Maximizing Seed Yield: A Review of Oregon PGR Research and Best Irrigation Practices

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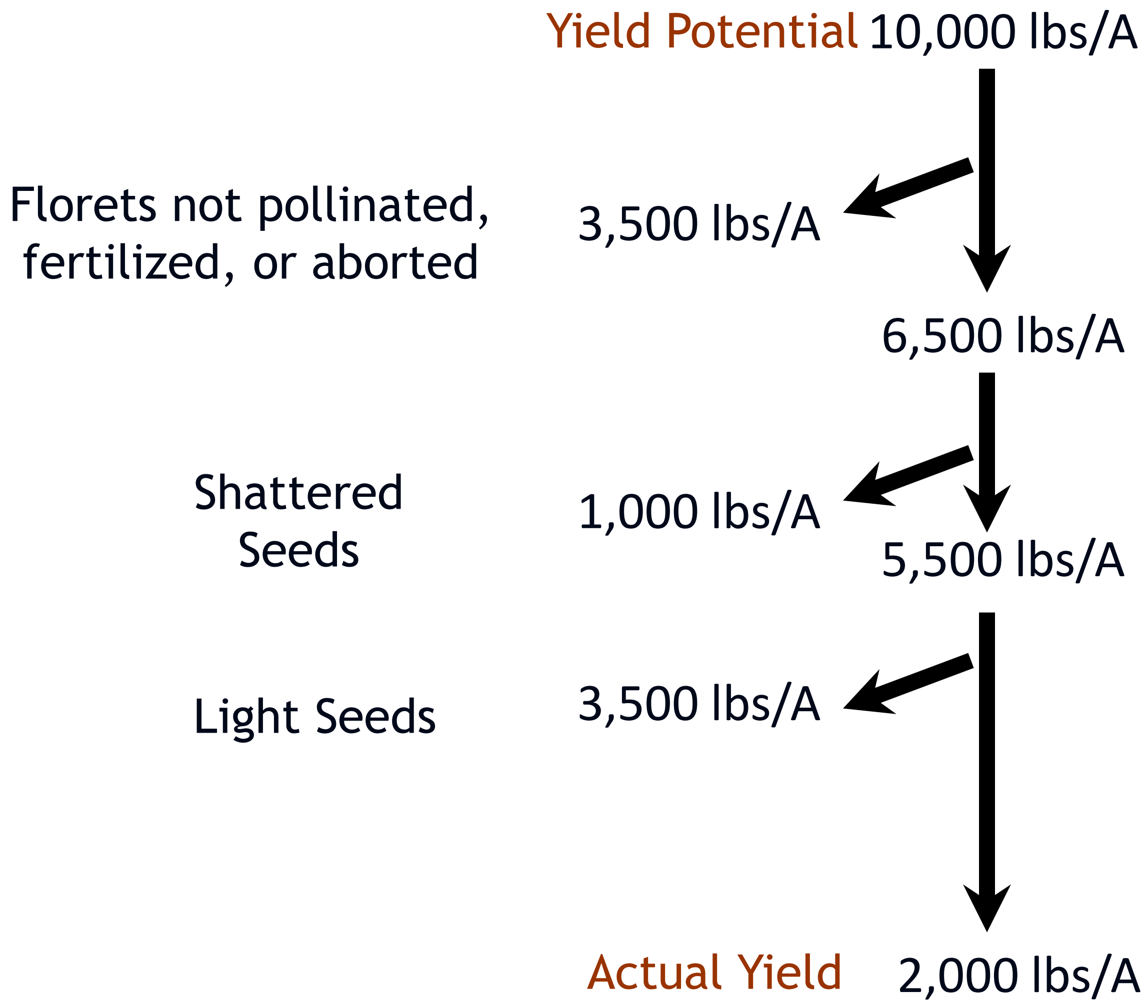
Seed Yield Potential vs. Actual Yield

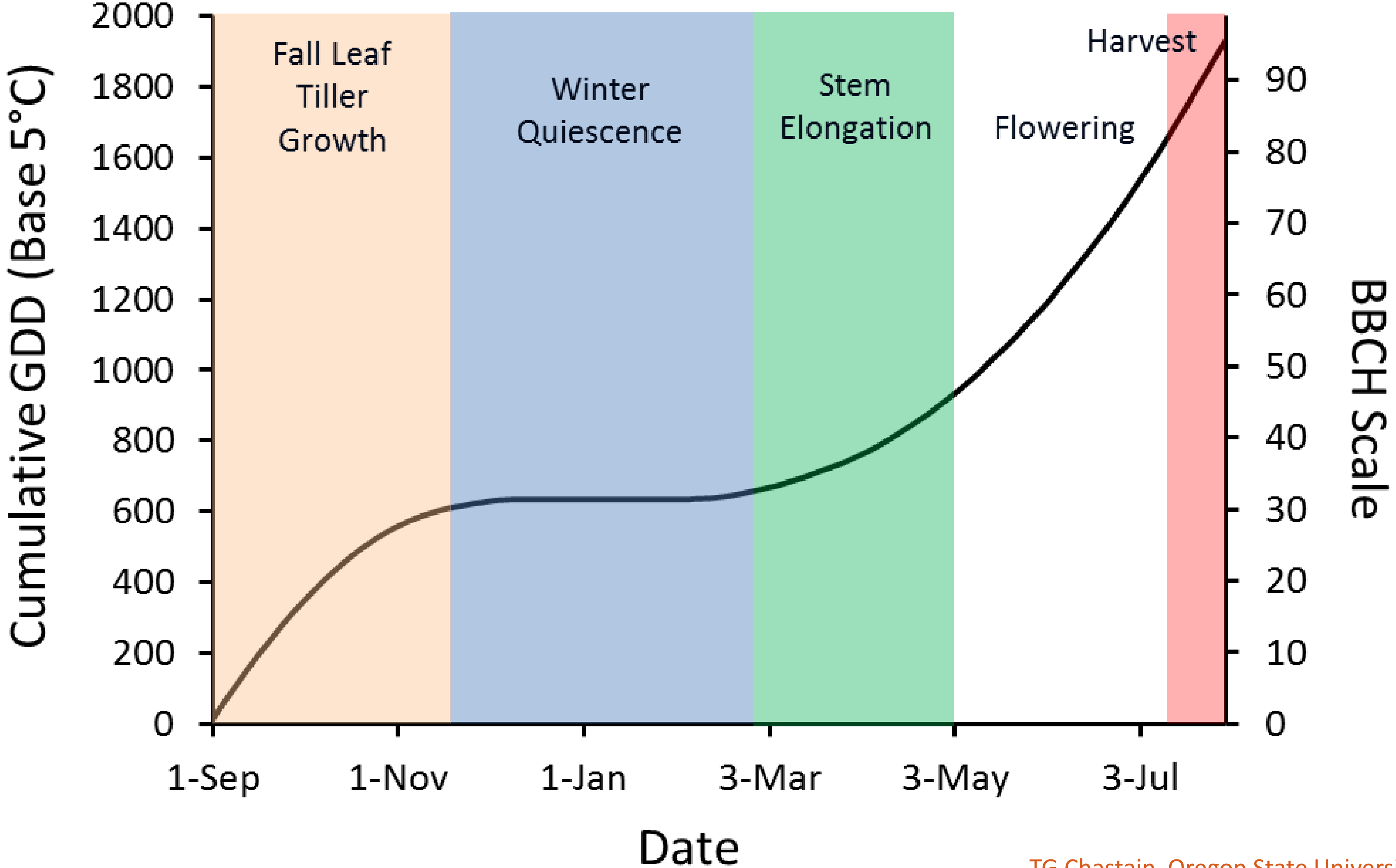
An example for perennial ryegrass



- Grass seed crops are biologically inefficient in the production of seed.
- Many flowers are produced by grasses yet relatively few of the flowers become seed.
- Research efforts are aimed at capturing a greater proportion of yield potential in grower's harvests.

Grass Seed Crop Growth and Development

Developmental stages of grass seed crops in relation to GDD from September 1st in Oregon



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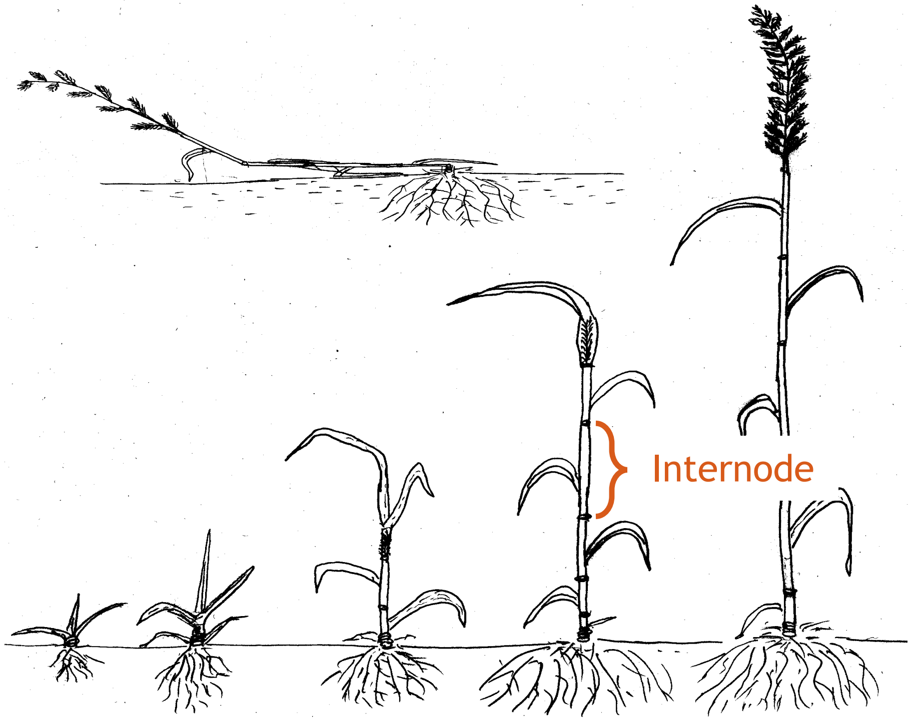
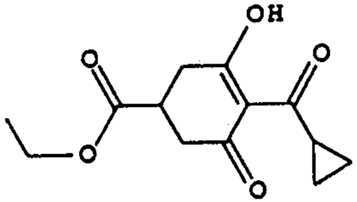
PGRs in Grass Seed Crops



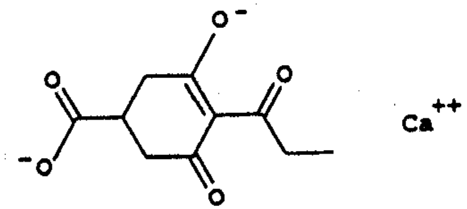
- Stem elongation is promoted by the hormone GA_1.
- When elongating stems cannot support the weight of inflorescences, tillers lodge or fall to the ground.
- Lodging restricts pollination and reduces fertilization, and in turn reduces seed yield.
- Plant growth regulators (PGRs) are organic compounds, other than nutrients, that when applied affect growth and development processes.
- PGRs are used as lodging control agents.

Lodged ryegrass (TG Chastain photo)

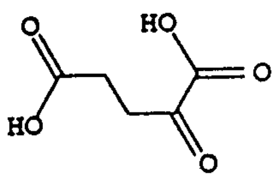
PGRs in Grass Seed Crops



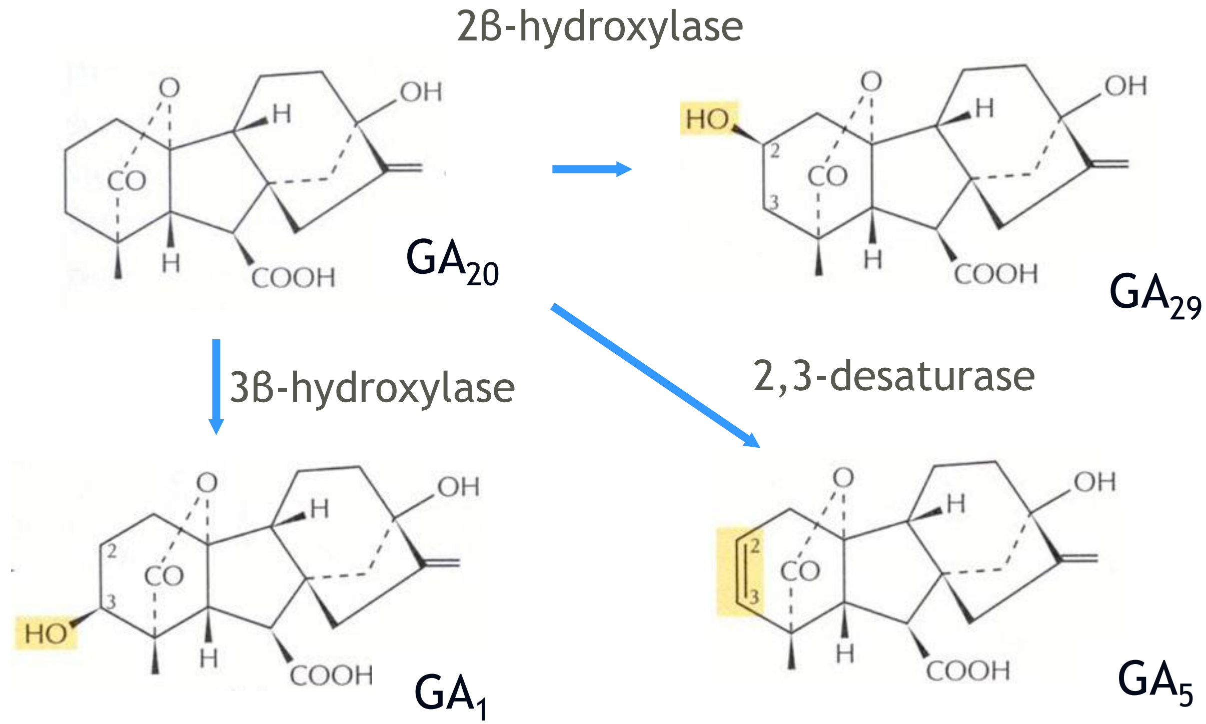
Trinexapac-ethyl (Palisade)



Prohexadione-calcium (Apogee)



2-oxoglutaric acid

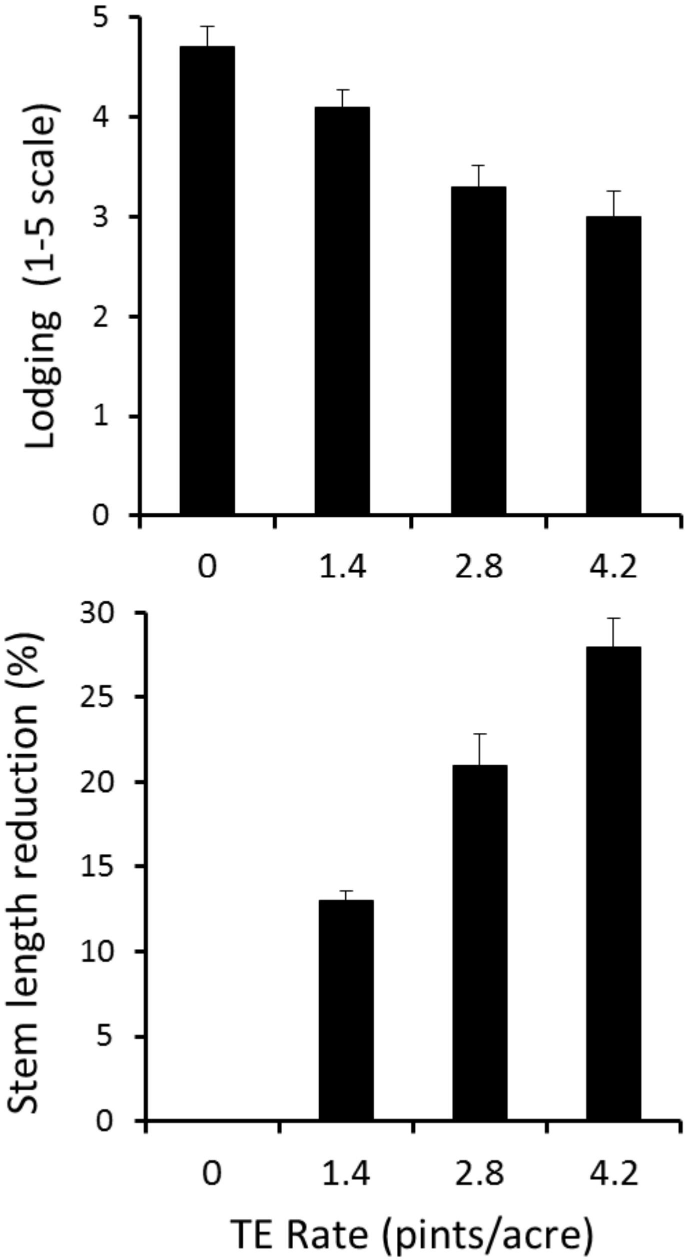


- Trinexapac-ethyl (TE) and prohexadione-calcium (PC) PGRs inhibit the 3-β hydroxylation of GA_{20} to GA_1. GA_1 promotes stem elongation, GA_5 promotes flowering, GA_{29} is inactive.
- These PGRs are structurally similar to 2-oxoglutaric acid, a cofactor in the hydroxylation reaction.

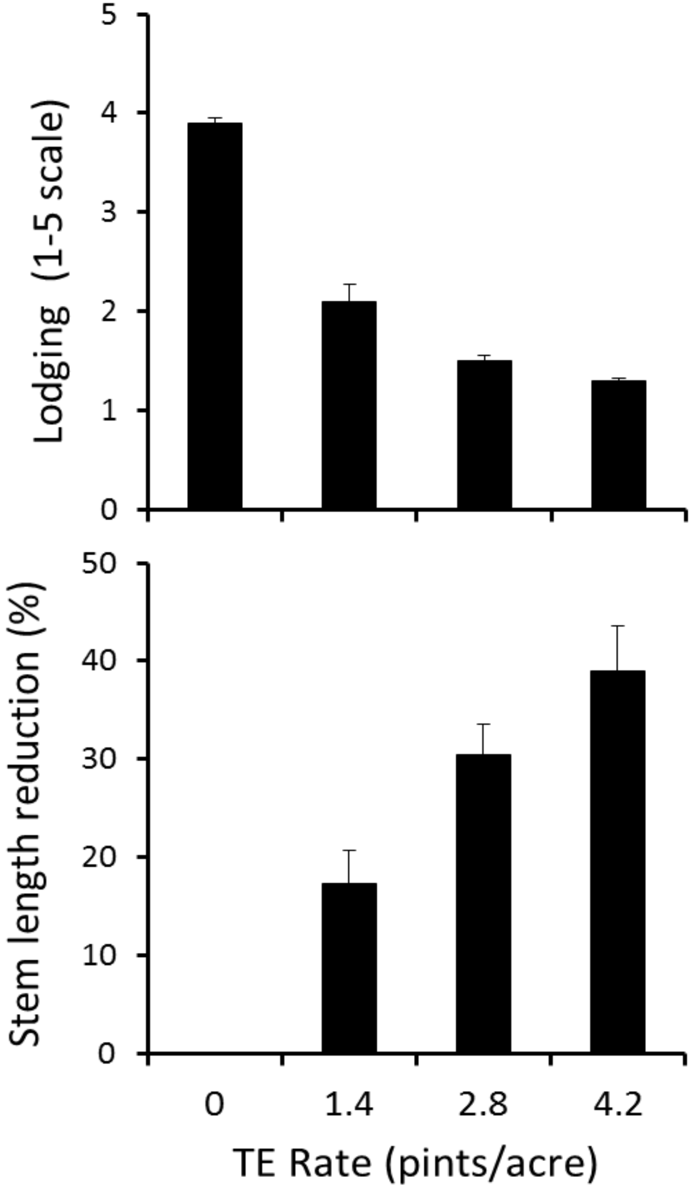
PGRs in Grass Seed Crops

TE rate effects on perennial ryegrass seed production in 9 years of trials (Chastain et al., 2014).

TE rate	Seed yield	Yield increase
pints/acre	lbs/acre	%
0	1305 a	0
1.4	1635 b	25.3
2.8	1868 c	43.1
4.2	2056 c	57.6

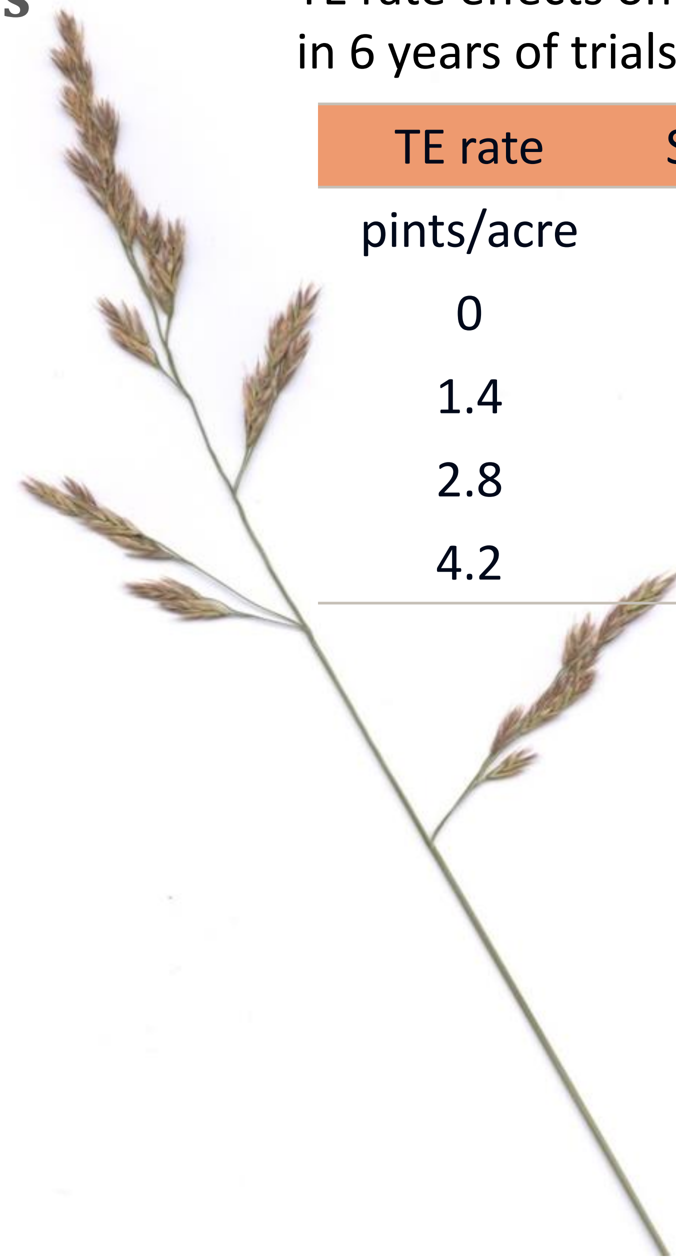


PGRs in Grass Seed Crops



TE rate effects on tall fescue seed production in 6 years of trials (Chastain et al., 2015).

TE rate	Seed yield	Yield increase
pints/acre	lbs/acre	%
0	1299 a	0
1.4	1832 b	41.0
2.8	1771 b	36.3
4.2	1856 b	42.9

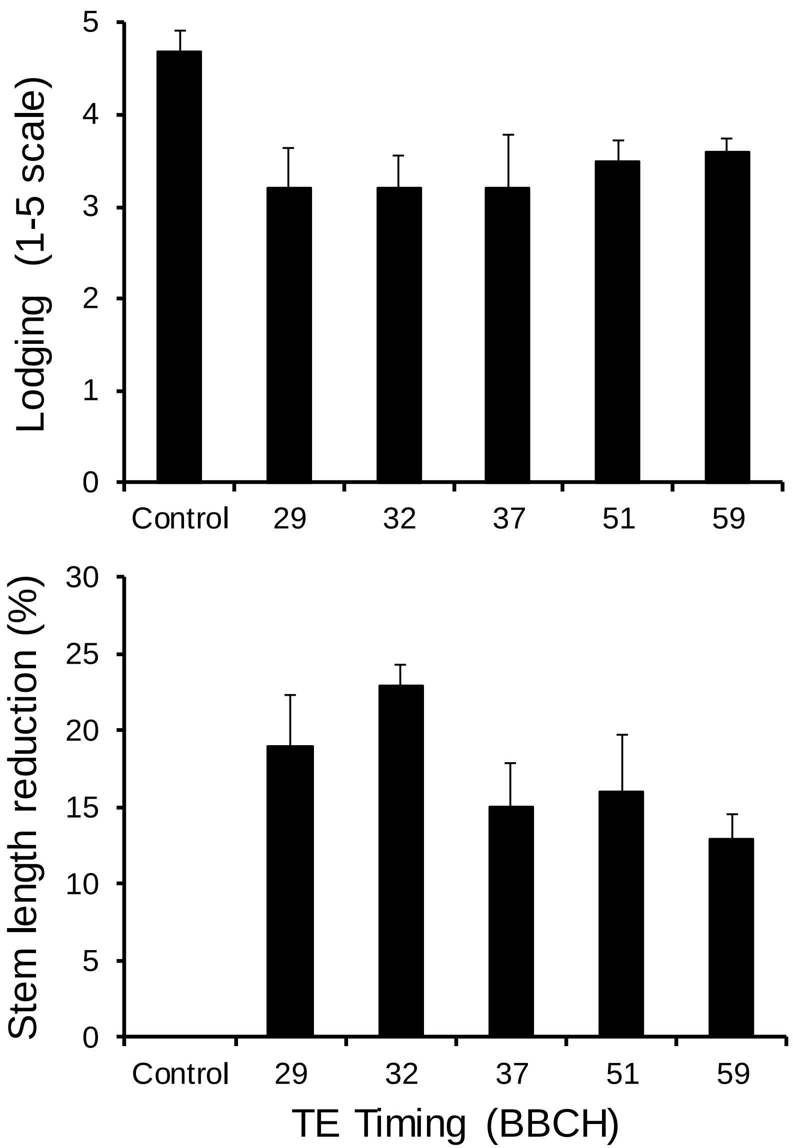


Tall fescue panicle
(TG Chastain photo)

PGRs in Grass Seed Crops

TE timing effects on perennial ryegrass (9 years) and tall fescue (6 years) seed yield (Chastain et al., 2014, 2015).

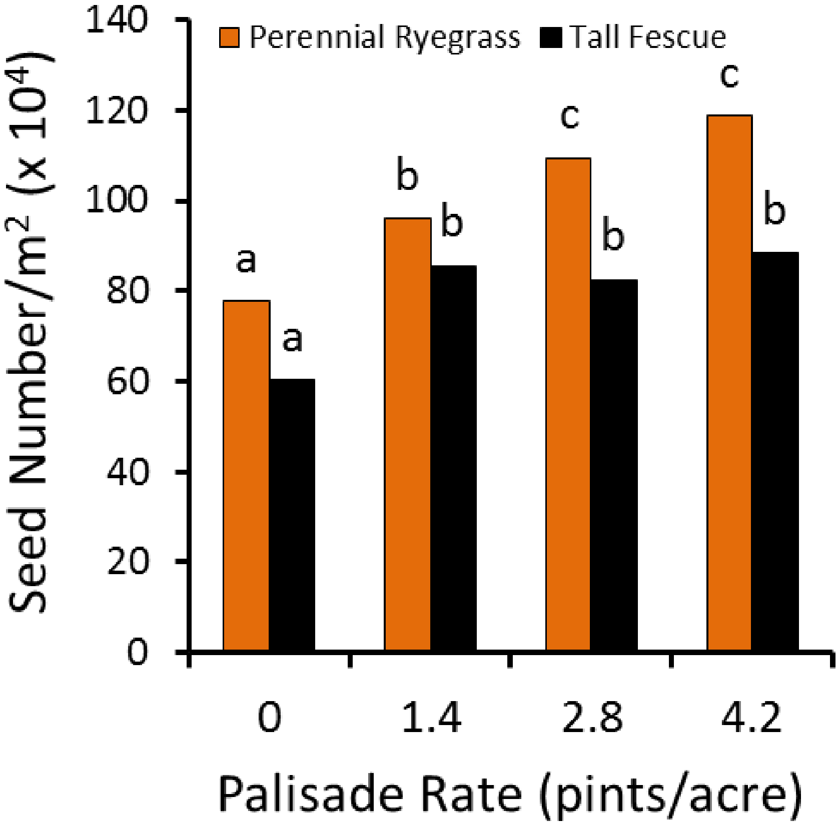
TE timing	Perennial ryegrass	Tall fescue
BBCH scale	--------lbs/acre-------	
29 - pre stem elongation	1580 b	--
32 – early stem elongation	1769 c	1775 a
37 – late stem elongation	1620 bc	1883 a
51 – early inflorescence emergence	1748 c	1879 a
59 – late inflorescence emergence	1355 a	--



PGRs in Grass Seed Crops

Trinexapac-ethyl treated

- Spike Length = 7.4 inches
- Spikelets/Spike = 22.3
- Seeds/Spike = 48.3



Untreated

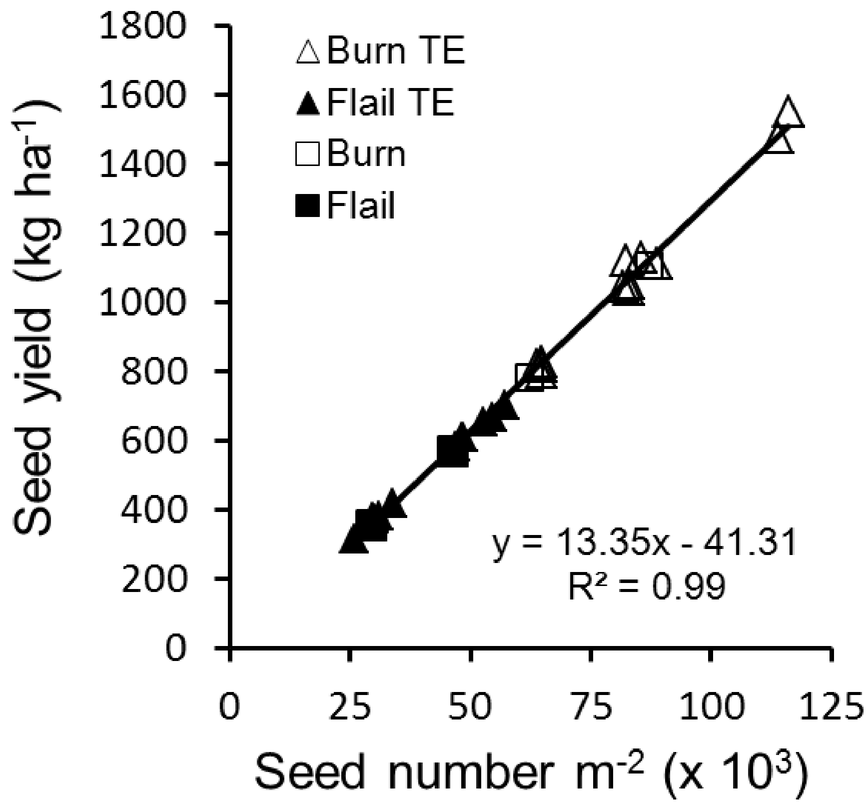
- Spike Length = 8.5 inches
- Spikelets/Spike = 23.0
- Seeds/Spike = 40.8

Effect of trinexapac-ethyl (TE) on perennial ryegrass spike morphology (TG Chastain photo)

PGRs in Grass Seed Crops

TE and residue management (Burn or Flail) effects on creeping red fescue seed yield (Zapiola et al., 2006, 2014).

TE rate	Seed Yield		Yield increase
	Burn	Flail	
pints/acre	lbs/acre		%
0	948 a	677 a	0
2.8	1307 b	862 b	27.3 to 37.9



PGRs in Grass Seed Crops

- TE and PC PGRs are effective lodging control agents and provide economic seed yield enhancement in grass seed crops.
- Greatest perennial ryegrass seed yield increases were observed with 2.8 pints/acre TE.
- Tall fescue yield was less rate sensitive and was best increased by 1.4 pints/acre TE.
- Best seed yields were attained by TE applications between early stem elongation (BBCH 32) and early inflorescence emergence (BBCH 51).

Perennial ryegrass spike (TG Chastain photo)

Irrigation in Grass Seed Crops

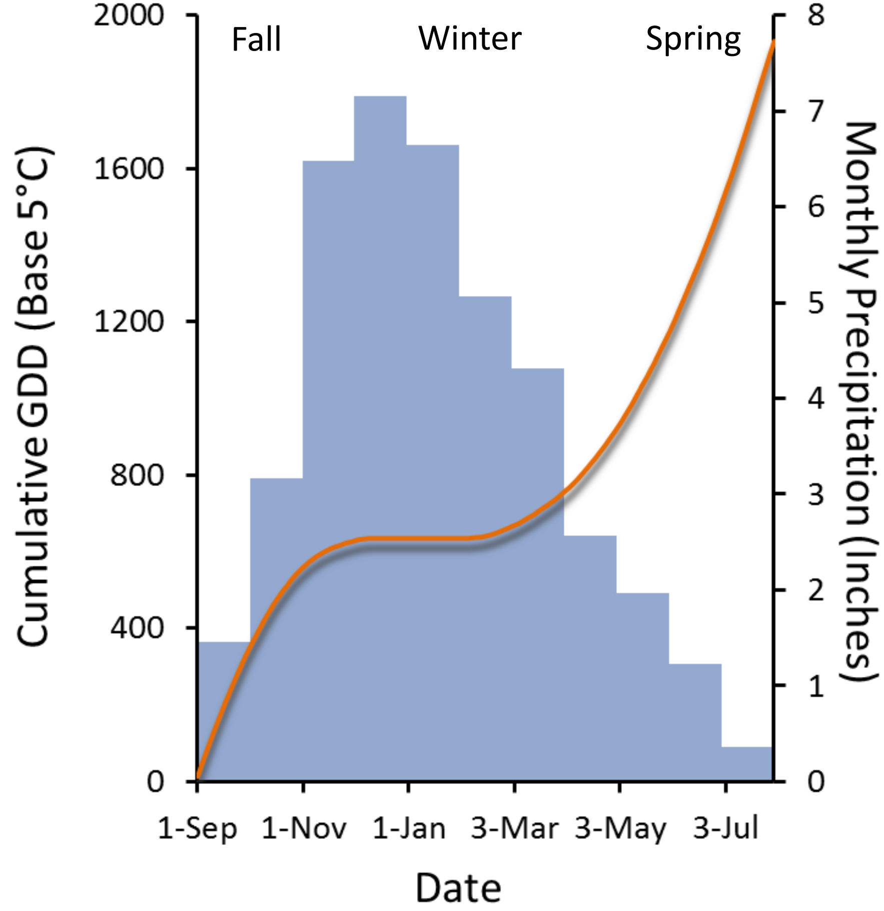
- Most Willamette Valley grass seed crops are grown without irrigation but increases in irrigated land (now 281,323 acres) means it is more likely.
- How much water is needed?
- Crop water use estimates and irrigation requirements are based on crop evapotranspiration (ET).
- An OSU publication reports ET values of 29 to 35 inches and recommends 16 to 27 inches of irrigation for grass seed crops in the valley.
- Are these sound recommendations?

Irrigation system (TG Chastain photo)

Irrigation in Grass Seed Crops

Seasonal irrigation timing effects and perennial ryegrass seed yield on a medium-textured soil in the Willamette Valley (Chastain et al, 2015).

Irrigation	Water applied	Seed yield	Yield increase
	inches	lbs/acre	%
None	0	1446 a	0
Fall	5	1421 a	0
Spring	4	1541 b	6.5



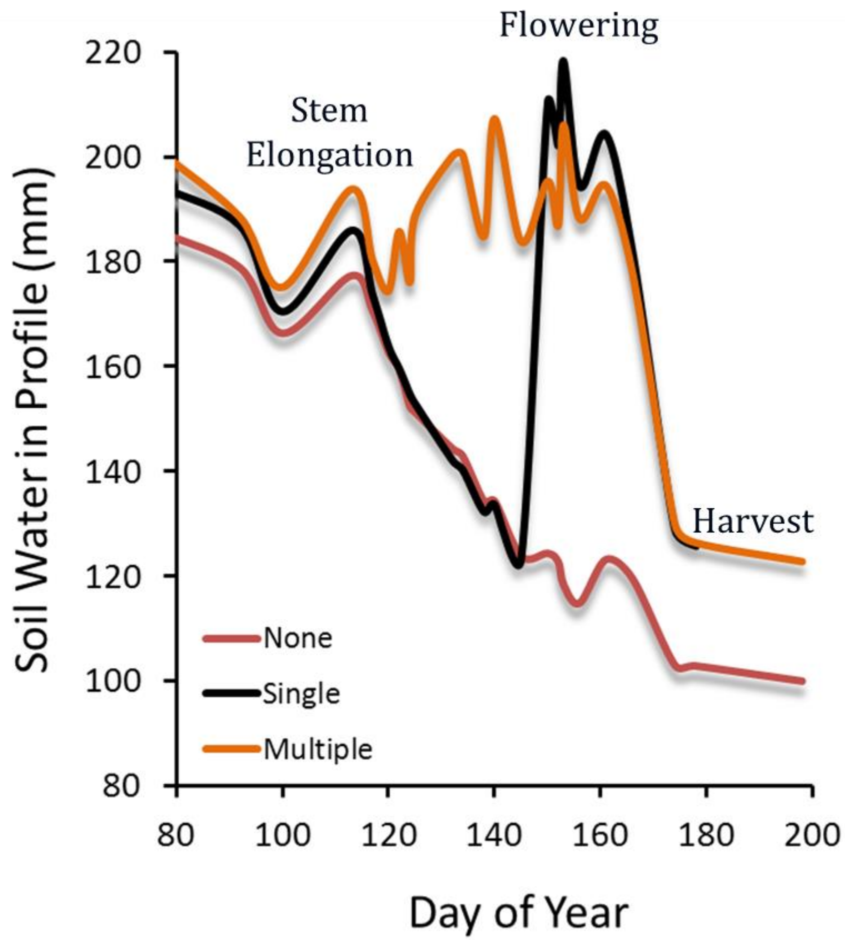
Growing degree days and precipitation in the Willamette Valley

Irrigation in Grass Seed Crops

Spring irrigation frequency effects and perennial ryegrass seed yield on a medium-textured soil in the Willamette Valley (Chastain et al, 2015).

Irrigation	Water applied	Seed yield	Yield increase
	inches	lbs/acre	%
None	0	1463 a	0
Single	3.7	1699 b	16.1
Multiple	6.5	1823 c	24.6

Spring rainfall (April-June) = 5.83 inches
Range = 5.14 to 8.17 inches



Irrigation effects on water in soil profile.

Irrigation in Grass Seed Crops

Spring irrigation frequency effects and tall fescue seed yield on a medium-textured soil in the Willamette Valley (Huettig et al, 2013).

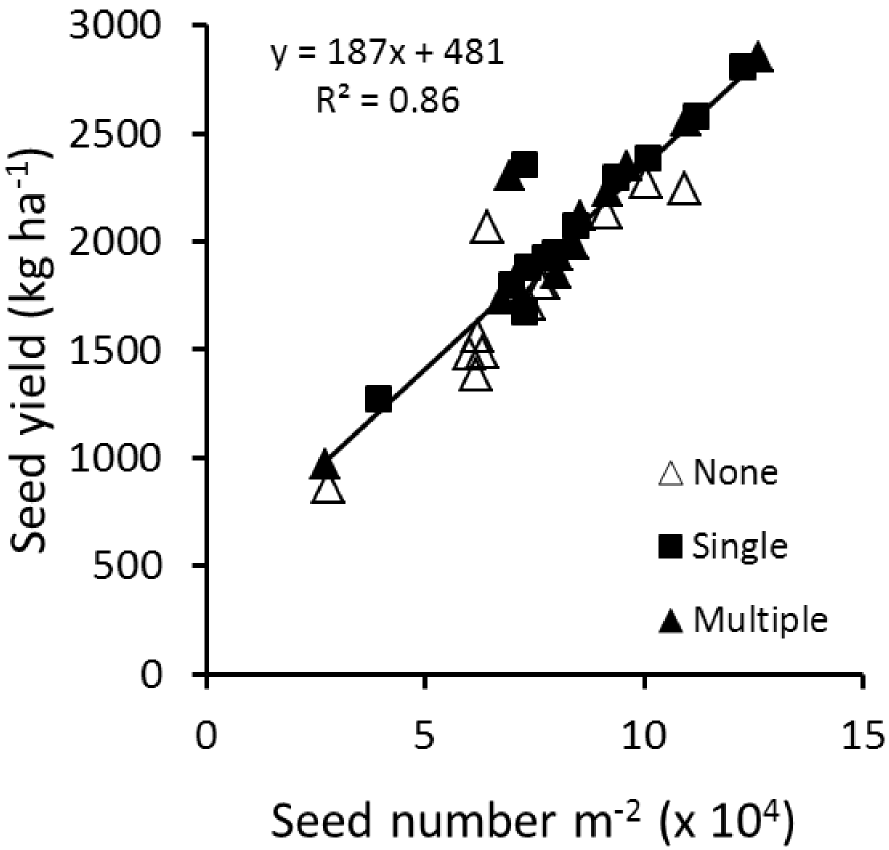
Irrigation	Water applied	Seed yield	Yield increase
	inches	lbs/acre	%
None	0	1565 a	0
Single	3.7	1860 b	18.9
Multiple	6.8	1866 b	19.3

Spring rainfall (April-June) = 5.83 inches
Range = 5.14 to 8.17 inches

Irrigation in Grass Seed Crops

- How does irrigation increase seed yield?
- Seed number was increased by irrigation. Irrigation-induced increases in seed number were likely the result of reduced seed abortion.
- Increased seed number accounted for 82% of the seed yield increase while seed weight contributed another 18%.

Spring irrigation effects on seed number and seed yield in tall fescue (Huettig et al, 2013).



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Irrigation in Grass Seed Crops

Spring irrigation (% of ET replaced) effects and perennial ryegrass seed yield on a light-textured soil in the Canterbury Plains, New Zealand (Chynoweth et al, 2012).

Irrigation	Water applied	Seed yield	Yield increase
	inches	lbs/acre	%
None	0	1783	0
33% ET	4	1848	3.7
66% ET	8	2248	26.1
100% ET	12	2232	25.2

Spring rainfall (October- December) = 7.68 inches

Irrigation system in New Zealand perennial ryegrass seed field (TG Chastain photo).

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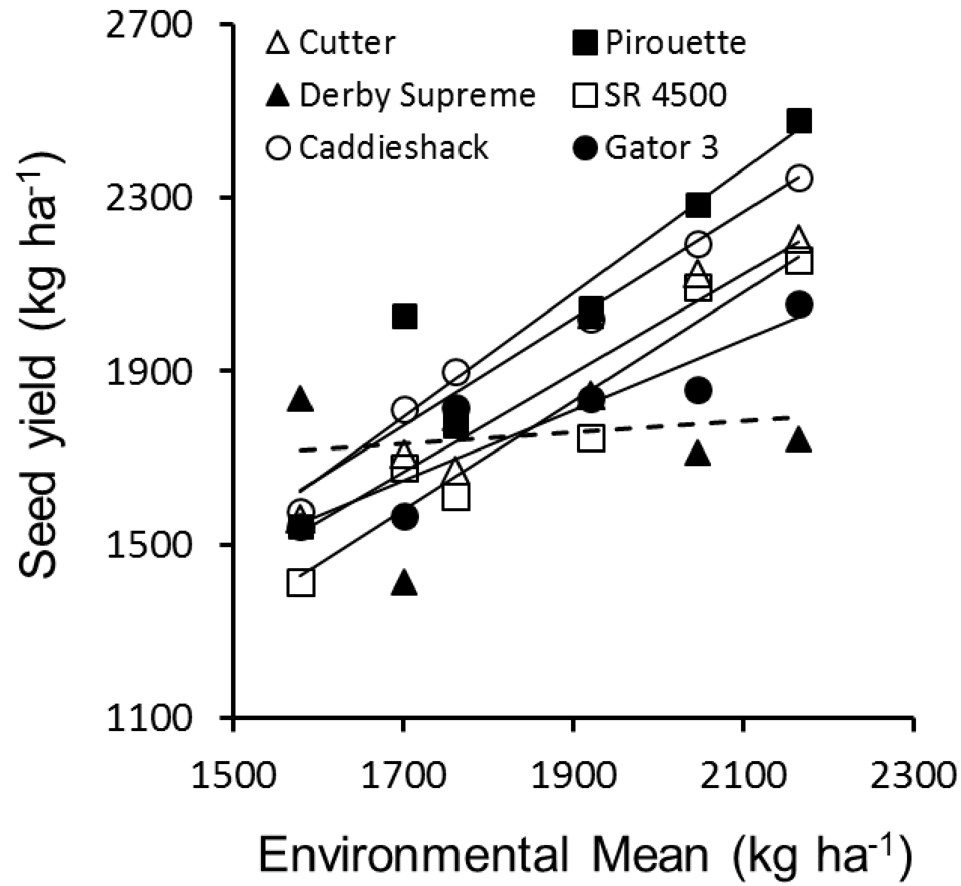
Irrigation in Grass Seed Crops

- Spring irrigation increased yield in all tall fescue cultivars tested and in all but one of the cultivars of perennial ryegrass tested.
- Derby Supreme perennial ryegrass seed yield remained the same across irrigation environments that increased yield of other cultivars.



Regression of seed yield in perennial ryegrass cultivars on spring irrigation environments (Chastain et al, 2015).

Irrigation in Grass Seed Crops

- Spring irrigation increased seed yield in perennial ryegrass and tall fescue, but fall irrigation did not affect seed yield.
- Tall fescue seed yield is increased by a single spring application timed to coincide with flowering (BBCH 60-65).
- Perennial ryegrass seed yield is best increased by multiple irrigations timed between spike emergence (BBCH 50) and flowering (BBCH 65).
- Measured water use in perennial ryegrass was 10.5 inches and tall fescue was 10.1 inches.

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PGRs in Red Clover Seed Crops

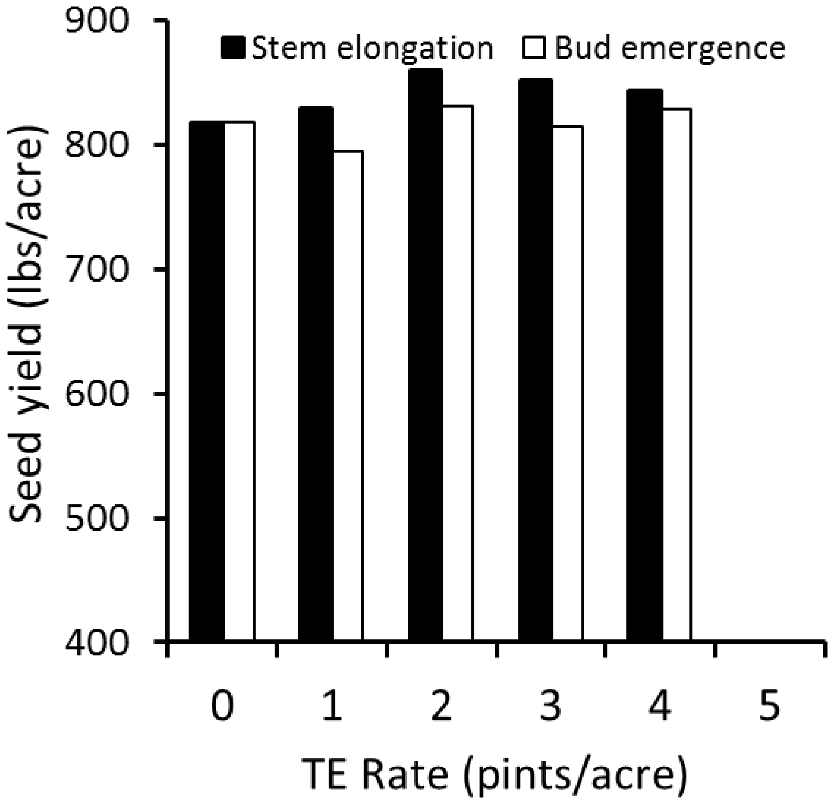
- Given the success and widespread adoption of TE in grass seed crops, the question is whether this PGR has efficacy in clover seed crops.
- Research work to address this question has been led by Nicole Anderson of OSU in cooperation with Ag Research of New Zealand.

Red clover (TG Chastain photo)

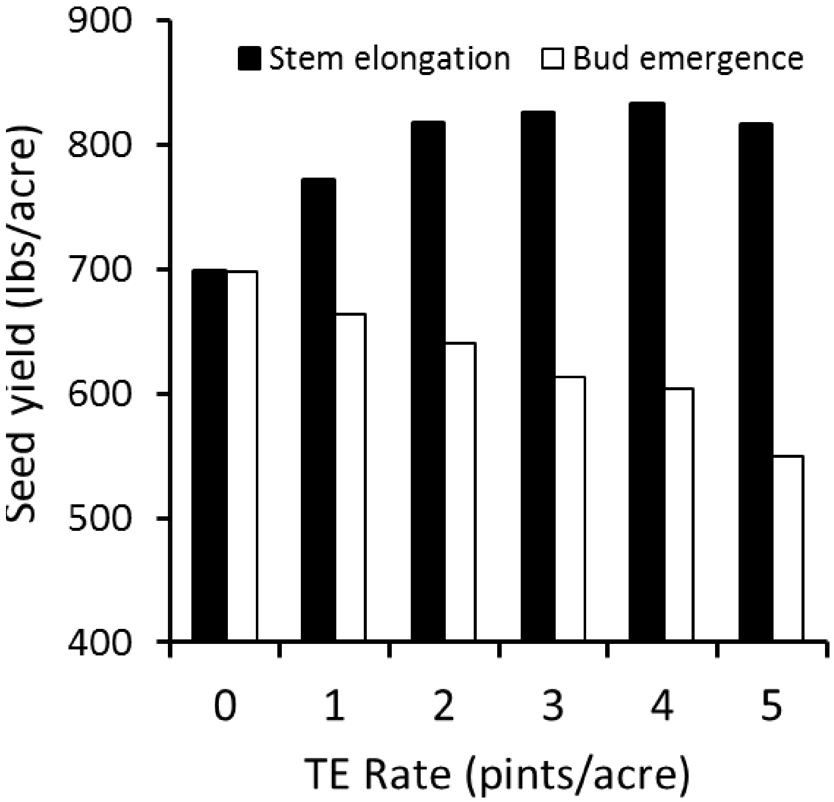
PGRs in Red Clover Seed Crops

PGR rate and timing effects on red clover seed yield. TE was applied at BBCH 32 (stem elongation) and BBCH 50 (bud emergence). (Anderson et al, 2015).

Stand 1 – 1st Year



Stand 1 – 2nd Year



PGRs in Red Clover Seed Crops

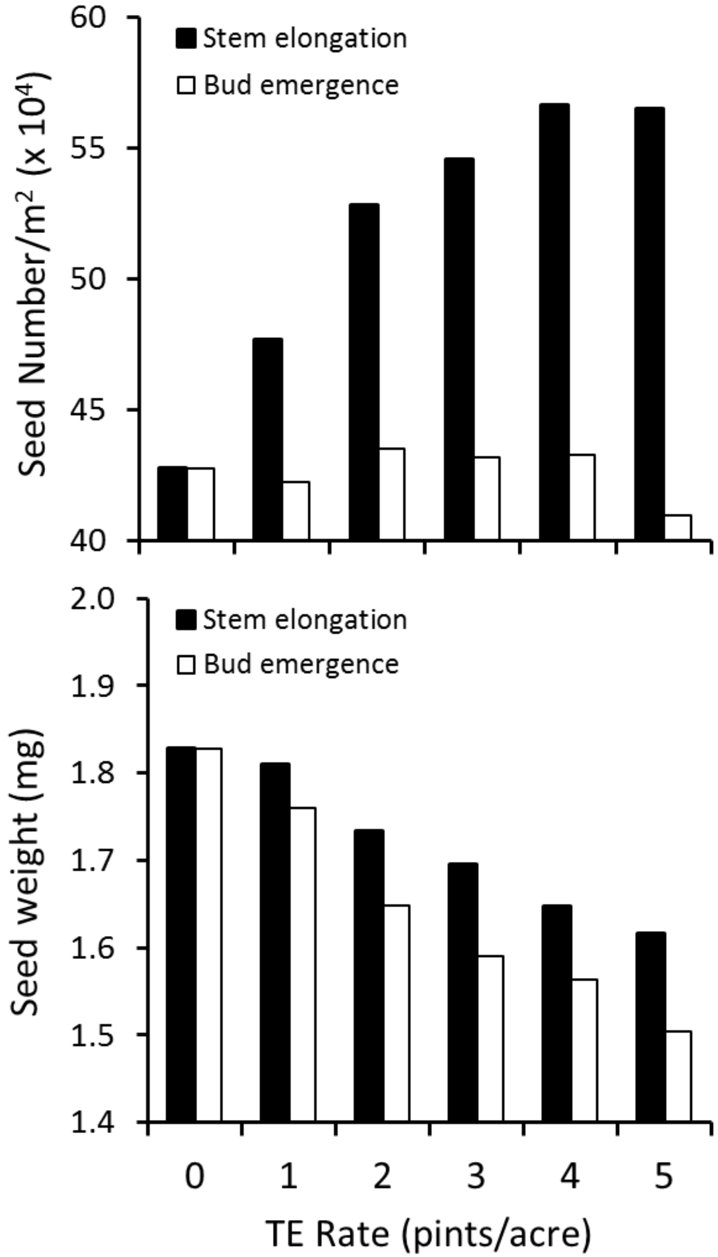
TE rate and stand age effects on red clover seed yield with TE was applied at BBCH 32 (stem elongation). (Anderson et al, 2015).

	Stand 1		Stand 2		Yield increase	
TE rate	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year
pints/acre	---------------- lbs/acre			--------------	------ % ------	
0	818	698	621	639	0	0
2	860	818	618	717	2.7	14.8
3	852	826	630	741	3.0	17.2
4	844	833	614	754	-1.4	18.7

Consistent seed yield increases were observed in 2nd year stands, but not in 1st year stands. Applications at bud elongation (BBCH 50) did not increase yield.

PGRs in Red Clover Seed Crops

- Why is seed yield increased by TE application at stem elongation but not at bud emergence?
- Seed number was increased with increased TE rate when applied at stem elongation but not at bud emergence.
- Seed weight declined with increased TE rate regardless of timing of application.



Irrigation in Red Clover Seed Crops

Irrigation effects on red clover seed yield (Anderson et al, 2015). Single irrigation was timed at BBCH 55 to support flowering and seed development.

Irrigation	Water applied	Stand 1 1st Year	Stand 1 2nd Year	Stand 2 1st Year	Stand 2 2nd Year	Yield increase
	inches	----------------	lbs/acre	--------------		%
None	0	787 a	678 a	505 a	667 a	0
Single	4	867 b	746 b	624 b	723 b	13.1

Seed yield was consistently increased with irrigation.

Irrigation increased seed number and seed weight, and thus contributed to the seed yield increases.

Red clover irrigation trials (TG Chastain photo)

The Future

Grass seed field in autumn (TG Chastain photo)

- Oregon’s seed production industry has been particularly adept at crafting solutions to vexing problems.
- The continued success of Oregon’s seed industry will be predicated on its ability to recognize new opportunities and to successfully address present and future problems.

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