N. Differences in peak suppression and reapplication interval between N rates (low and high) in combination with PH

was less dramatic than those observed in TE treatments. Prohexadione-Ca combined with high rates of N resulted in peak suppression at 163 GDD and a reapplication interval of 212 GDD, whereas PH combined with low N showed peak suppression at 187 GDD and a reapplication interval of 243 GDD (Figure 1). Interestingly, the reapplication interval for PH on annual bluegrass was less than previous recommendations for creeping bentgrass of 280 GDD (Kreuser, 2016).

A sine wave regression model was also used to look at the relationships between relative clipping yield and GDD within each month (June, July, and August; averaged across years) to show nuance in reapplication intervals across a season (Figures 2, 3, & 4). In June, few differences in peak suppression or reapplication interval were observed between low and high rates of N for either TE or PH, but the data indicates that TE has a longer reapplication interval in June than PH (Figure 2). During July, significant differences in reapplication intervals were observed between the two rates of N for both PGRs, with low rates of N extending the reapplication intervals compared to high N rates (Figure 3). Then in August, few differences were once again observed between PGRs or N rates, with reapplication intervals ranging from 199 to 209 GDD (Figure 4). These results indicate that when the turfgrass is exposed to high levels of abiotic stress (i.e. during late summer; July applications), the reapplication intervals for PGRs combined with low N rates were extended by > 130 GDD compared to high N rates. During months when the turfgrass had optimum growing conditions (early summer and early fall; June and August applications, respectively), few differences were observed between PGR types and N rates.

REFERENCES

- Hempfling, J.A. C.J. Schmid, R. Wang, B.B. Clarke, and J.A. Murphy. 2017. Best management practices effect on anthracnose disease of annual bluegrass. *Crop Sci.* 57:1-9
- Inguagiato, J.C., J.A. Murphy, and B.B. Clarke. 2008. Anthracnose severity on annual bluegrass influenced by nitrogen fertilization, growth regulators, and verticutting. *Crop Sci.* 48:1595–1607.
- Kreuser, W.C. 2016. The perils of PGR over-regulation. *Golfdom.* April. 72(4):30-33.
- Kreuser, W.C., and D.J. Soldat. 2011. A growing degree day model to schedule trinexapac-ethyl applications on *Agrostis stolonifera* golf greens. *Crop Sci.* 51:2228-2236.
- Kreuser, W.C., J.R. Young, and M.D. Richardson. 2017. Modeling Performance of Plant Growth Regulators. *Agric. Environ. Lett.* 2:170001.
- Kreuser, W.C., G.R. Obear, D.J. Michael, and D.J. Soldat. 2018. Growing Degree-Day models predict the performance of Paclobutrazol on bentgrass golf putting greens. *Crop. Sci.* 58:1402–1408.
- McMaster, G.S., and W.W. Wilhelm. 1997. Growing degree-days: One equation, two interpretations. *Agric. For. Meteorol.* 87:291-300.

Reasor, E.H., J.T. Brosnan, J.P. Kerns, W.J. Huchens, D.R. Taylor, J.D. McCurdy, D.J. Soldat, and W.C. Kreuser. 2018. Growing degree day models for plant growth regulator applications on ultradwarf hybrid bermudagrass putting greens. *Crop Sci.* 58:1801–1807.

Schmid, C.J., B.B. Clarke, and J.A. Murphy. 2017. Anthracnose severity as influenced by nitrogen source. *Crop Sci.* 57:1-8

USGA. 2018. USGA recommendations for a method of putting green construction. US Golf Assoc., Far Hills, NJ.

Figure 1. Normalized relative clipping yield of annual bluegrass putting green turf in Corvallis Oregon averaged across June, July, and August treatments during 2023 and 2024, after a single application (within each month) of trinexapac-ethyl (left) or Prohexadione-Ca (right) combined with weekly applications of nitrogen at 0.075 lb N/1,000 ft² (low N; top) or 0.15 lb N/1,000ft² (high N; bottom). Equation and R² values are from the sinewave model used to calculate relative growth suppression. Vertical line indicates reapplication interval.

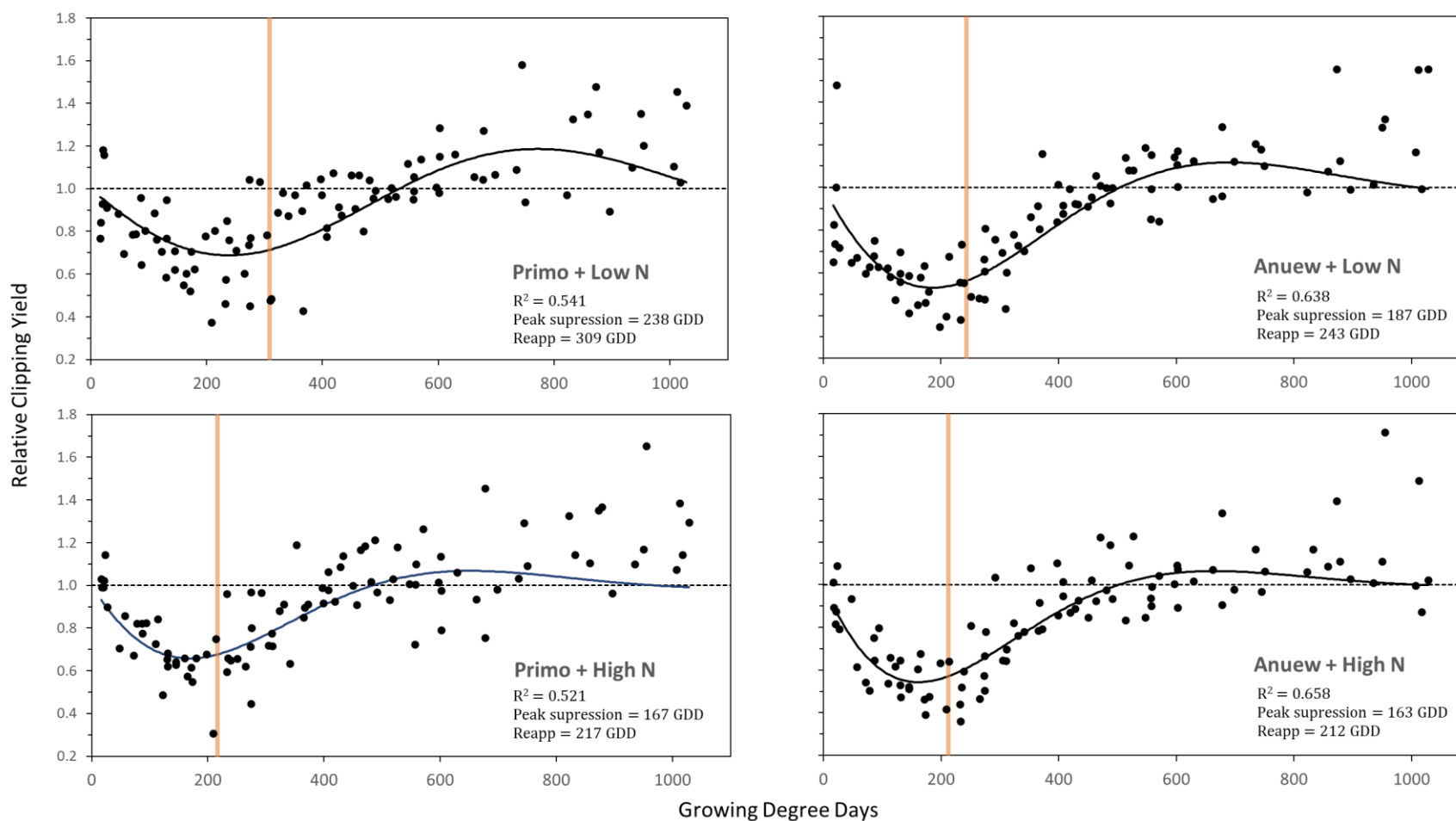


Figure 2. Normalized relative clipping yield of annual bluegrass putting green turf in Corvallis Oregon during June of 2023 and 2024 (average across years), after a single application of trinexapac-ethyl (left) or prohexadione-Ca (right) combined with weekly applications of nitrogen at 0.075 lb N/1,000 ft² (low N; top) or 0.15 lb N/1,000ft² (high N; bottom). Equation and R² values are from the sinewave model used to calculate relative growth suppression. Vertical line indicates reapplication interval.

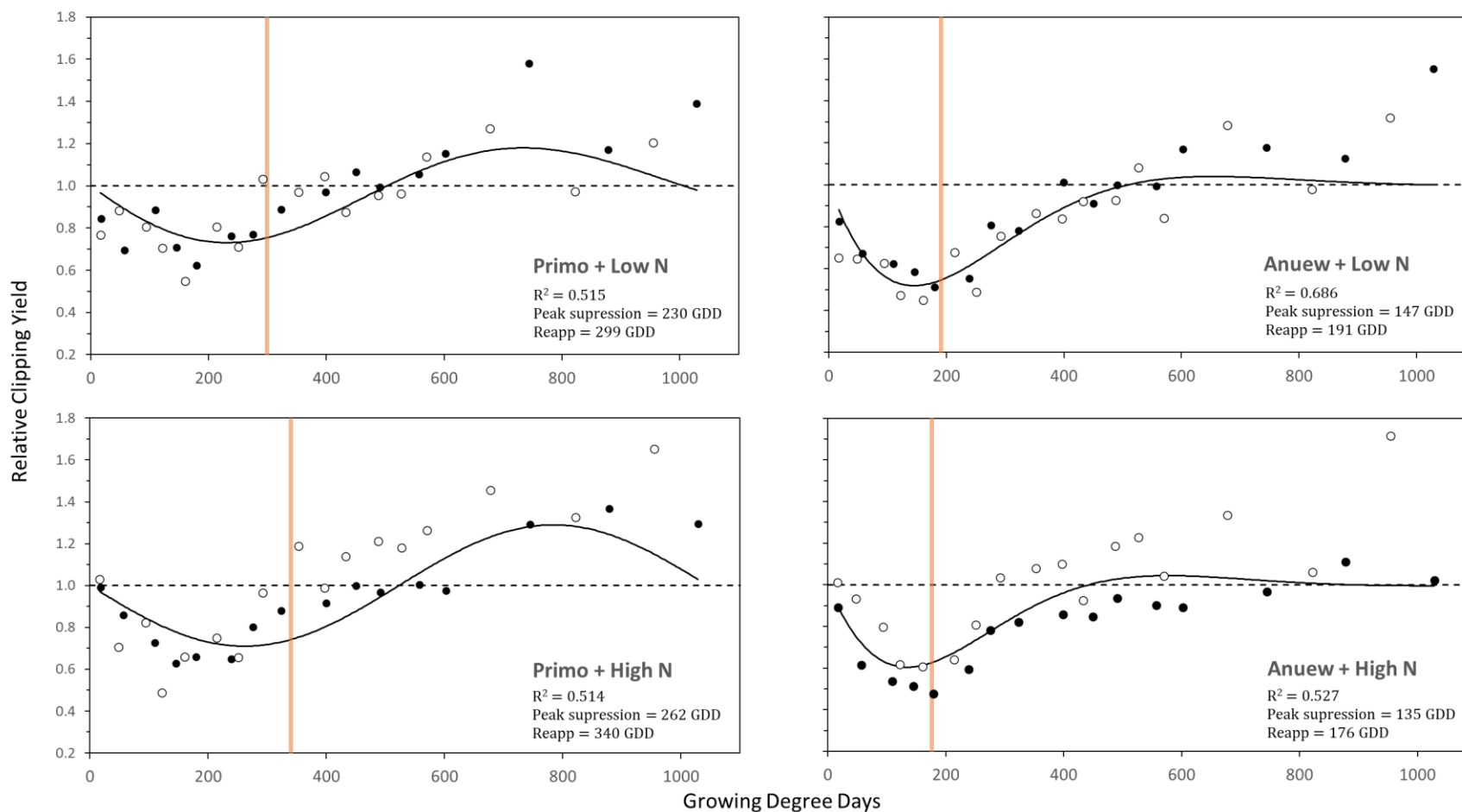


Figure 3. Normalized relative clipping yield of annual bluegrass putting green turf in Corvallis Oregon during July of 2023 and 2024 (average across years), after a single application of trinexapac-ethyl (left) or prohexadione-Ca (right) combined with weekly applications of nitrogen at 0.075 lb N/1,000 ft² (low N; top) or 0.15 lb N/1,000ft² (high N; bottom). Equation and R² values are from the sinewave model used to calculate relative growth suppression. Vertical line indicates reapplication interval.

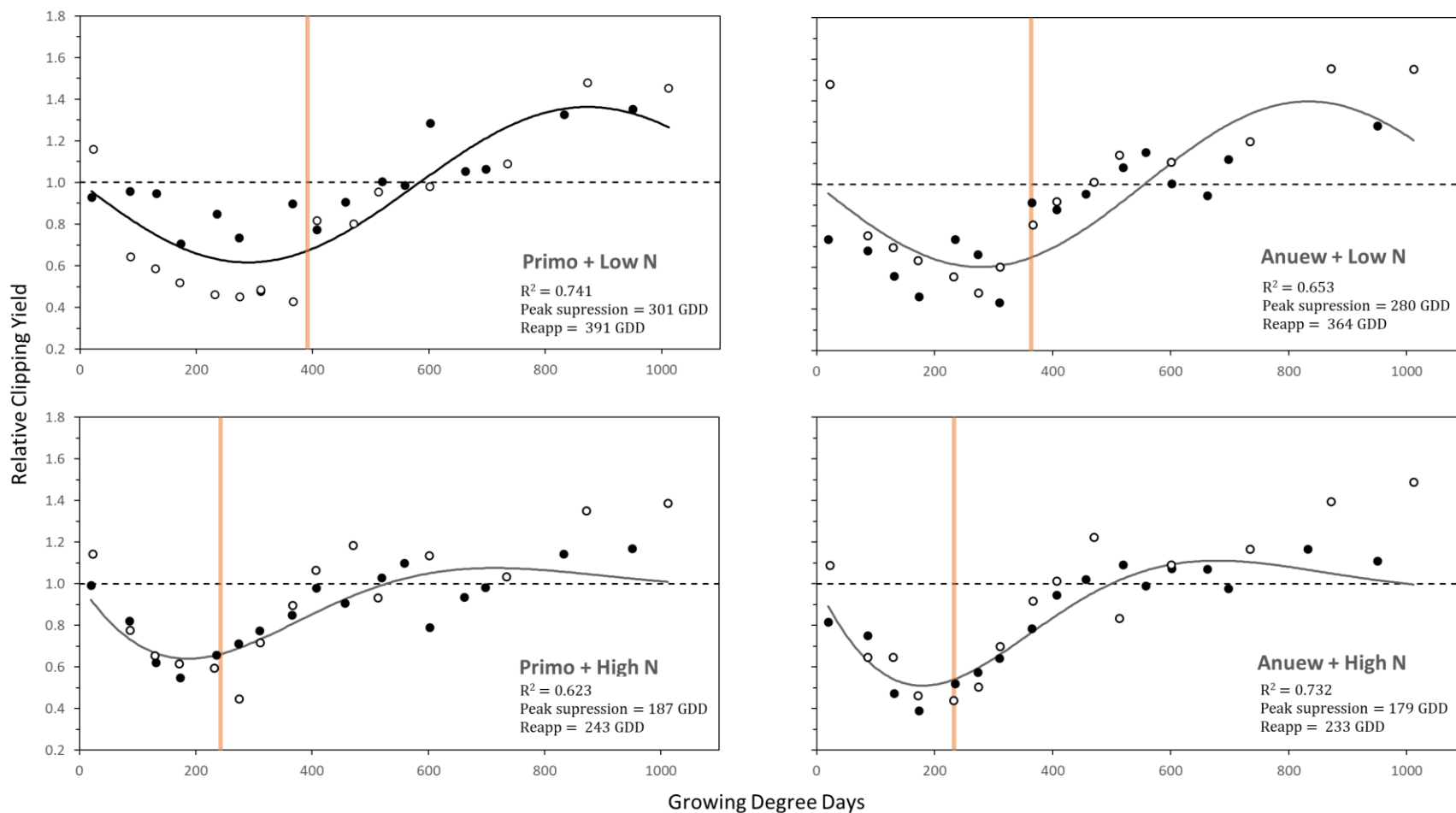


Figure 4. Normalized relative clipping yield of annual bluegrass putting green turf in Corvallis Oregon during August of 2023 and 2024 (average across years), after a single application of trinexapac-ethyl (left) or prohexadione-Ca (right) combined with weekly applications of nitrogen at 0.075 lb N/1,000 ft² (low N; top) or 0.15 lb N/1,000ft² (high N; bottom). Equation and R² values are from the sinewave model used to calculate relative growth suppression. Vertical line indicates reapplication interval.

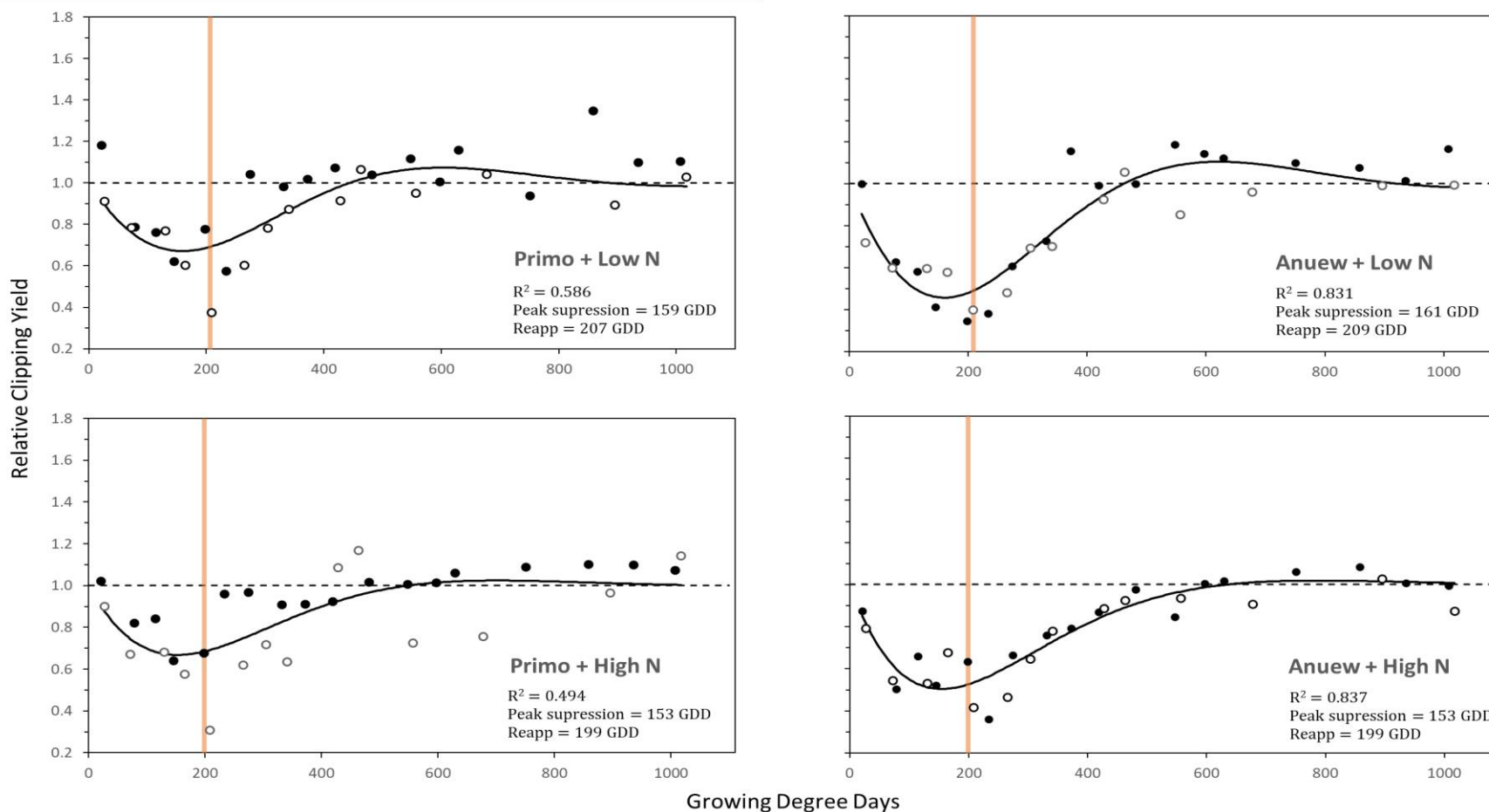




Image: Preparing PGR trial for clipping collection.



Image: Robert Starchvick presenting findings from the trial at the Oregon State University summer turfgrass field day.