Introduction to Plant Growth Regulators for Use in Grass Seed Crops

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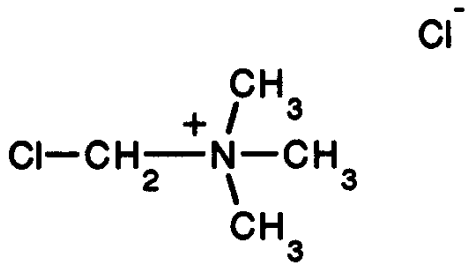
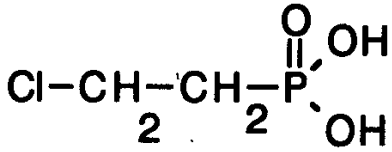
What is a Plant Growth Regulator?

- **Plant growth regulators** (PGRs) are organic compounds, other than nutrients, that when applied affect processes such as growth and development.
- Plant growth and development processes are mediated by **hormones**. These processes can be successfully manipulated by application of the appropriate PGR.
- PGRs are active at low concentrations but have pronounced effects akin to hormones. PGRs may affect growth, development or both processes.



Chlormequat chloride
(CCC, Cycocel)



Ethephon
(Cerone, Ethrel, Finish)

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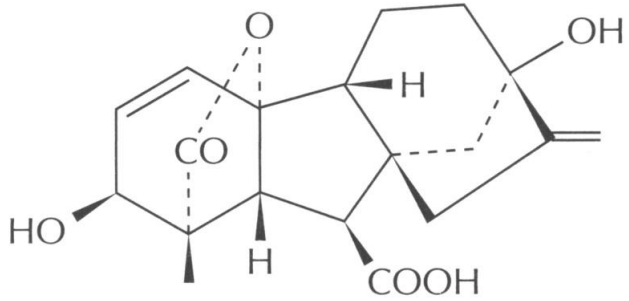
Classification of Plant Growth Regulators

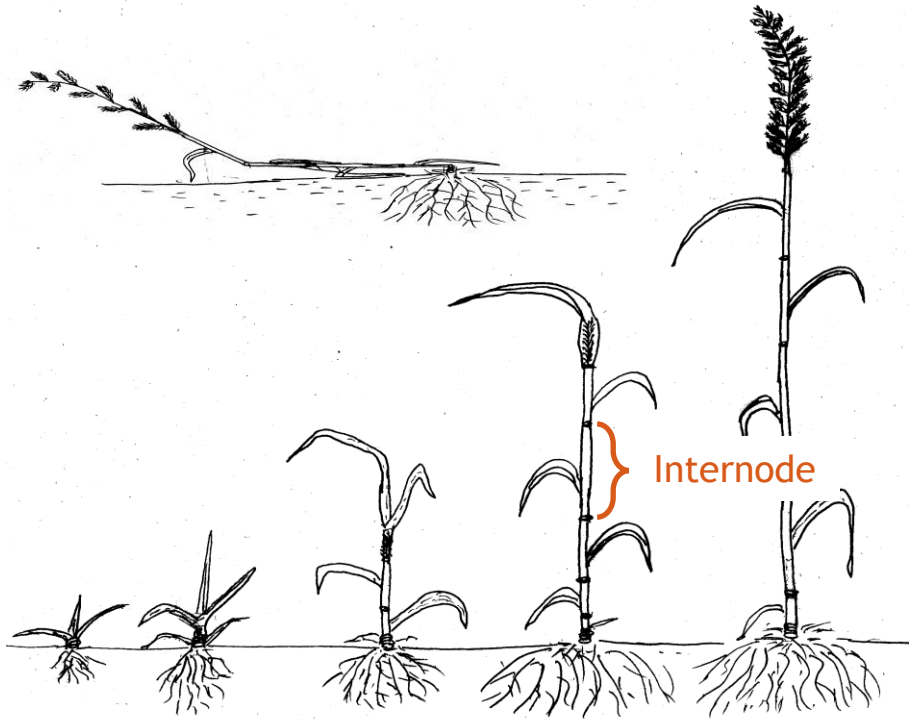
- PGRs may be naturally occurring compounds, synthetic analogs of hormones, or inhibitors of hormone biosynthesis.
- PGRs are classified into groups by activity, function, or mode of action.
- Some herbicides and fungicides may have PGR properties.



GA_3

PGR Class
Gibberellins (GA) and synthetic analogs
Cytokinins and synthetic analogs
Auxins and synthetic analogs
Ethylene
Ethylene biosynthesis inhibitors
Onium compounds
Triazoles
Acylcyclohexanediones

PGRs for Lodging Control in Grass Seed Crops



- Stem elongation results from activity of the intercalary meristem. Each internode elongates independently and is promoted by the hormone GA_1.
- When the tiller cannot support the weight of the inflorescence, the tiller lodges or falls to the ground.
- Lodging restricts pollination and reduces fertilization. Seed filling is reduced due to self-shading of the lodged crop.
- Seed number is reduced by lodging.

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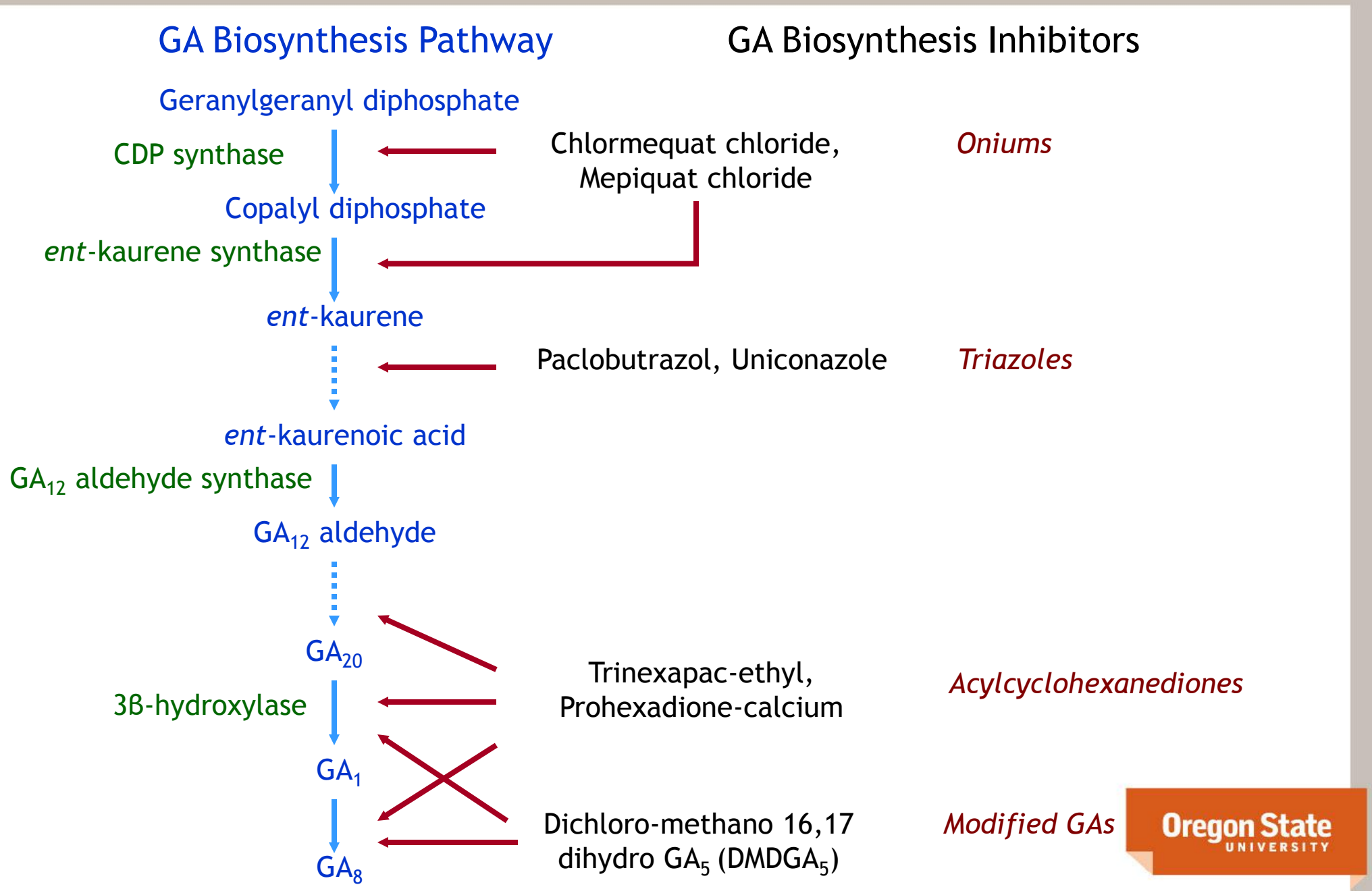
GA Biosynthesis Pathway
GA Biosynthesis Inhibitors
Geranylgeranyl diphosphate
CDP synthase
Copalyl diphosphate
ent-kaurene synthase
ent-kaurene
ent-kaurenoic acid
GA12 aldehyde synthase
GA12 aldehyde
GA20
3B-hydroxylase
GA1
GA8
Chlormequat chloride,
Mepiquat chloride
Oniums
Paclobutrazol, Uniconazole
Triazoles
Trinexapac-ethyl,
Prohexadione-calcium
Acylcyclohexanediones
Dichloro-methano 16,17
dihydro GA5 (DMDGA5)
Modified GAs
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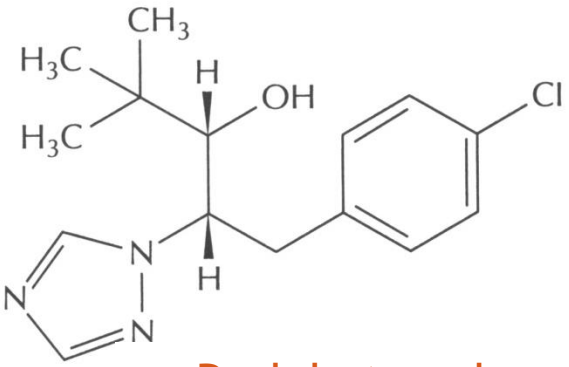
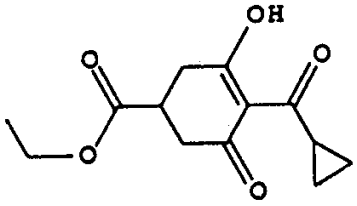
PGRs for Lodging Control in Grass Seed Crops

- PGR use in grass seed crops is not a new phenomenon and the most widely researched and used of the early PGRs was paclobutrazol, a triazole that affects ent-kaurene in the GA biosynthesis pathway.
- Seed yield was increased and lodging reduced by paclobutrazol.
- While this PGR worked well in some species such as the fine fescues, inconsistent results and occasional soil persistence problems eventually ended the use in other important grass seed crops.

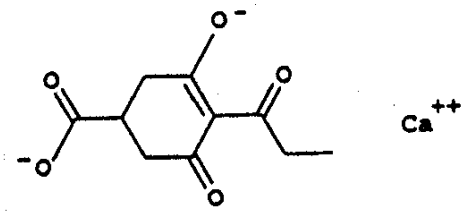


Paclobutrazol
(Parlay)

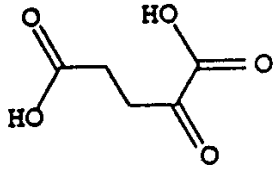
Acylcyclohexanedione PGRs



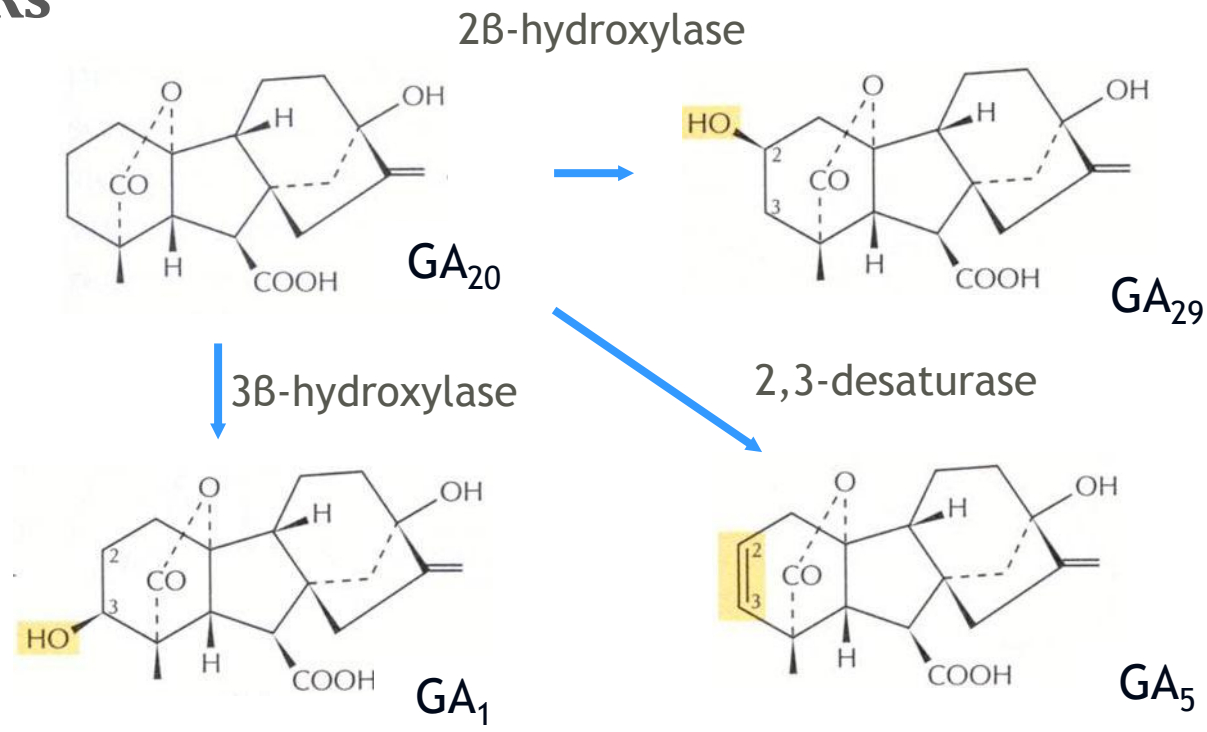
Trinexapac-ethyl (Moddus, Palisade)



Prohexadione-calcium (Apogee)



2-oxoglutaric acid



- Trinexapac-ethyl (TE) and prohexadione-calcium (PC) plant PGRs are inhibitors of the 3-β hydroxylation of GA_{20} to GA_1. GA_1 promotes stem elongation, GA_5 promotes flowering, GA_{29} is inactive.
- The PGRs are structurally similar to 2-oxoglutaric acid, a cofactor in the hydroxylation reaction.

Acylcyclohexanedione PGRs

Perennial ryegrass spikes

- While TE and PC shorten stems and reduce lodging, seed yield may be increased even with low incidence of lodging.
- TE and PC increase the efficiency of carbon partitioning to seed.

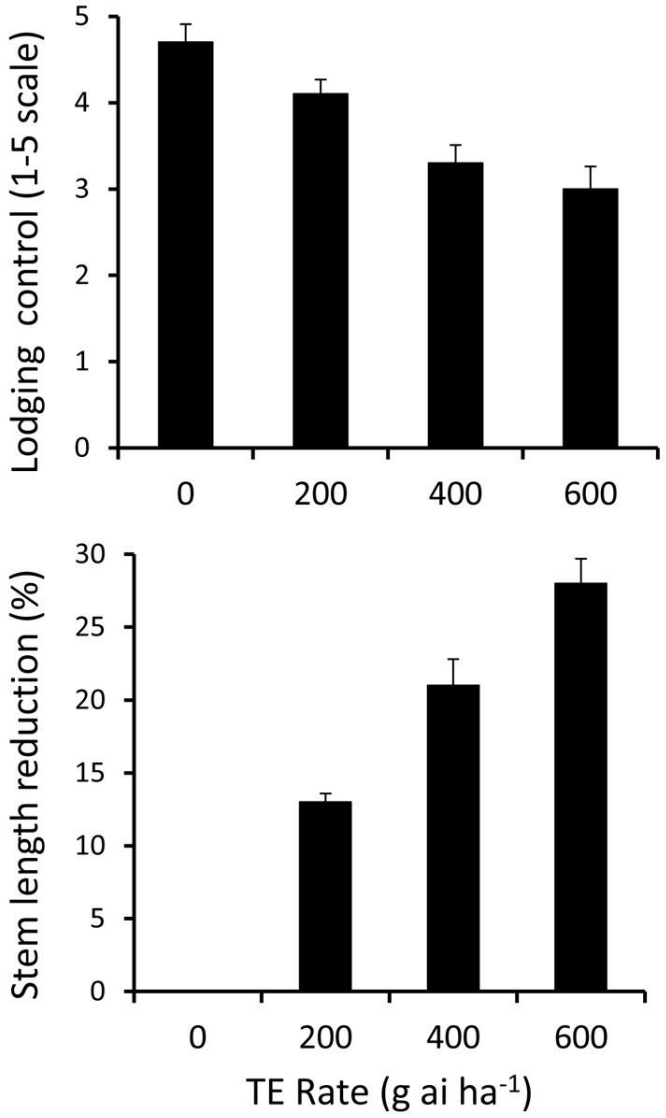
Acylcyclohexanedione effects
Increased floret number
Increased seed set
Increased seed number
Increased seed yield
Increased harvest index
Mixed effects on seed weight
Decreased stem length
Decreased lodging

Acylcyclohexanedione PGRs

- The efficacy of TE and PC applications is influenced by rate, seasonal timing, environment, nitrogen management, residue management, etc.

TE effects on perennial ryegrass seed production in 9 years of trials (Chastain et al., 2013).

TE rate (g ai/ha)	Seed yield (kg/ha)
0	1462 a
200	1831 b
400	2090 c
600	2303 c



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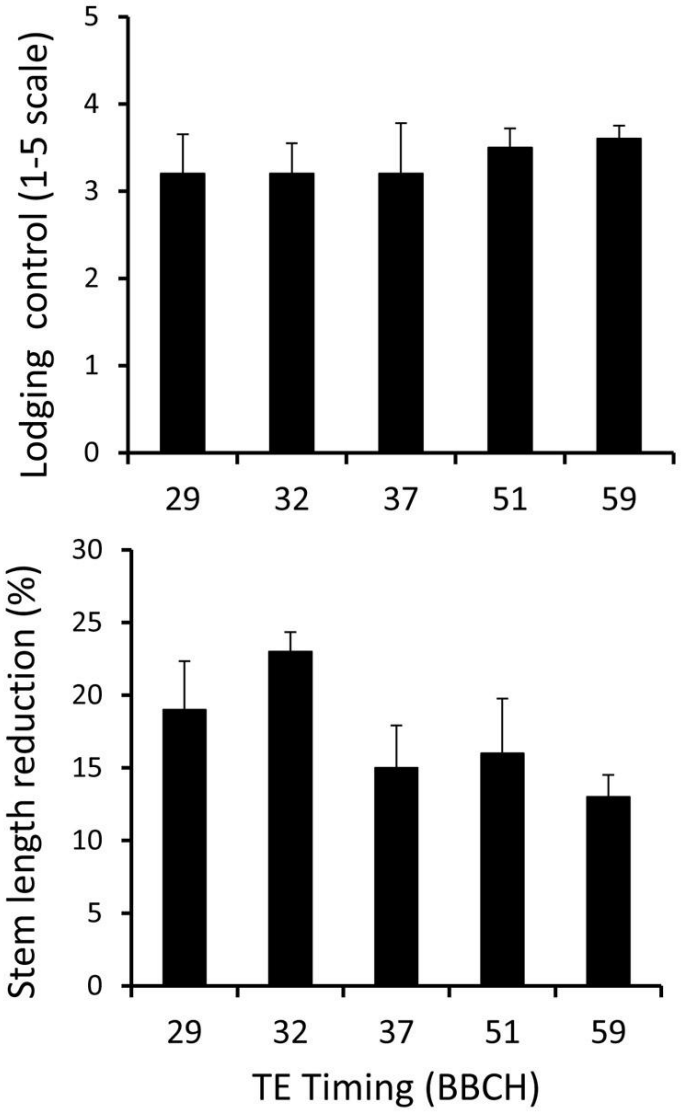
Acylcyclohexanedione PGRs

- The seasonal timing of TE and PC is important for optimal seed yield.

TE effects on perennial ryegrass seed production in 9 years of trials (Chastain et al., 2013).

TE timing (BBCH scale)	Seed yield (kg/ha)
29	1770 b
32	1981 c
37	1814 bc
51	1958 c
59	1518 a



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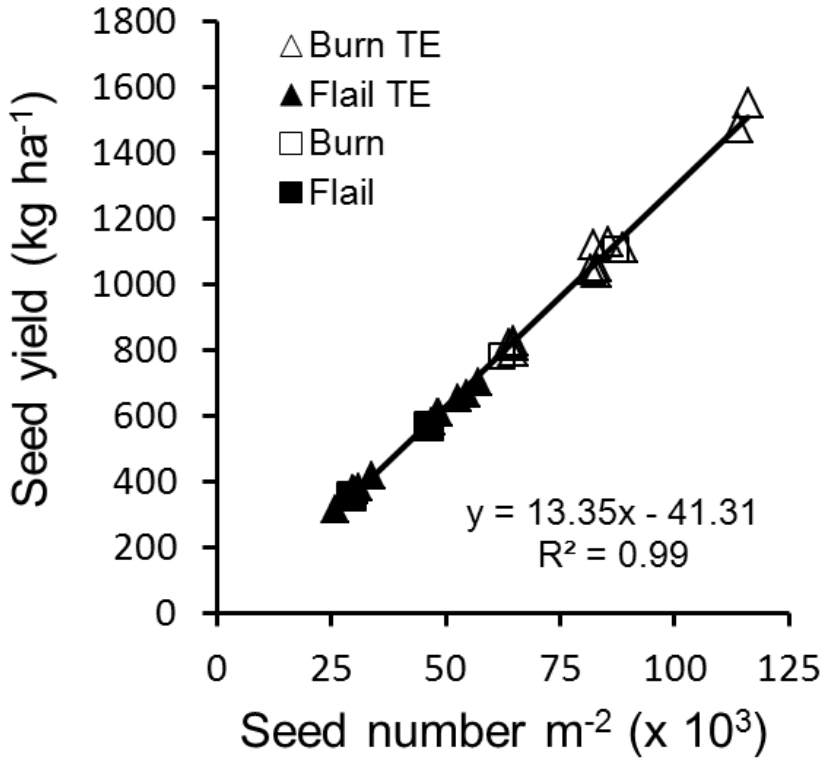
Interaction of PGRs and Residue Management

TE and residue management (Burn or Flail) effects on cumulative creeping red fescue seed yield over a 4-year period (Zapiola et al., 2006).

TE rate (g ai/ha)	Timing	Seed Yield (kg/ha)	
		Burn	Flail
0		4245 a	3035 a
400	Fall	4301 a	3058 a
400	Spring	5855 b	3862 b



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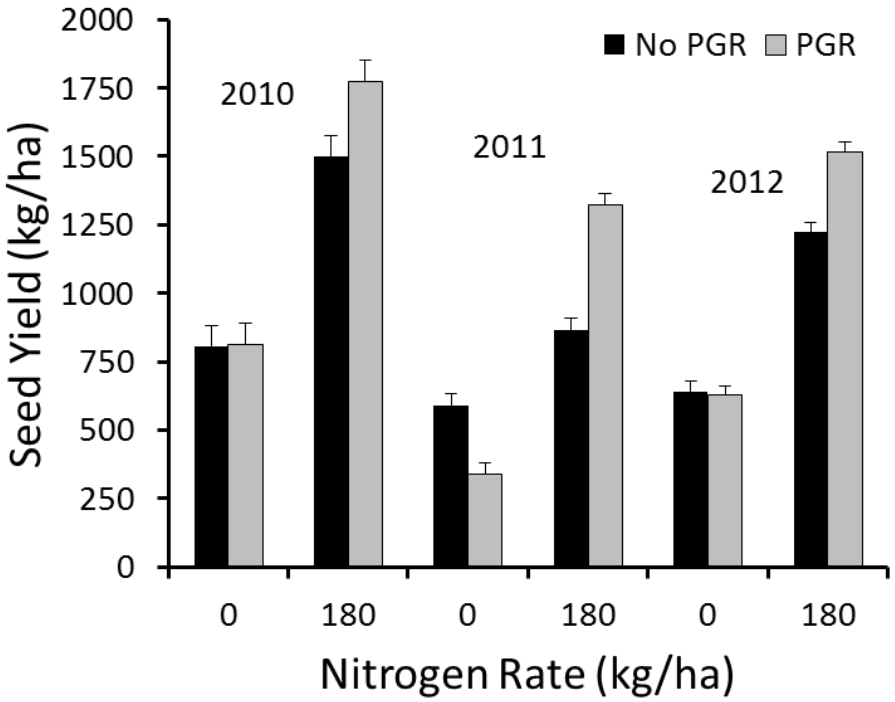
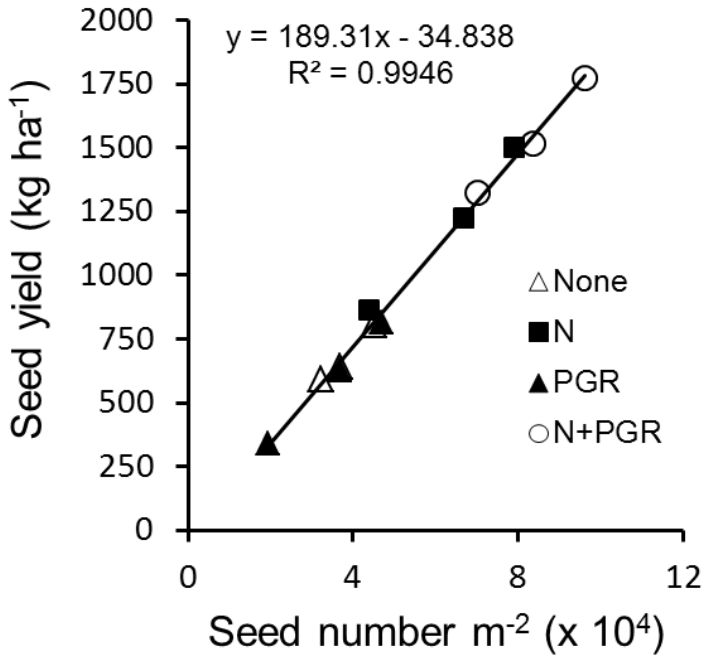
Interaction of PGRs and Nitrogen

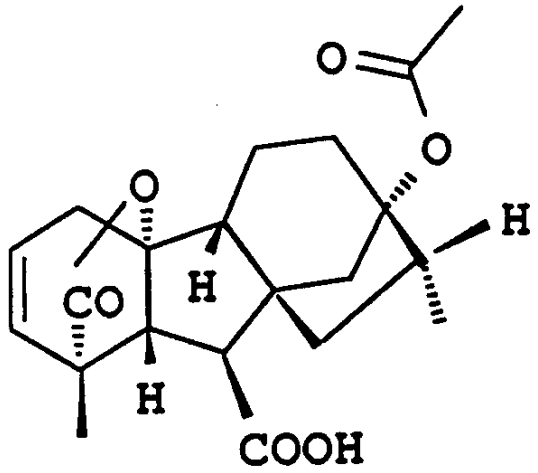




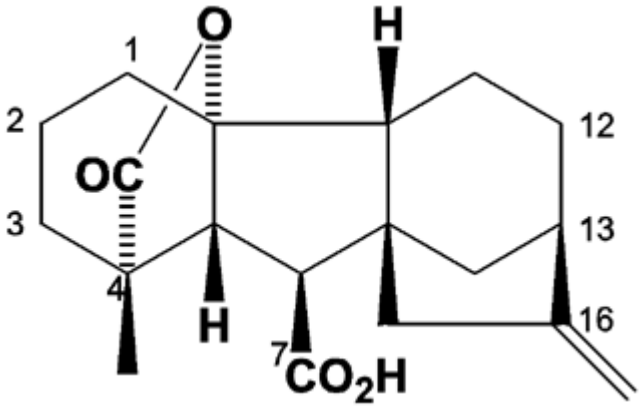
The Future?

GA analogs

- This new group of PGRs are not yet used in commercial agriculture and include versions that inhibit stem elongation and promote flowering at the same time.
- Dichloro-methano 16,17-dihydro GA_5 ($DMDGA_5$) has shown good potential for growth retardation in turfgrasses.
- 16,17-dihydro GA_5 and 16,17-dihydro GA_5 –13 acetate ($DiHGA_5$ acetate) are experimental modified GAs that reduce stem elongation.
- The next generation of PGRs will likely be even more effective and possibly economical than those presently available.



$DiHGA_5$ acetate



16,17-dihydro GA_5

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