GDDs for Timing PGR Applications:
Impact on growth & performance

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- Installed backyard putting green
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- MS for Wisconsin, 2010 – PGR research
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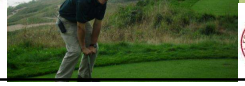

Cornell University

Growing Turf Program at University of Nebraska-Lincoln

- 40+ undergraduate turfgrass science majors
  - Steady increase
  - High job placement
- Expansive undergrad internship program
  - Increases our exposure
  - Expands student's experiences
- Broad range of research
  - Drs. Amundsen, Gaussoin, Kreuser & ***New Prof Soon***

★ TLMT Internships 2012-14

Today's Road Map

- PGR Introductions
- Modeling PGR performance with GDDs
  - Primo Maxx
  - Anuew
  - Class B PGRs and their combinations
- Why even use PGRs?
- Wrap-up

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Plant Growth Regulators

- Definition: A Plant Growth Regulator (PGR) is any natural or synthesis compound that regulates plant growth
- Impacts
  - Clipping Yield Inhibition/Rebound
  - Tiller Density
  - Root Mass and Density
- Examples
  - Hormone Inhibitors
  - Hormones
  - Herbicides
  - Seaweeds/Humic Acids

DMI Fungicides
Paclobutrazol
Gibberellic Acid
Glyphosate
Ethephon
Trinexapac-ethyl
Diquat
Mefluidide
Acibenzolar

Classification of PGRs

		Common Examples
• **Class A: (Type II)**	**Late Gibberellic Acid Inhibitors**	**Trinexapac-ethyl Prohexadione-Ca**
• **Class B: (Type I)**	**Early Gibberellic Acid Inhibitors**	**Paclobutrazol Flurprimidol**
• Class C:	Cell Division Inhibitors	Mefluidide
• Class D:	Herbicides	Glyphosate
• Class E:	Plant Hormones/Mimics	Ethephon
• Class F:	Naturally Occurring PGRs	Humic Acids

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Class A Compounds

- Late Inhibition of Gibberellic Acid
  - Final Step in Pathway
- Foliar Absorption
  - Rapid Uptake (15 to 60 Minutes)
  - Effective in Wide Range of Spray Volumes
  - Liquid and Dry Formulations
- Safest PGR
  - Widespread Usage
  - Safe on Most Grasses
- 50% Yield Suppression Typical

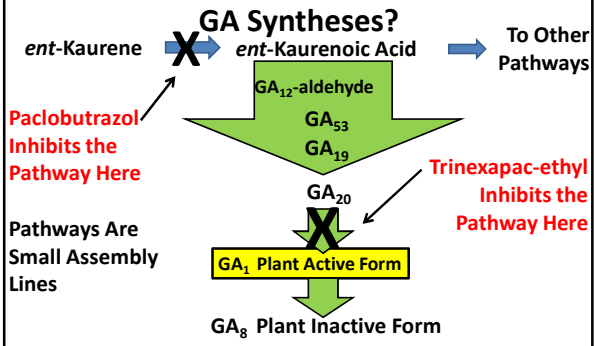
Common Products	
Trinexapac-Ethyl	Primo Maxx
	Governor
Prohexadione-Ca	Anuew

Class B Compounds

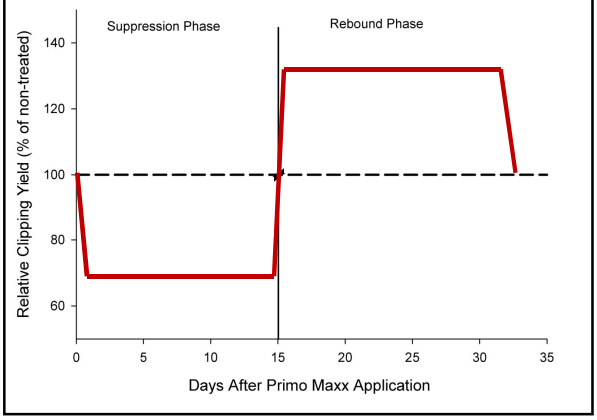
- Early Inhibition of Gibberellic Acid
  - Can disrupt other pathways
- Root Absorption
  - Irrigated in with ¼ inch
- More Phytotoxic
  - Slight Discoloration, *Poa annua*
  - Widespread usage
- 50% Yield Suppression Typical

Common Products	
Flurprimidol	Cutless
Paclobutrazol	TGR
Paclobutrazol	Trimmit

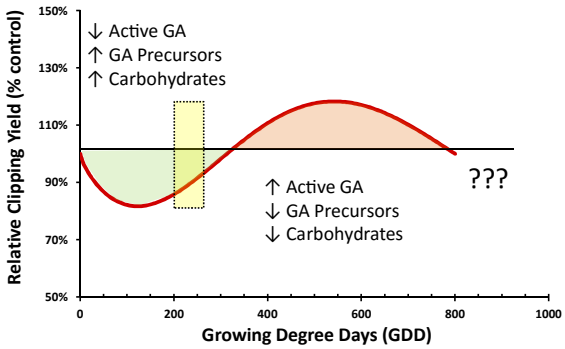
How do Class A and B PGRs Inhibit GA Syntheses?



Is there a Benefit to Mixing a Class A with Class B???

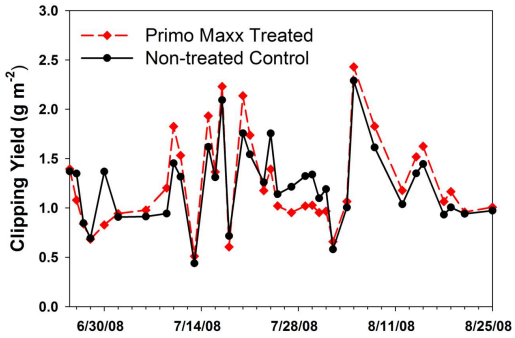


Generalized GDD model



The Biggest Challenge with PGRs

Its Hard to Know if They Are Working



Labels Can Be Imprecise – Good and Bad

Example: 2008 PGR Label

The rates presented in the **Application Rate Table** provide approximately 50% growth inhibition over a 4-week period with little or no discoloration of turf growing under favorable conditions.

Excessive turf growth, which may occur with high fertilization or during spring flushes, may require higher rates of Any PGR Under these conditions, Any PGR rates may need to be increased up to 50% to provide an adequate length of control.

For extended growth suppression up to 8 weeks, when temporary discoloration can be tolerated, a maximum of twice the recommended Any PGR rate from the **Application Rate Table** may be applied.

Rate can be legally increased 100%

Application Timing

Apply Any PGR to actively-growing turf. If turf is going into dormancy because of high or low temperatures or lack of moisture, apply a lower rate of Any PGR .

Repeat applications of Any PGR may be made as soon as the turf resumes growth or more suppression is desired, but do not apply more than 7.0 fl. oz./1,000 sq. ft. per year.

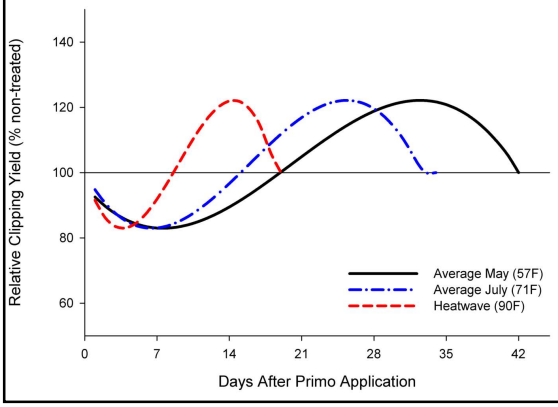
It can be re-applied as often as desired

PGR Metabolism

- **Decreased Efficacy During Summer**
  - **Lickfelt el al. (2005)**
  - **Beasley and Branham (2007)**
- **TE Metabolism Directly Related to Air Temperature (Beasley and Branham, 2005)**
  - **6.4 Day Half Life at 18°C (64°F)**
  - **3.1 Day Half Life at 30°C (86°F)**

Doubling temperature (°C) roughly doubled PGR breakdown (metabolism)

Suppression and rebound shortened at higher temp

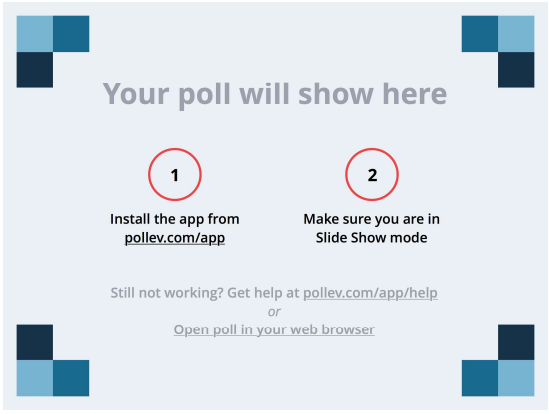


Growing degree days (GDD) factors in air temp

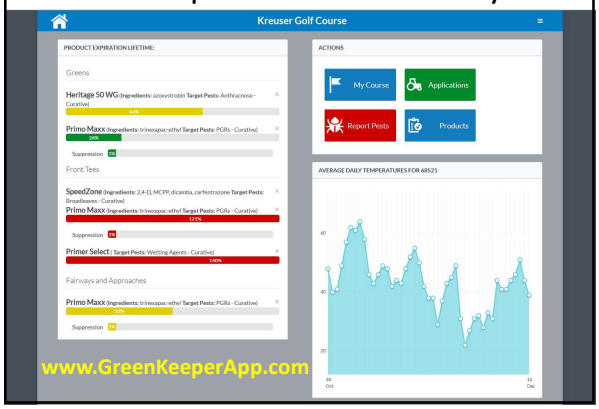
- Heat units (GDD) predicts TE re-application intervals
- Calculating GDD

Date	High (F)	Low (F)	Average (F)	Average (C)	GDD (C)
5/1/16	75	50	63	17	17
5/2/16	72	47	60	15	32
5/3/16	85	65	75	24	56
5/4/16	93	72	83	28	84

  - Use GDD Excel tracker and GreenKeeper
    - EASY!!!



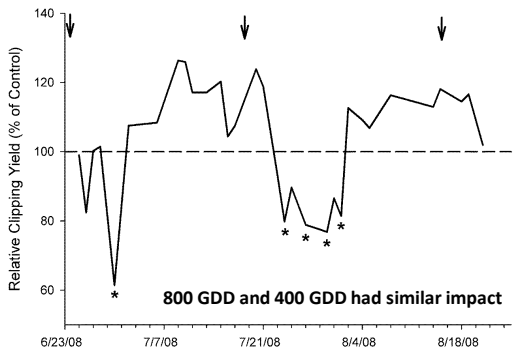
GreenKeeper Tracks GDDs for you!



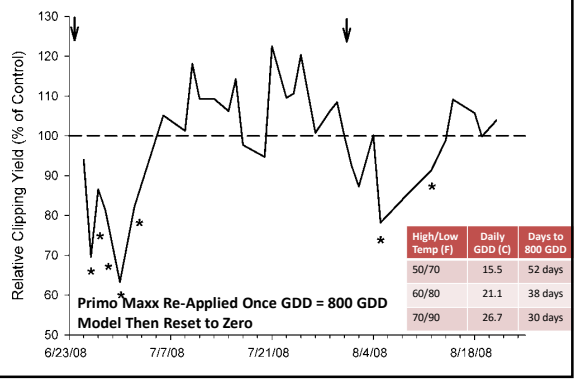
GDD models created to determine ideal GDD re-application intervals

- Primo applied to ***Creeping Bentgrass*** research ***Green***
- Collected clippings daily
- Re-applied Primo Maxx at various GDD intervals or every four weeks
- Observe which threshold provided consistent growth suppression

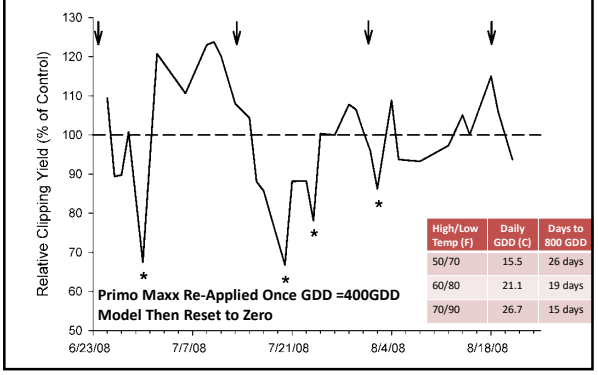
Four Week Primo Maxx Applications



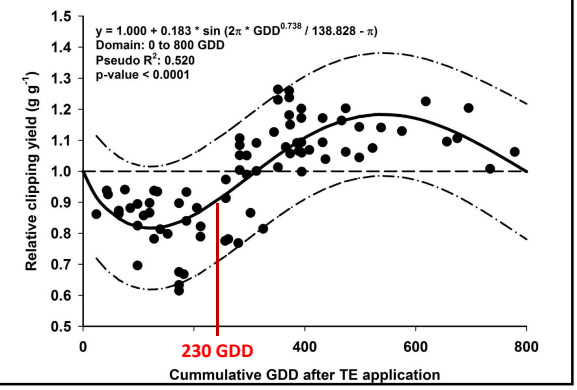
800 GDD re-application interval



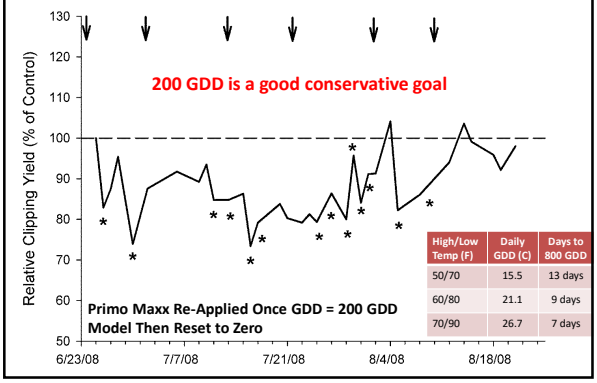
400 GDD re-application interval



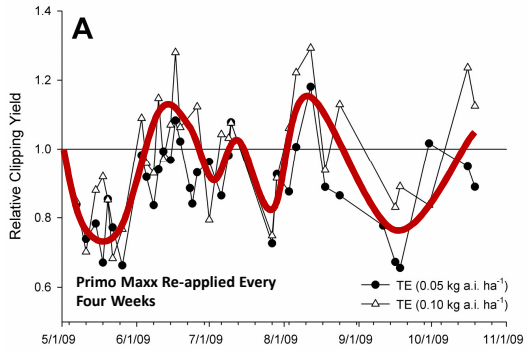
Trinexapac-ethyl (Primo Maxx) GDD Model



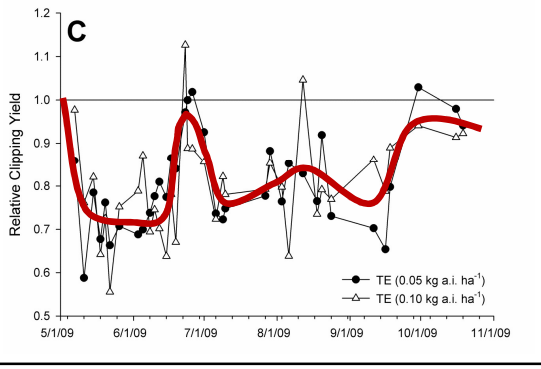
200 GDD TE Applications



Doubling application rate doesn't extend growth suppression phase



200 GDD TE At 1x and 2x Rates



Country Club Of VA, Richmond, example

- Troy Fink, CGCS, James River Course
- A4, USGA greens, <1% Poa
- 150 GDD spray trigger: May-Sept
- 1.75 lb N/M from 20 Apr to 15 Sept
- 4.3 lb N total

Country Club Of VA, Richmond, example

- Apr 20, 1st Primo application
- 5.5 oz/A or 0.125 oz/M all season
- Until June 17, apps needed based on 150 GDD trigger every 7 to 12 days
- After June 17, GDD spray trigger < 7 days, so added in Cutless at 10 oz/A to maintain weekly sprays until 14-Aug, then back to Primo-only until Oct 3
- Average GDD interval between apps: 160

Country Club Of VA, Richmond, example

Troy Fink quote:

"Regulation was the best I've ever had. Clippings would barely cover the bottom of the bucket to a 1-inch depth. If weather interfered with proper 150 GDD timing, an increase in clippings was always seen, but re-applying at next application would bring everything back to normal."

University of Minnesota research supports 200 GDD interval

Tested lower Primo Maxx Rates

- 0.13, 0.094, 0.063, 0.031 fl oz/M
- 200 GDD re-application interval still required at lower rates
  - Suggest 200 "safe" interval
- Lowest rates provided less clipping yield suppression

Member Driven Research

Growing Degree Day Modeling for Primo Applications on Creeping Bentgrass Putting Greens

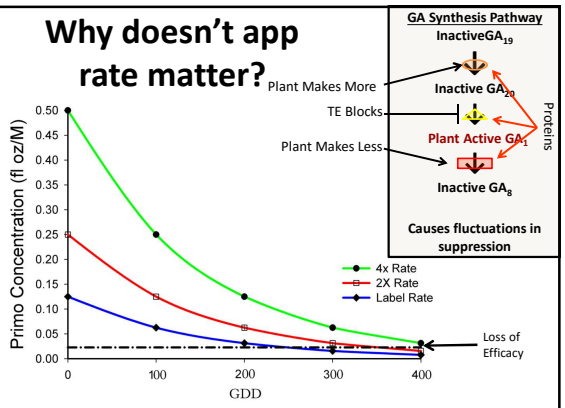
Dr. Brian Horgan, Sam Bauer, Matt Cavanaugh

Plant growth regulator use on golf courses has increased dramatically over the past two decades. During this time, researchers and superintendents have constantly been looking for ways to improve the application strategies for these products. Trinexapac-ethyl (TE), trade name Primo Maxx, is a commonly applied gibberellic acid synthesis inhibitor which is used for growth suppression, turfgrass quality, and density improvement.

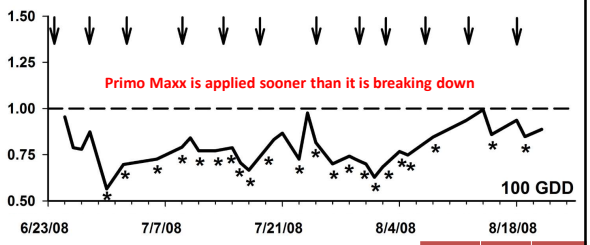
Research has demonstrated that the metabolism of TE occurs at a faster rate when temperatures increase in the summer months (Branham and Beasley, 2007). For this reason, growing-degree-day (GDD) models have been used to schedule TE applications on greens being used by many golf course superintendents relies on applications every 200 GDD (base 0° C) which was developed by researchers at the University of Wisconsin-Madison. These researchers did not find a difference in the magnitude or duration of suppression by increasing the application rate from 0.125 oz to 0.25 oz of Primo Maxx per 1000ftsq (Kreuser and Soldat, 2011); this suggests that application rates may be too high. For more background on the utilization of GDD for plant growth regulator applications, see the comprehensive review by Dr. Bill Kreuser from the University of Nebraska-Lincoln in the April 3rd, 2015 issue of USGA Green Section Record (Kreuser, 2015).

Extension Turfgrass Science

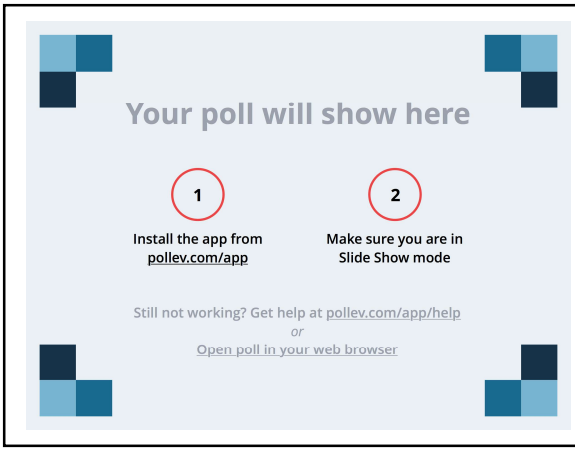
Why doesn't app rate matter?



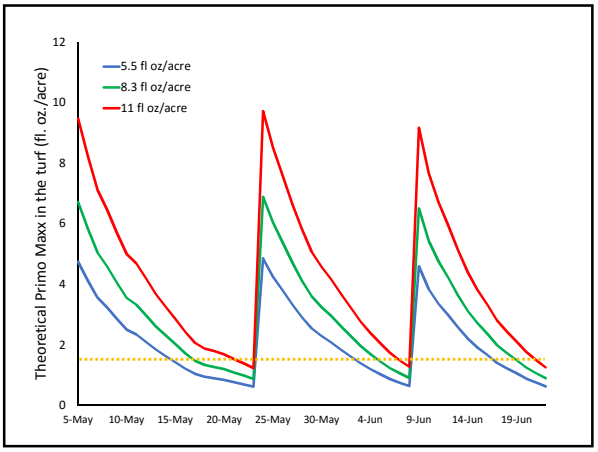
Shrinking the interval increases the magnitude of growth suppression

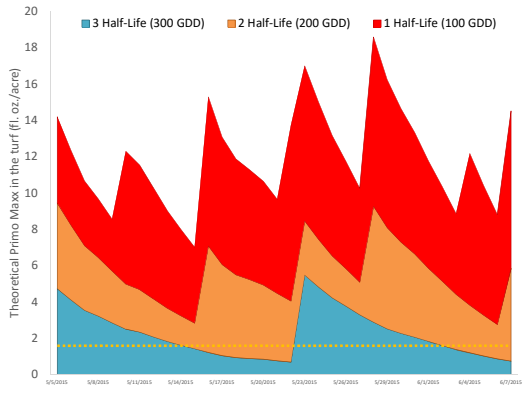


High/Low Temp (F)	Daily GDD (C)	Days to 800 GDD
50/70	15.5	6 days
60/80	21.1	5 days
70/90	26.7	4 days



Over-regulation is possible at low rates





PREPACKED PGRS ARE MORE PREDICABLE

Etiolation caused by Xanthomonas reduced by TE

Impact of biostimulants and trinexapac-ethyl on etiolation (caused by *Xanthomonas translucens*) in creeping bentgrass putting green turf in Raleigh, NC during fall 2011. Values within a treatment grouping followed by the same letter do not significantly differ by Tukey's HSD test, $\alpha = 0.05$.

	Etiolation (%)[a]				
	23-Sep	27-Sep	30-Sep	13-Oct	AUEPC[b]
Biostimulant[c]					
Knife Plus	24 a	25 a	13 a	10 a	219 a
CytoGro	16 a	21 a	7 a	7 a	158 a
Astron	28 a	36 a	8 a	12 a	252 a
Nitrozyme	24 a	26 a	10 a	10 a	208 a
BioMax	19 a	29 a	8 a	12 a	209 a
PerkUp	15 a	24 a	7 a	6 a	167 a
Non-treated	20 a	28 a	7 a	9 a	201 a
Trinexapac-ethyl Interval (TEI)[d]					
7 d	2 b	7 b	2 b	1 b	38 b
14 d	4 b	15 b	2 b	2 b	78 b
None	56 a	60 a	22 a	25 a	489 a

J.A. Roberts et al. / Crop Protection 72 (2015) 119–126

Etiolation caused by Acidovorax increased by TE

Impact of biostimulants and trinexapac-ethyl on etiolation (caused by *Acidovorax avenae*) in creeping bentgrass putting green turf in Raleigh, NC during summer 2013. Values within a treatment grouping followed by the same letter do not significantly differ by Tukey's HSD test, $\alpha = 0.05$.

	Etiolation (%)[a]								
	10-Jun	17-Jun	24-Jun	2-Jul	8-Jul	16-Jul	21-Jul	28-Jul	AUEPC[b]
Biostimulant[c]									
Knife Plus	26 a	22 a	5 a	2 a	2 a	4 a	17 a	9 a	464 ab
CytoGro	23 a	19 a	5 a	2 a	1 a	2 a	15 a	8 a	405 ab
Astron	24 a	23 a	7 a	2 a	1 a	3 a	16 a	9 a	467 ab
Nitrozyme	23 a	23 a	8 a	3 a	2 a	3 a	19 a	11 a	506 a
Non-treated	21 a	19 a	5 a	2 a	1 a	2 a	13 a	7 a	388 b
Trinexapac-ethyl Interval (TEI)[d]									
7 d	43 a	36 a	12 a	3 a	2 a	4 a	39 a	19 a	849 a
14 d	16 b	22 b	4 b	2 b	1 ab	3 a	6 b	7 b	338 b
None	12 b	6 c	3 b	1 b	1 b	2 a	3 b	1 c	151 c

J.A. Roberts et al. / Crop Protection 72 (2015) 119–126

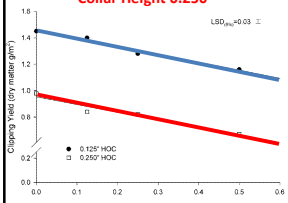
Etiolation Summary

- Unclear connection between Primo and 2 types of bacterial etiolation
  - In Roberts data, turf quality never declined
- Some bacteria make GA & this may be why Primo effects could be negated
- Many supers have gone to Primo + Cutless low rate summer combos as a stronger anti-GA combo against etiolation

The Mowing Height Effect

Actual Clipping Yield

Collar Height 0.250”

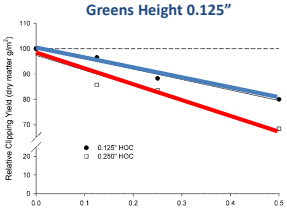


Primo Maxx Application Rate

Collar Height Grass Grows 50% Slower Than Greens Height Grass

Relative Clipping Yield

Greens Height 0.125”

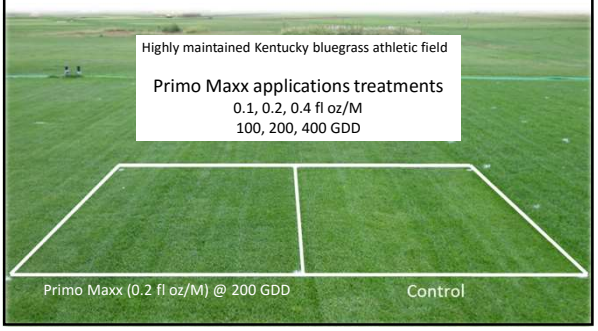


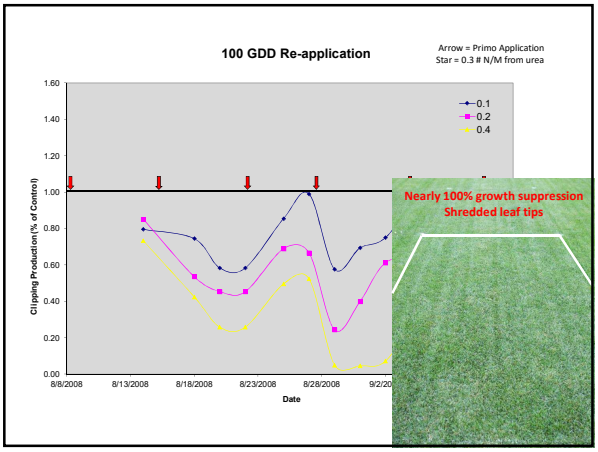
Primo Maxx Application Rate

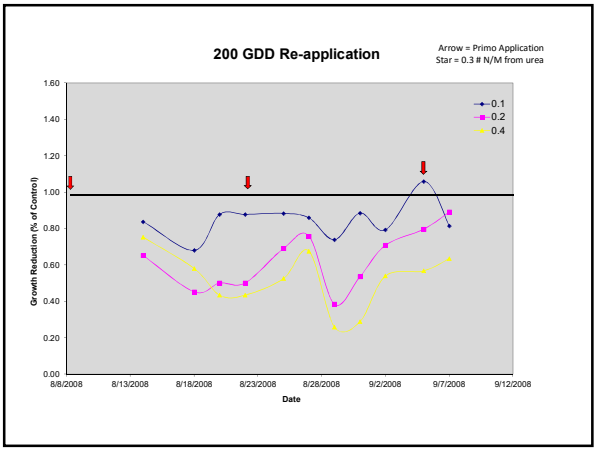
More Relative Yield Suppression on Collar Height Grass Than Greens

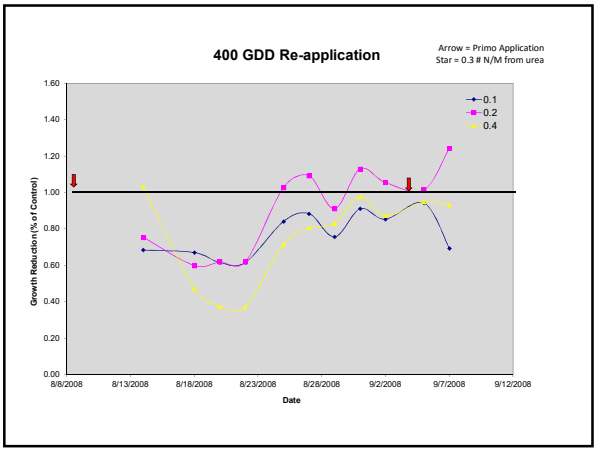
Primo Maxx on Kentucky Bluegrass

Very Limited Data Set from 2008

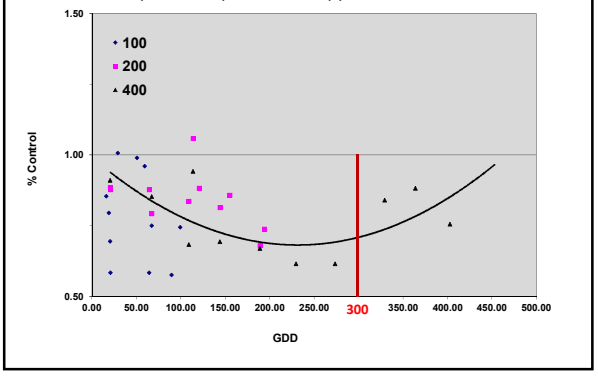




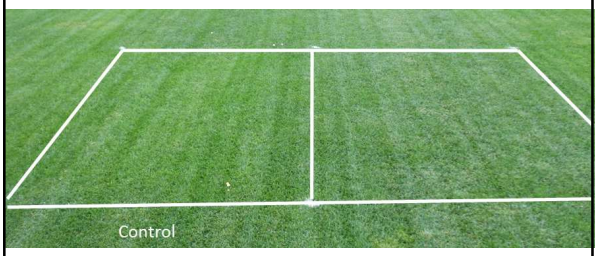




Early GDD modeling suggest period is ~900 GDD
Amplitude dependent on application rate



Best visual turfgrass quality at 0.20 fl oz/M every 200 GDD



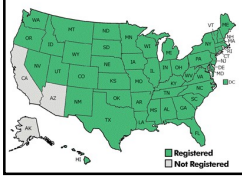
Lots more KBG research next year

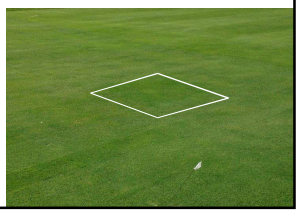
Trinexapac-ethyl Summary

- Applying PGRs on calendar schedules are inefficient
- GDDs (base 0°C) predict PGR duration
  - Bentgrass greens (200-230 GDD)
  - KBG field/fairway (300 GDD) – Greater growth suppression – More data required!!!
- Application re-application interval more important than rate to sustain suppression phase
- Higher mown turf more sensitive to PGR application

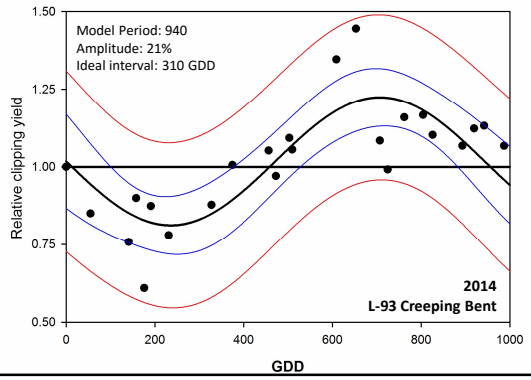
Anuew™ PGR on the block

A.I.:	Prohexadione-Ca
PGR Class:	Class A – Late GA Inhibitor
Uptake:	Foliar
Formulation:	Extruded granule (dry product)
Rate Range:	1.8 to 29.1 oz/acre (0.04 to 0.67 oz/M)
	1.8 to 7.25 oz/acre – Cool-season greens
	7.25 to 14.5 oz/acre – Warm-season greens

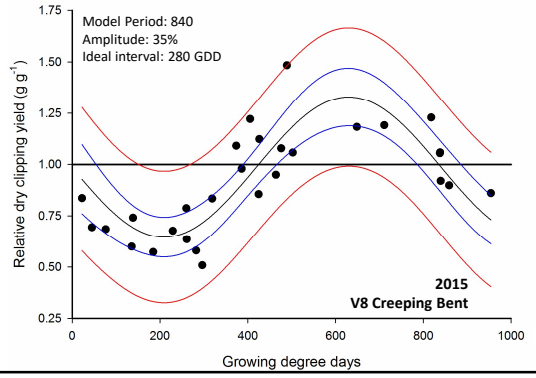




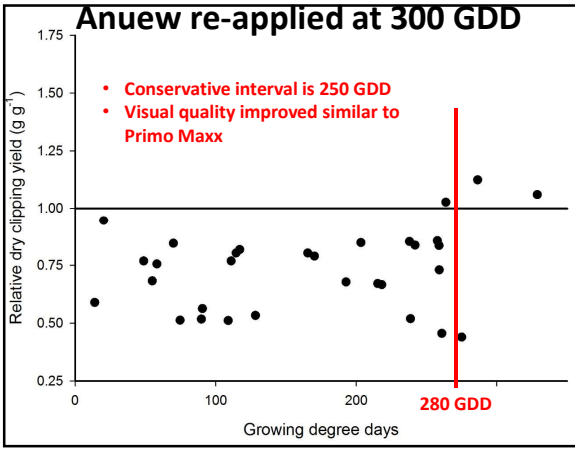
Prohexadione-Ca performance on greens



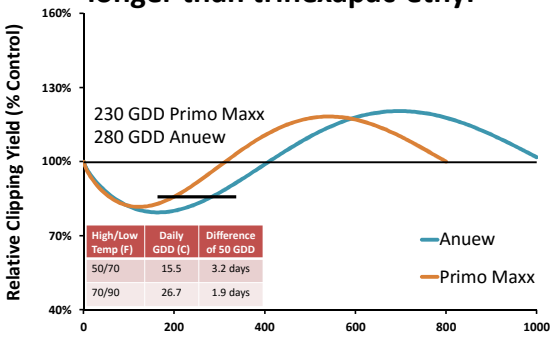
Prohexadione-Ca performance on greens



Anuew re-applied at 300 GDD



Prohexadione-Ca (Anuew) lasts slightly longer than trinexapac-ethyl



High/Low Temp (F)	Daily GDD (C)	Difference of 50 GDD
50/70	15.5	3.2 days
70/90	26.7	1.9 days

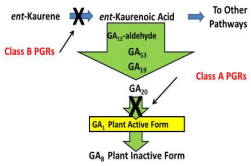
Anuew Summary

- Another Class A PGR
  - Similar growth suppression as trinexapac-ethyl
    - Greens
    - Bentgrass fairway turf (not shown)
  - Lasts roughly 50 GDD longer (250-280 GDD)
- Some reports of phytotoxicity
  - Weren't observed
  - Improved turfgass quality with frequent application

Today's Road Map

- PGR Introductions
- Modeling PGR performance with GDDs
  - Primo Maxx
  - Anuew
  - Class B PGRs and their combinations
- Why even use PGRs?
- Wrap-up

What's the ideal interval for other PGRs?



Is there a benefit to mixing A.I.?

- Legacy (flurprimidol + TE)
- Musketter (paclobutrazol + flurprimidol + TE)
- DYI mixtures

Goal: Develop GDD models for all PGRs

Questions:

- Can root absorbed Class B PGRs be modeled?
- Do Class B PGRs have a strong rebound?
- Can mixing PGRs improve control?

Objective:

Create GDD models for Class B PGRs

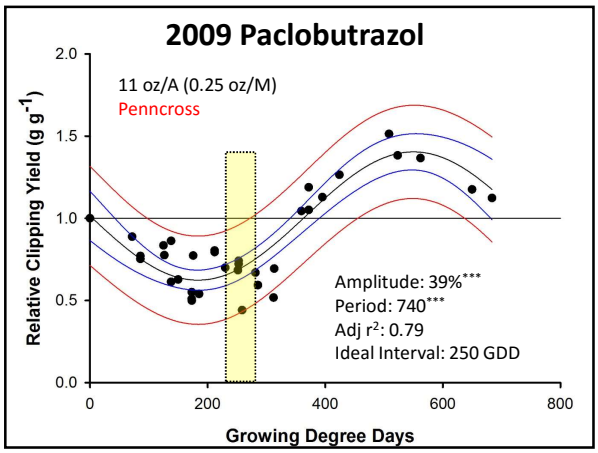
Methods: Locations and Treatments

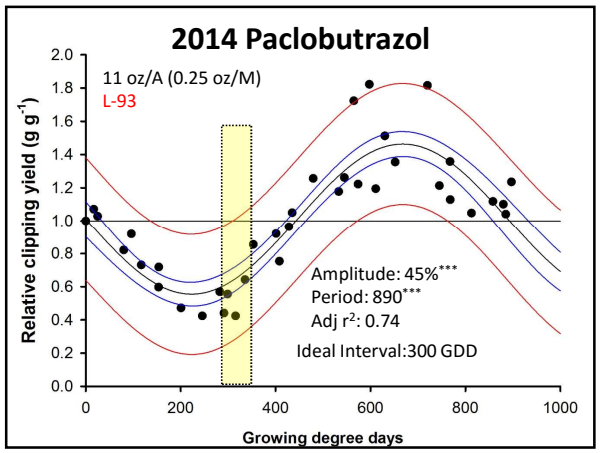
Locations:

- 2009 – Penncross green in Madison, WI
- 2014 – L-93 green in Mead, NE

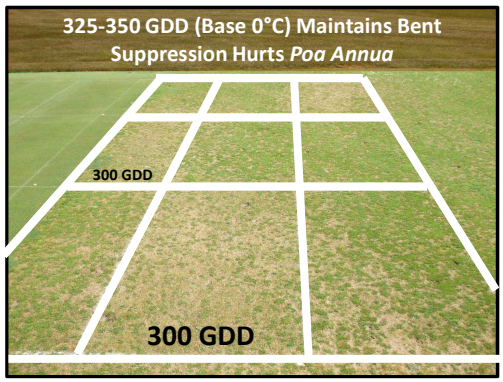
Treatments (3 replicates)

- Non-treated control
- Paclobutrazol (Trimmit 2SC)
  - 0.19 kg a.i. ha^{-1} (11 oz $acre^{-1}$)
  - 1000 GDD
  - 400 GDD (2009) & 300 GDD (2014)





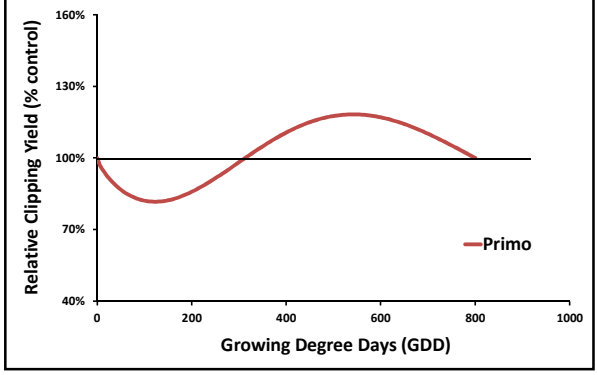
Paclo. GDD impacts annual bluegrass



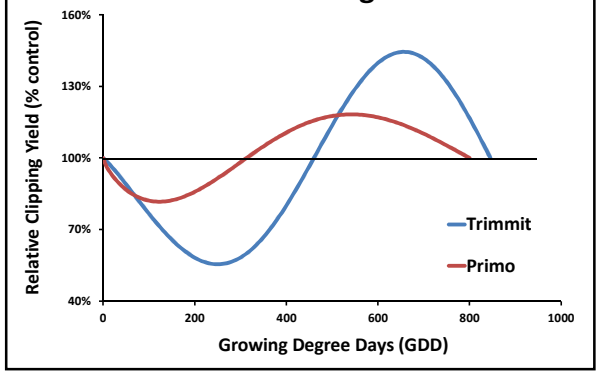
GDDs predicted paclobutrazol performance on bentgrass greens

- GDD models highly correlated to clipping yield
  - Small year/cultivar interaction
  - 250 to 300 GDD re-application window
- Still question about rate, species, mowing height

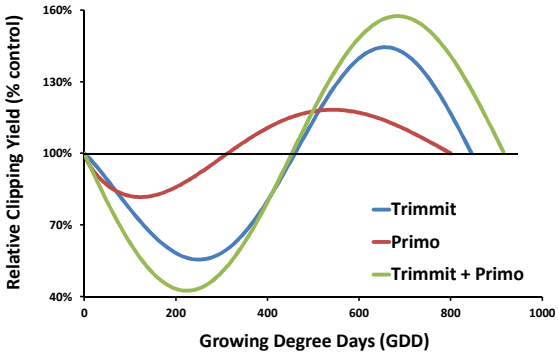
Comparing Trimmit to Primo Maxx



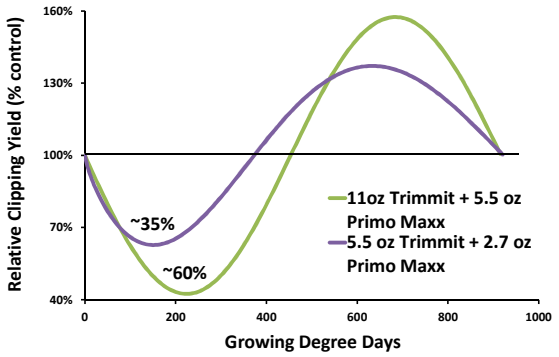
Comparing Plant Growth Regulator Performance on Bentgrass Greens



Combining Trimmit and Primo



Evidence of rate response



Multiple PGRs studied in 2015

Nebraska, Texas Tech, Arkansas

- Trimmit, Cutless, Legacy, Musketeer
- Variable rates in Nebraska
  - 2 to 3 rates (lowest label to highest label)

Quick Results

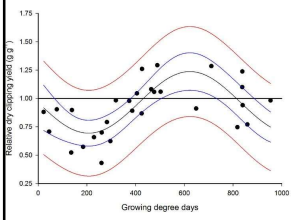
Still strongly correlated

Evidence of rate response

Sometimes the model is not symmetrical

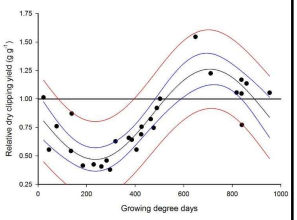
Low rate vs high rate Trimmit 2SC

5.5 oz/A (0.13 oz/M)



31% Suppression
270 GDD Interval

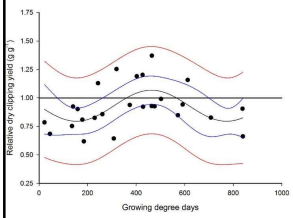
16 oz/A (0.38 oz/M)



53% Growth Suppression
310 GDD Interval

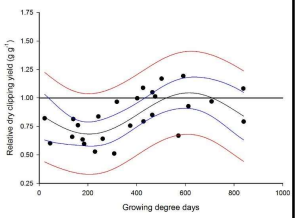
Low rate vs high rate Cutless 50W

2.0 oz/A (0.05 oz/M)



20% Suppression
200 GDD Interval

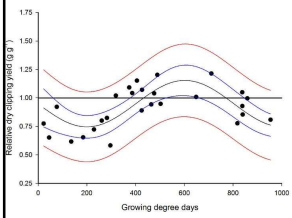
8.0 oz/A (0.18 oz/M)



32% Growth Suppression
270 GDD Interval

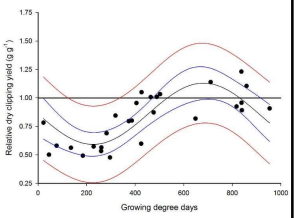
Low rate vs high rate Legacy

4.8 oz/A (0.11 oz/M)



25% Suppression
270 GDD Interval

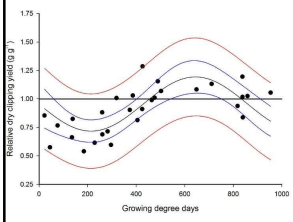
9.6 oz/A (0.22 oz/M)



41% Growth Suppression
300 GDD Interval

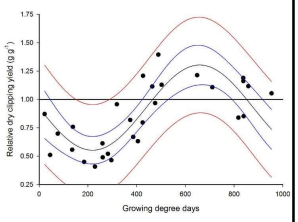
Low rate vs high rate Musketter

12 oz/A (0.27 oz/M)



28% Suppression
290 GDD Interval

22 oz/A (0.51 oz/M)



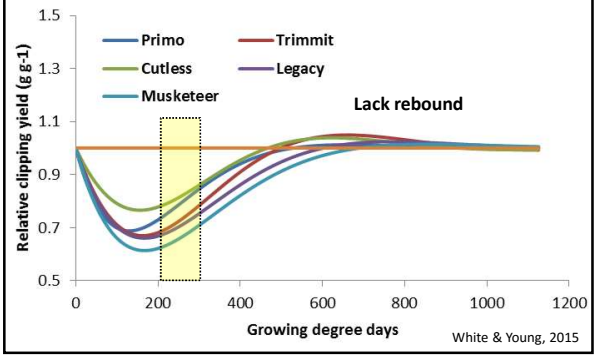
45% Growth Suppression
290 GDD Interval

Comparing PGR Performance

Active Ingredient	Common Name	Growth Suppression	Duration of Effect	Ideal GDD
Trinexapac-ethyl	Primo Maxx	20%	800 GDD	230 GDD
Paclobutrazol	Trimmit	30-50%*	850-950 GDD*	280-310 GDD*
Flurprimidol	Cutless	20-30%*	600-800 GDD*	210-270 GDD*
Anuew	Prohexadione-Ca	25%	840 GDD	280 GDD
Flurprimidol + Trinexapac-ethyl	Legacy	20-35%*	810-910 GDD*	270-300 GDD*
Flurprimidol + Paclobutrazol + Trinexapac-ethyl	Musketeer	25-40%*	880 GDD	290

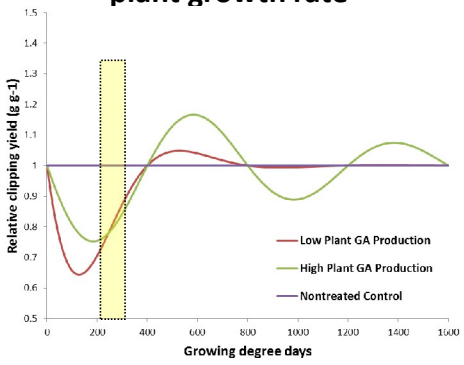
* Range from low to high application rate

Turf under stress has weak rebound



White & Young, 2015

Hypothesis: Lack of rebound due to plant growth rate



Today's Road Map

- PGR Introductions
- Modeling PGR performance with GDDs
  - Primo Maxx
  - Anuew
  - Class B PGRs and their combinations
- **Why even use PGRs?**
- Wrap-up

What's the benefit of using PGR?

- **Increased color, quality and density**
- **Increased water use efficiency**
  - Slightly lower ET (King et al., 1997: Marcum and Jiang, 1998; Ervin and Koski, 2001)
  - Increase salinity tolerance and improved dry down
    - (Jiang and Fry, 1998; Pessarakli et al., 2006)
- **Improved heat stress tolerance**
  - More stress hormones and antioxidants (Ervin and Zhang, 2003)
  - Increase sod storage life in heat (Heckman et al., 2001 & 2002)
- **Increased non-structural carbohydrates**
  - During suppression phase (Han et al., 1998 & 2004; Richie 2001; and Ervin and Zhang, 2007)

Positive Side-Effects

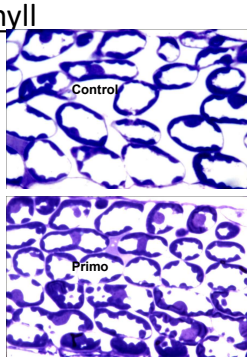
Morphology & Physiology

TE increases cell density and chlorophyll

Table 1: Effects of trinexapac-ethyl (TE) (0.27 kg·ha^{-1} (a.i.) on mesophyll cells and chlorophyll concentration of Kentucky bluegrass.

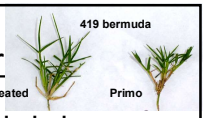
Observation	Control	Treated	*P*	CV (%)
Mesophyll cells (4 wk)				
No./mm^2	550	750	0.003	22.4
Length (µm)	56	45	0.001	13.5
Width (µm)	32	30	0.160	11.7
Chlorophyll content (mg·g^{-1} FW)				
2 WAT - a	2.71	2.94	0.170	13.0
b	1.31	1.60	0.001	11.3
Total	4.02	4.55	0.004	8.4
4 WAT - a	2.76	2.65	0.010	3.3
b	0.62	1.10	0.033	53.3
Total	3.39	3.74	0.110	13.3

Ervin and Koski. 1998. HortSci. 33(7):1200-1202.



Primo increases Tiller

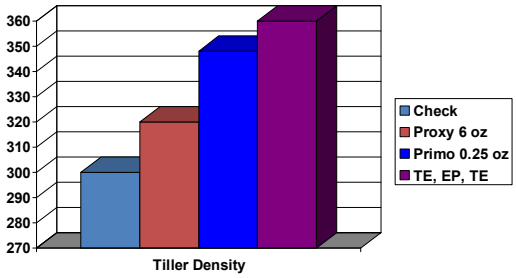
Ervin, HortSci. 1998; Crop Sci. 2001; HortSci, 2001



Species	Tillers per 4 inch plug: Primo	No Primo
Perennial ryegrass	341	203
Kentucky bluegrass	266	233
Zoysia	338	301

Class B's also increase tiller density of C3 & C4 turfgrasses

Poa annua density in response to Proxy, Primo



Tiller Density

Restricting Poa flowering with Proxy/Primo can result in greater spring to summer density

From: Calhoun, MSU: Apps on 5/5, 6/2, 7/2; 0.2" mow ht

Primo: Rooting increase for C3?

Colorado (Ervin)
PR: no effect
KBG: no effect

Auburn (Walker, Guertal)
CB: no effect

Virginia Tech (Schmidt, Zhang)
CB: no effect

Iowa State (Christians)
CB: no effect

Kansas State (Fry, Marcum)
PR: no effect
TF: no effect

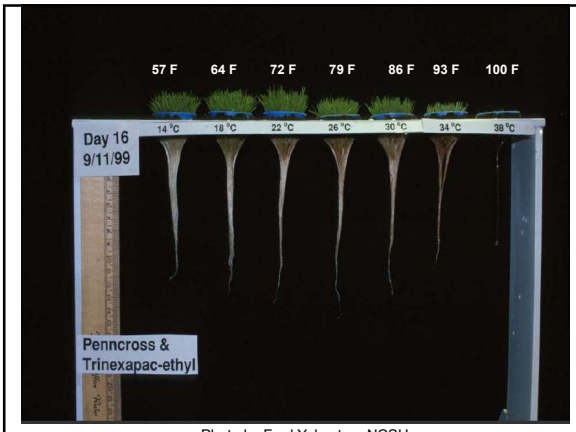


Photo by Fred Yelverton, NCSU

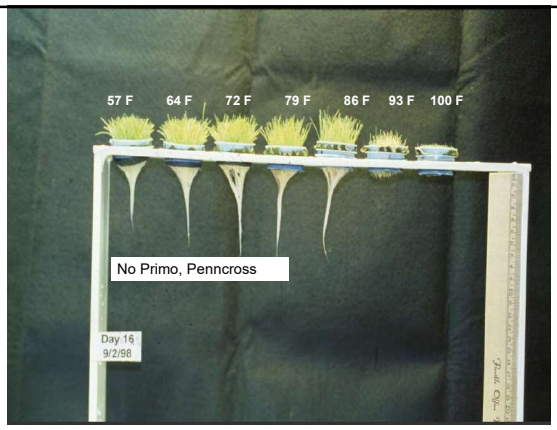


Photo by Fred Yelverton, unpublished research

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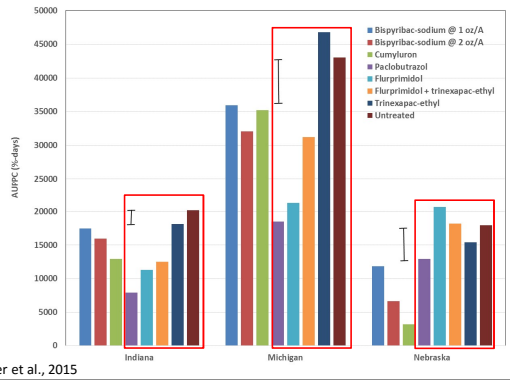
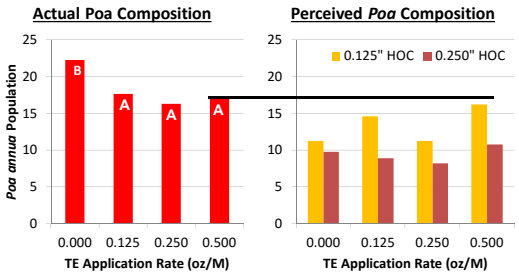
Annual bluegrass control on greens



Reicher et al., 2015

TE can give the appearance of more annual bluegrass in bentgrass greens

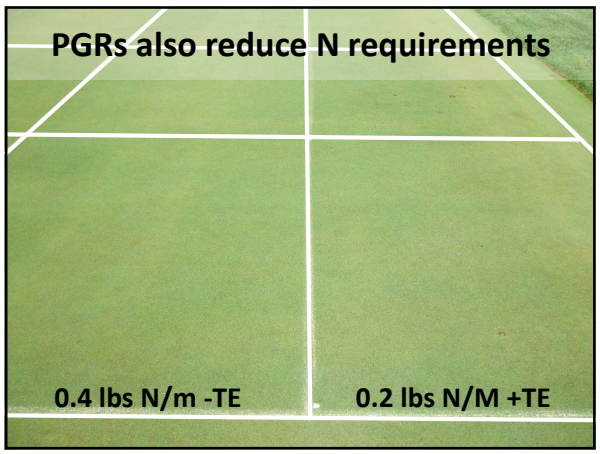


- TE Decreased *Poa Annua*
- Mowing height not sig
- Supers underestimate *Poa*
- Except low HOC, high TE rate

TE Increases Visual Contrast of *Poa annua* in bentgrass

- Differences in Color Response
  - Poa = Lighter Green
  - Bent = Darker Green
- Grass Species Segregate Out
  - Less Leaf Inter-mixing

PGRs also reduce N requirements



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Studied PGRs Effect on Ball Roll

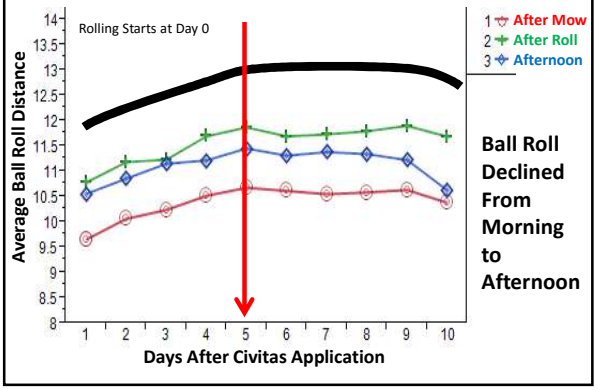
- **Research Questions & Objectives**

1. When are putting greens fastest?
2. How Do PGRs affect ball roll distance
   1. Within a day?
   2. Over the course of 10 days?
3. Does Clipping Yield influence Ball Roll Distance?

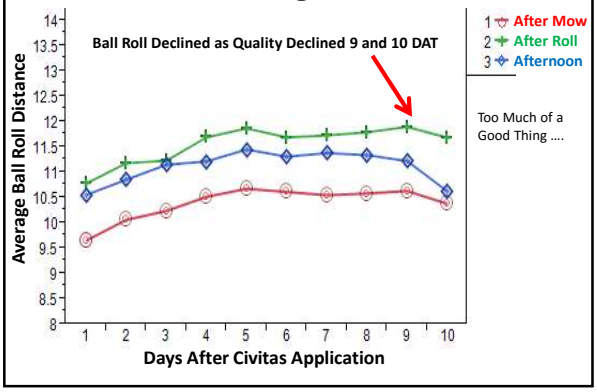
Details of the Experiment

- Bent/Poa Putting Green
- Treatments
  - Primo (0.125 oz/M @ 200GDD)
  - Trimmit & Cutless (0.25 oz/M @ 300GDD)
- Measured
  - Clipping Yield Daily
  - Ball Roll After Mowing, After Rolling, Afternoon

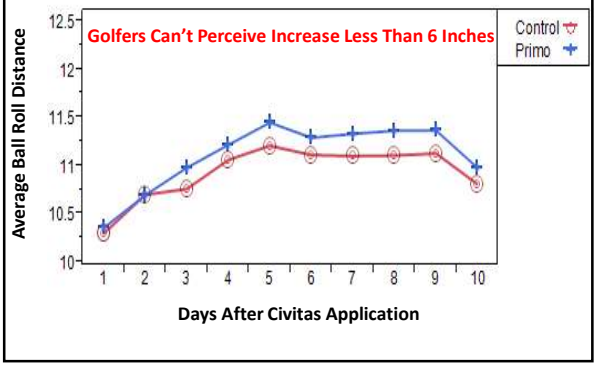
When Are Putting Greens Fastest?



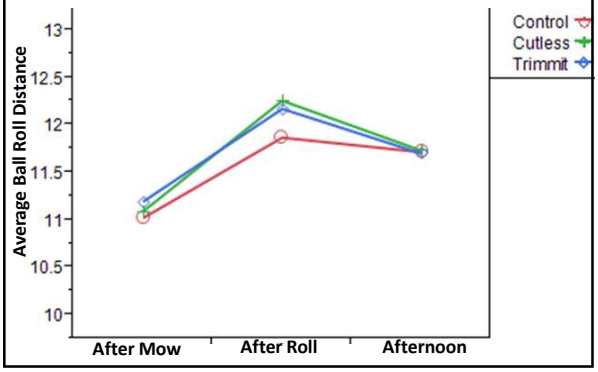
When Are Putting Greens Fastest?



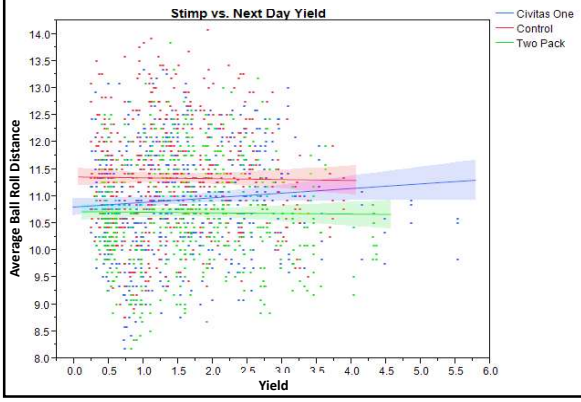
Primo increased ball roll a little



Trimmit and Cutless increased ball roll after rolling but not sustained into Afternoon



Ball roll *Not* related to clipping yield



Ball Roll Summary…..

- Ball roll greatest 4 to 5 days after daily rolling
- As quality declined, ball roll declines
- PGRs had a small benefit on ball roll distance
- Ball roll not directly related to clipping yield
- Management Strategies:
  - Grow healthy turfgrass
  - Roll once daily prior to an event
  - Use PGRs to increase plant health despite variable effect on ball roll

Today's Road Map

- PGR Introductions
- Modeling PGR performance with GDDs
  - Primo Maxx
  - Anuew
  - Class B PGRs and their combinations
- Why even use PGRs?
- **Wrap-up**

Effective PGR Use on Cool-Season Turf

- All PGR can be modeled with GDDs
  - Calendar-based intervals inefficient
  - Rate impacts magnitude much more than duration
  - Higher mowed turf more susceptible
- PGR benefits are real when suppression phase maintained
  - Green speed benefits are minimal
- Download our Excel Tracker Version 2.2015
  - Watch for the launch of our GreenKeeper app

Download the newest version of our PGR Excel Tracker (version 3.0)

Temperature Unit	Fahrenheit
Select PGR	Primo Maxx
Enter Rate (oz/acre)	5.5
Default GDD Interval	200
Use the Default GDD Interval?	Yes
---------- If 'No', then define GDD re-application interval below ----------	
User Defined GDD Interval (0 to 800 GDD)	150

Date	Observed High Temperature	Observed Low Temperature	PGR Applied	Daily GDD	Cummulative GDD	Approximate Relative Yield	Required Action	Forecasted Temp High	Forecasted Temp Low
4/15/2015	75.0	60.0	No PGR Applied	19.7	19.7	93%	None	32	
4/16/2015	80.0	65.0	No PGR Applied	22.5	42.2	88%	None		
4/17/2015	78.0	66.0	PGR Applied Today	22.2	22.2	92%	None		
4/18/2015	74.0	61.0	No PGR Applied	19.7	41.9	88%	None		
4/19/2015	75.0	58.0	No PGR Applied	19.2	61.1	85%	None		
4/20/2015	72.0	60.0	No PGR Applied	18.9	80.0	83%	None		
4/21/2015	68.0	63.0	No PGR Applied	18.6	98.6	82%	None		
4/22/2015	80.0	60.0	No PGR Applied	21.1	119.7	82%	None		
4/23/2015	84.0	67.0	No PGR Applied	24.2	143.9	82%	None		
4/24/2015	85.0	65.0	No PGR Applied	23.9	167.8	83%	None		
4/25/2015	88.0	69.0	No PGR Applied	25.8	193.6	85%	None		
4/26/2015	90.0	71.0	No PGR Applied	26.9	220.6	88%	Re-apply PGR		
4/27/2015	94.0	73.0	PGR Applied Today	28.6	28.6	91%	None		
4/28/2015			No PGR Applied			100%			
4/29/2015			No PGR Applied			100%			

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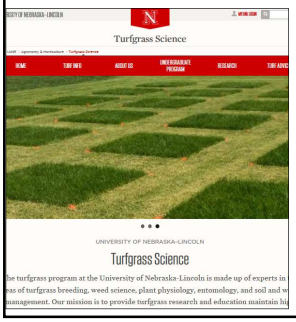

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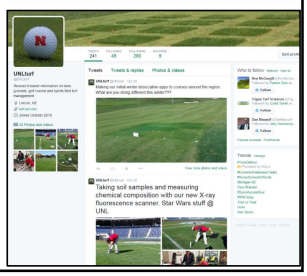

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