Pollination and Seed Yield in Grass Seed Crops

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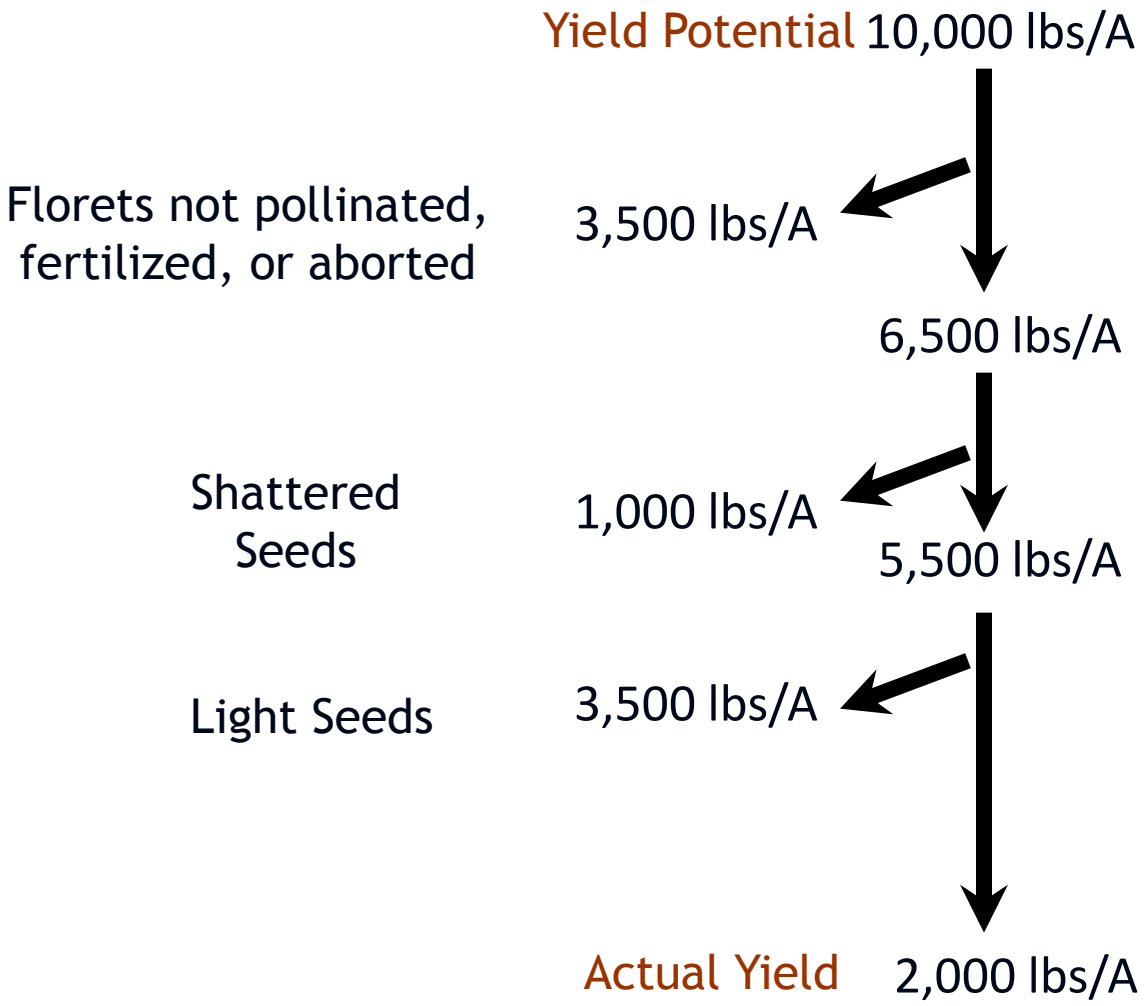
Seed Yield Potential vs. Actual Yield

An example for perennial ryegrass



- Grass seed crops are biologically inefficient in the production of seed.
- Many flowers are produced by these grasses yet relatively few of the flowers become seed.
- There are several reasons for this inefficiency – some are known but others are unknown and un-researched.

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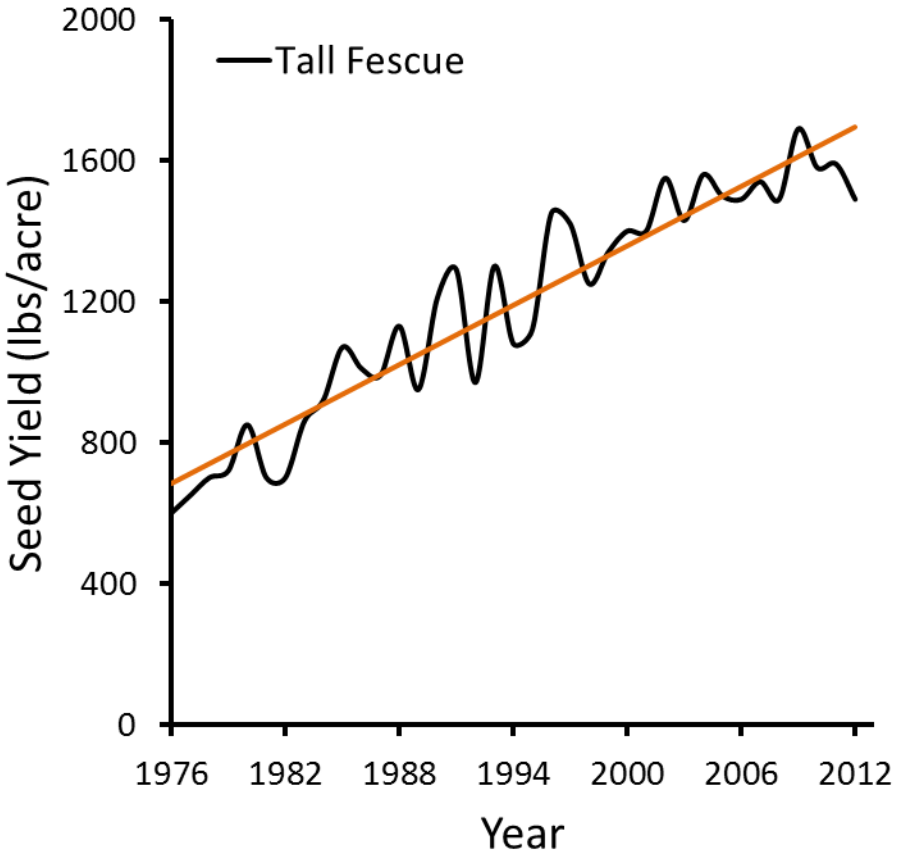
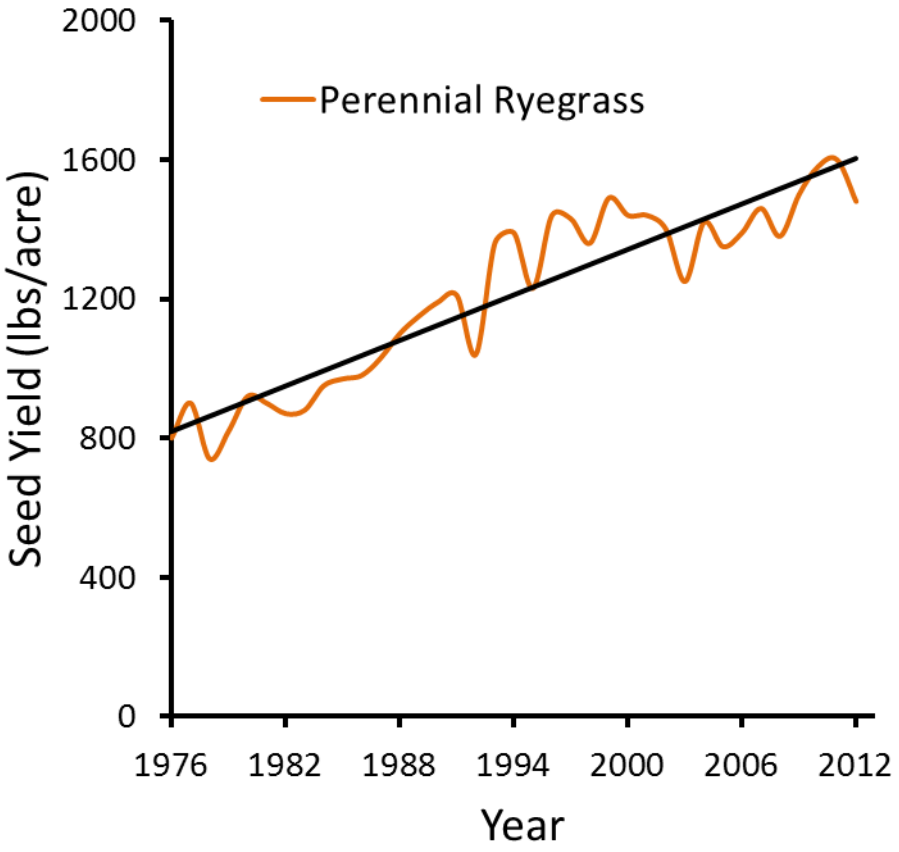
Seed Yield Trends in the Willamette Valley





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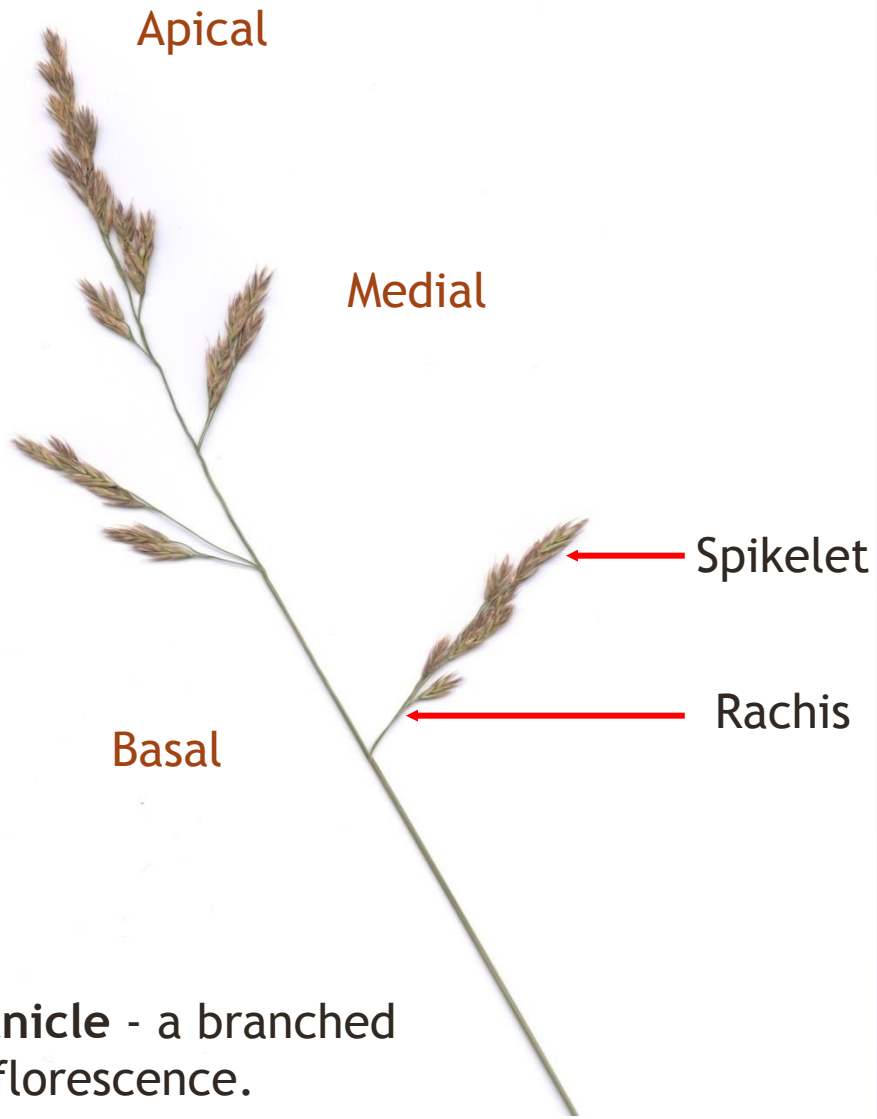
Pollination

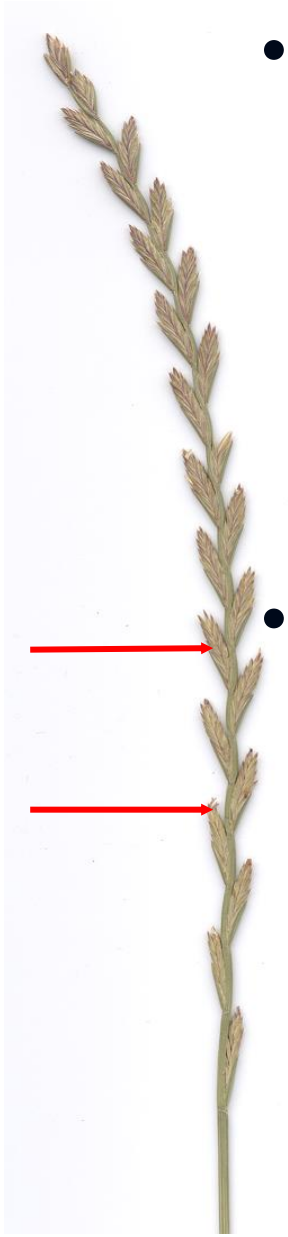
- **Pollination** is the process of pollen transfer. There are a variety of agents of pollination including wind, insects, birds, bats, spiders, mites, and water.
- Some crops are self-pollinated whereas others are cross-pollinated.
- Pollination is essential to seed production in most grass seed crops. There are a few apomictic seed crops such as Kentucky bluegrass where pollination may not be required for seed production.

Annual ryegrass in flower

Inflorescence



Panicle - a branched inflorescence.



- An **inflorescence** is a group of flowers. Spikelets release pollen first in the apical part of the inflorescence and proceed downward from there to the basal spikelets.
- Pollination on an individual inflorescence can be spread over a 4-10 day period.

Spike - a non-branched inflorescence.

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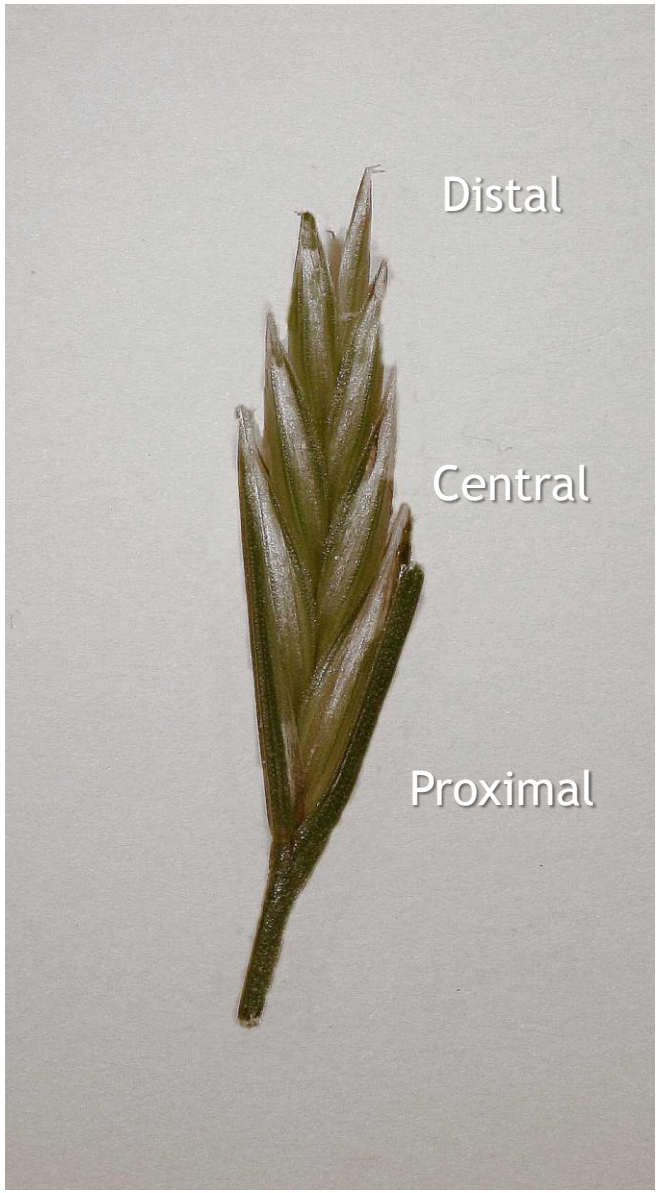
Spikelet



- A **spikelet** is a sub-unit of the inflorescence. Each spikelet is composed of two glumes and one to many **florets** (flowers).
- Florets open and release pollen beginning with the proximal florets of the spikelet and ending with the distal florets. The palea of each floret opens over a 7-minute period.

Perennial ryegrass spikelet

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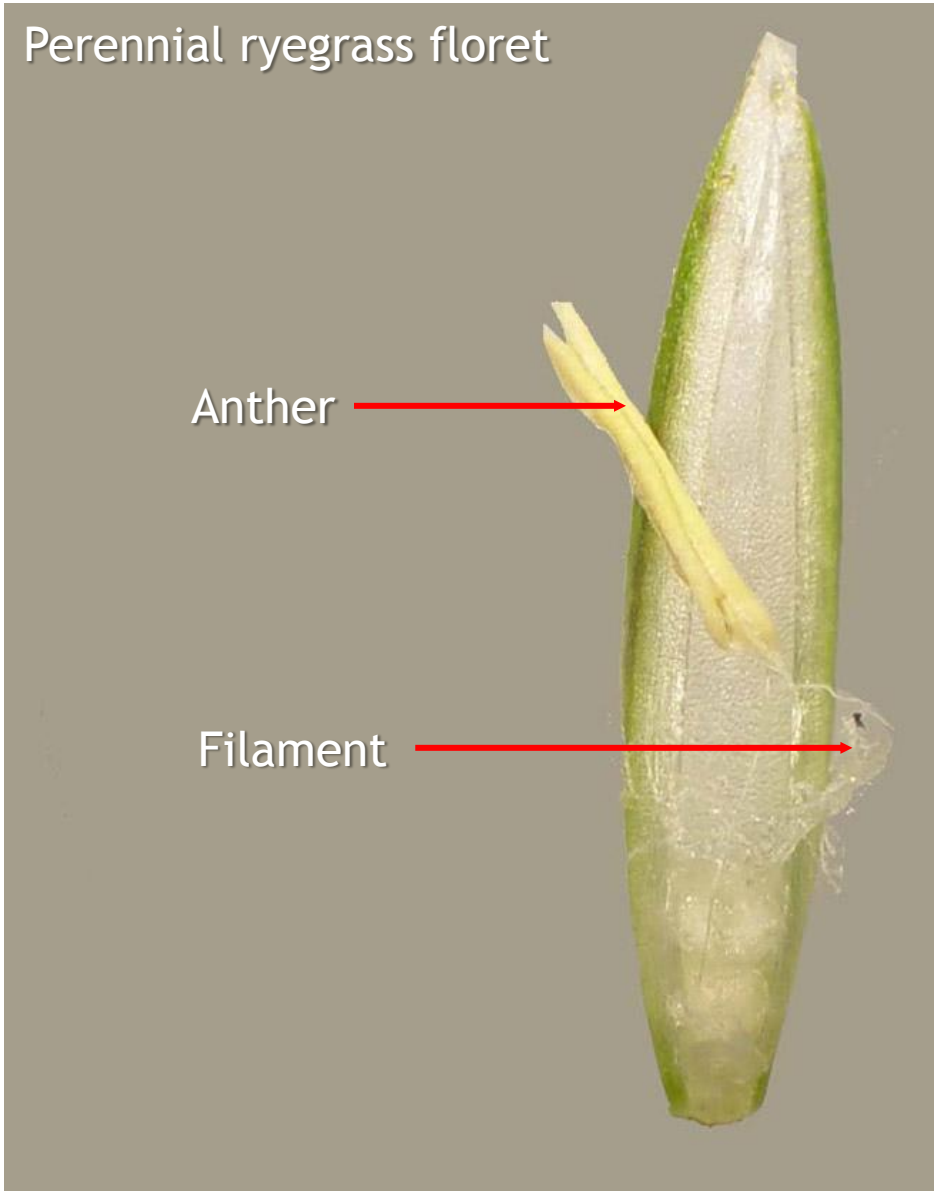
Stamen



- The **stamen** is the male part of the grass floret.
- The upper portion of the stamen is known as the **anther**. The anther is the site of pollen production.
- The lower portion of the is known as the **filament**. The filament serves as a support structure for the anther.
- The anthers start releasing pollen within about 10 minutes after the stamen emerges from the floret.

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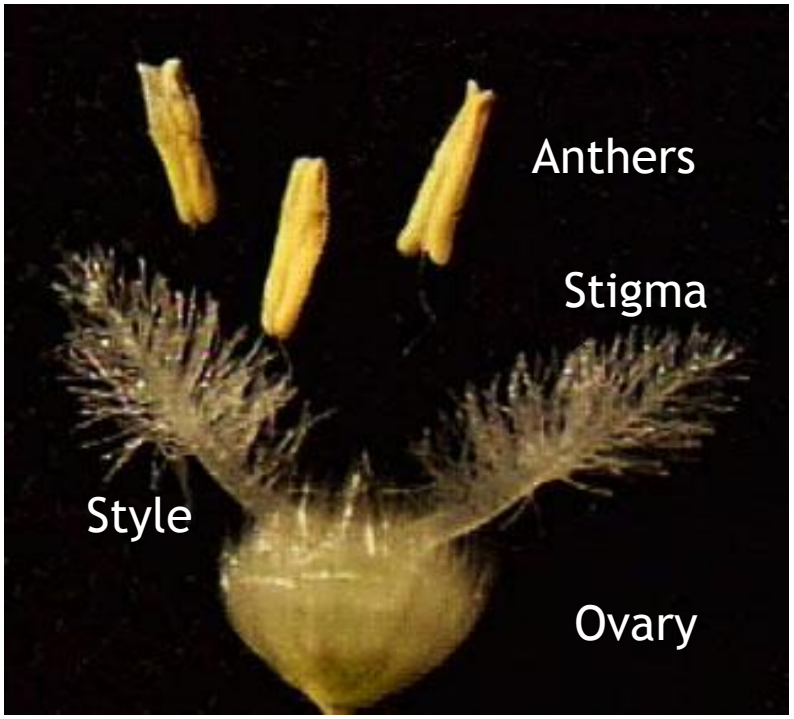
Pollen

- Pollen is the delivery system for transfer of genes from one plant to another.
- Grass seed crops are wind pollinated but they are also cross-pollinated because most have high levels of self-incompatibility.

Grass pollen (scanning electron micrograph)

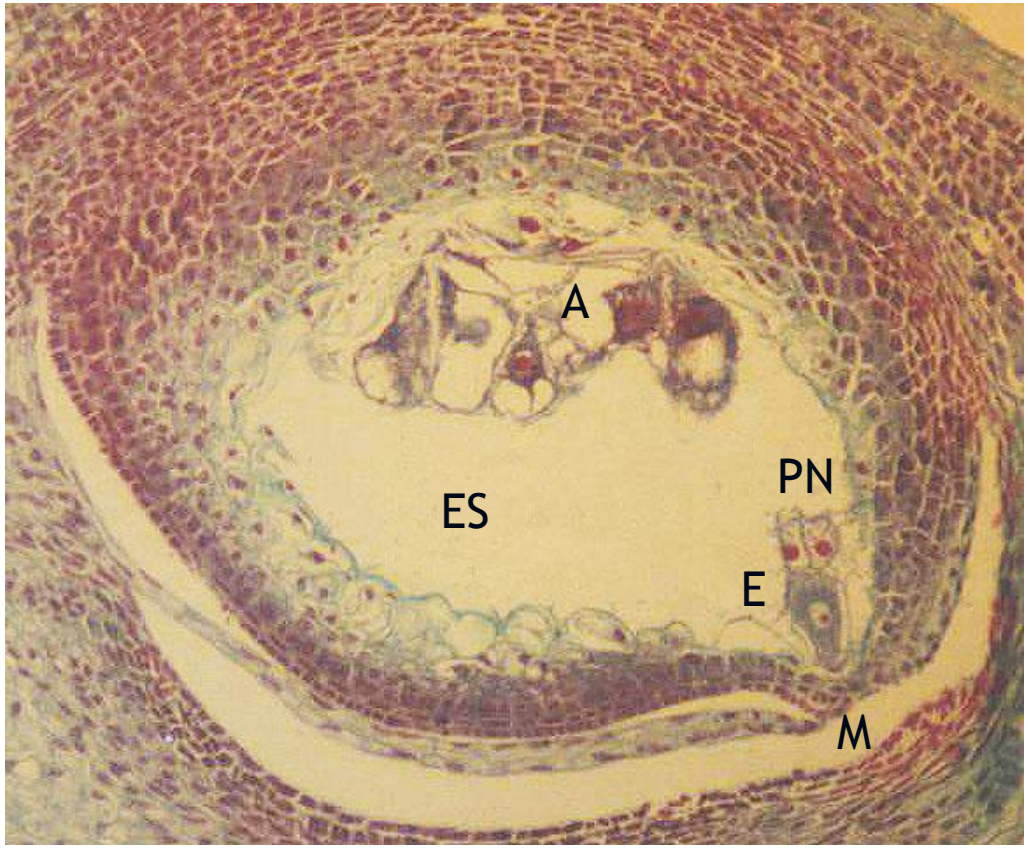
Pistil



Oat pistil (Iowa State University photo)

- The **pistil** is the female part of the grass floret.
- The upper portion of the pistil known as the **stigma**. The stigma is feathery and sticky in grasses and catches the airborne pollen. The stigma is the only part of the pistil visible outside the floret.
- The middle portion of the pistil is known as the **style**. The style serves as a support structure for the stigma.
- The bottom portion of the pistil is the **ovary**. The ovary contains a single **ovule**. A seed is a **mature, ripened ovule**.

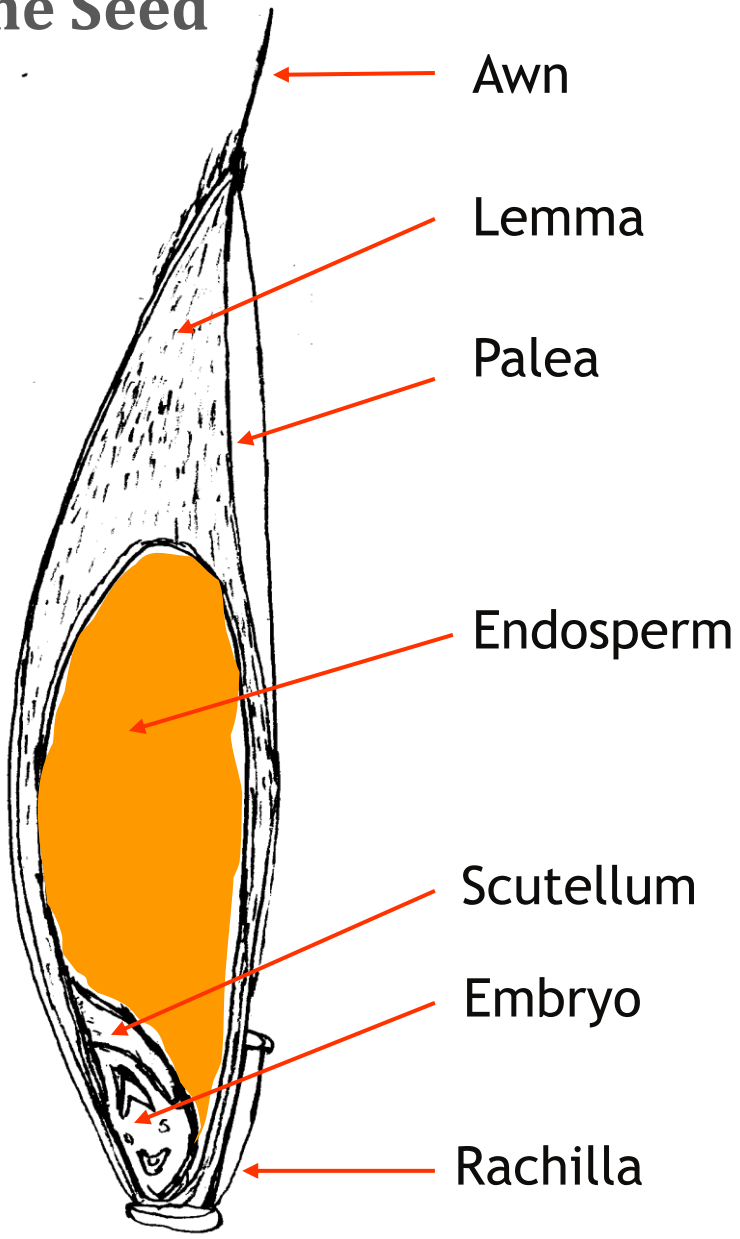
Double Fertilization



Wheat ovule showing embryo sac (ES), egg cell (E), two polar nuclei (PN), micropyle (M), and antipodals (A) (A. Huber photo)

- After pollen land on the stigma, they germinate to form **pollen tubes**. These tubes grow down through the style to the ovary. Pollen tube enters the ovule through the **micropyle**.
- **Sperm cells** emerge from the pollen tube and fuse with the **egg cell** and the two **polar nuclei**.
- The fusion of one sperm cell and polar nuclei forms the **endosperm nucleus**. The fusion of the 2nd sperm cell with the egg cell gives rise to the **zygote**.
- This is known as **double fertilization** and marks the start of seed development.

The Seed

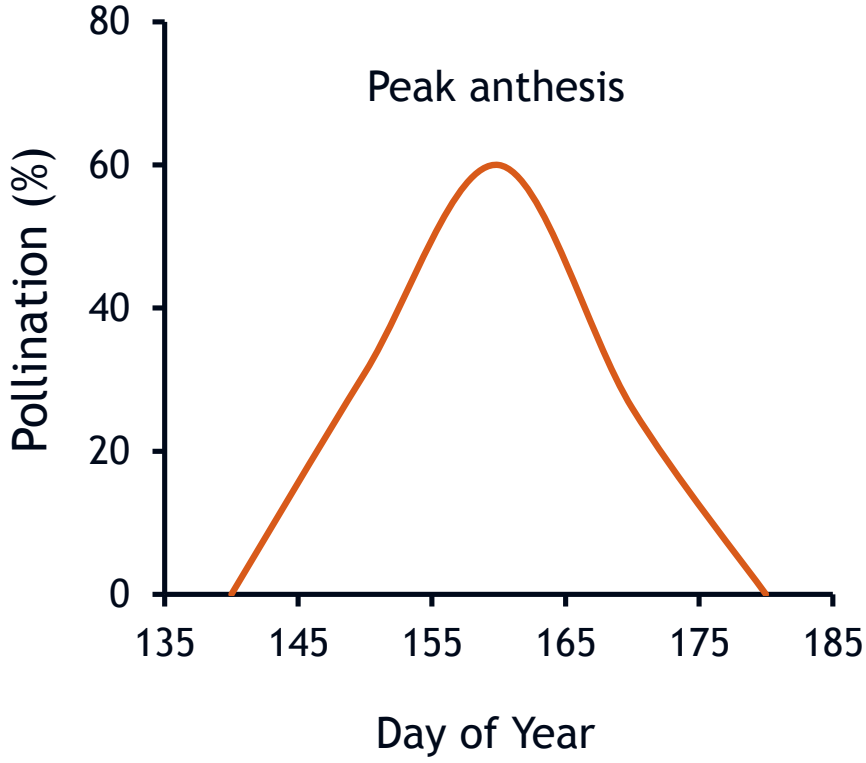


- The zygote develops into the **embryo** which contains a shoot and a root. The cotyledon of monocots is known as the **scutellum**.
- The endosperm nucleus develops to form the **endosperm,** the primary food storage organ and the source of most of the weight of the seed at harvest.
- The **lemma**, **palea**, **awn**, and **rachilla** are parts of the grass floret and are produced by the mother plant.

Longitudinal section of a grass seed

Environment and Pollination

- From beginning to end, pollination in a grass seed field can be spread out over a 21-day period or longer reaching a maximum known as **peak anthesis**.
- Pollination does not take place at the same time each year. In a cool spring, pollination is shifted later in the season while in a warm spring it is shifted earlier. The magnitude of the shift depends on the warmth or coolness of the season but typically the shift is only a few days to a week.
- Cloudy cool weather can extend the length of pollination while hot, dry weather will shorten the pollination period.



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Pollen Viability

- **Pollen viability** is the ability of pollen to germinate and produce a pollen tube.
- Tall fescue pollen can remain viable for up to 48 hours while most grass pollen is viable for only a few hours.
- Grass pollen quickly loses viability in high temperatures.
- Cold or heat during pollen development can reduce pollen viability.
- Pollen tube growth increases in perennial ryegrass over the range of 57˚F to 79˚F.

Effect of temperature and exposure time on pollen viability (%) in Kentucky bluegrass (Teare et al., 1970)

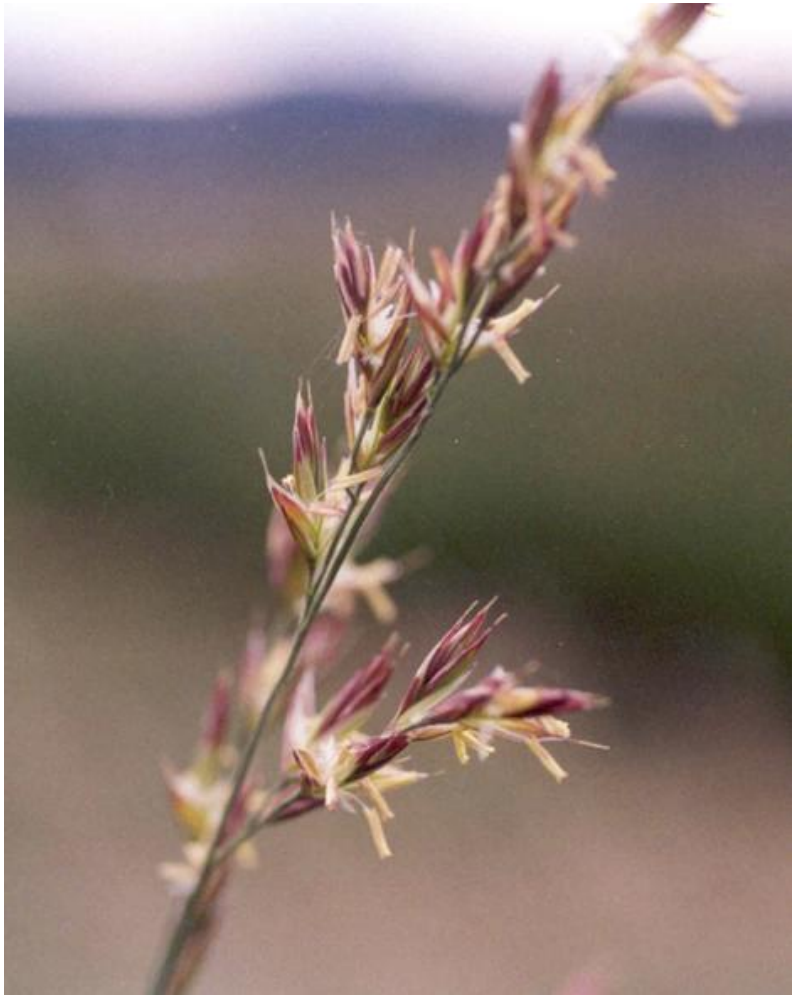
Temperature (˚F)	1 hour	2 hour	8 hour
80	50	45	7
90	28	30	3
100	24	15	0
110	10	8	0

Effect of temperature during pollination in perennial ryegrass (Elgersma et al., 1993)

Temperature (˚F)	Pollinated florets
57	638
63	621
68	583

Pollen Viability

- Pollen is generally released from mid-morning until afternoon.
- Pollen viability is highest in the morning and is low later in the afternoon (Fei and Nelson, 2003; Teare et al., 1970). A second, lower peak in viability in the afternoon has been observed in creeping bentgrass.
- Factors such as drought stress and dehydration (low humidity), N supply, and others can adversely affect pollen viability.
- The stigma can dry out due to drought or excessively high temperatures during flowering.



Red fescue anthers and stigmas

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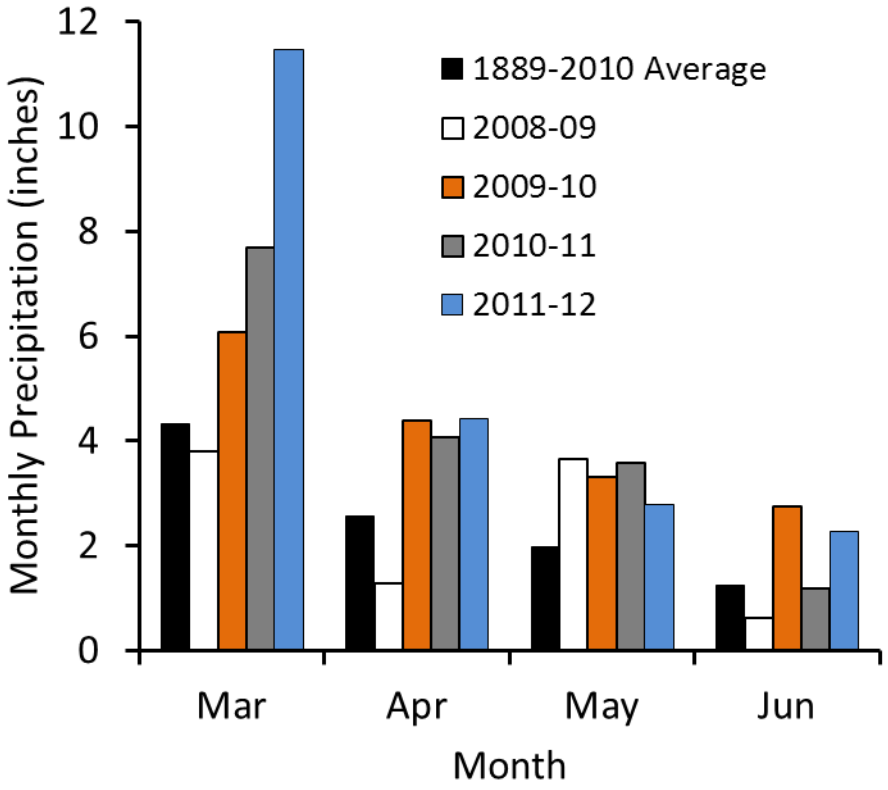
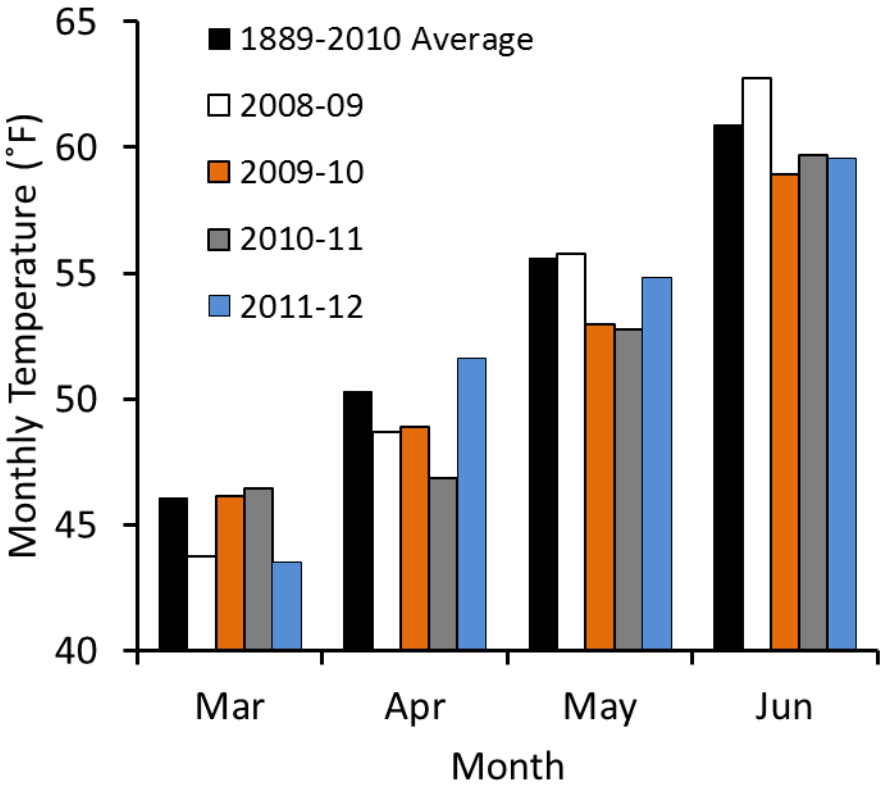
Weather Effects





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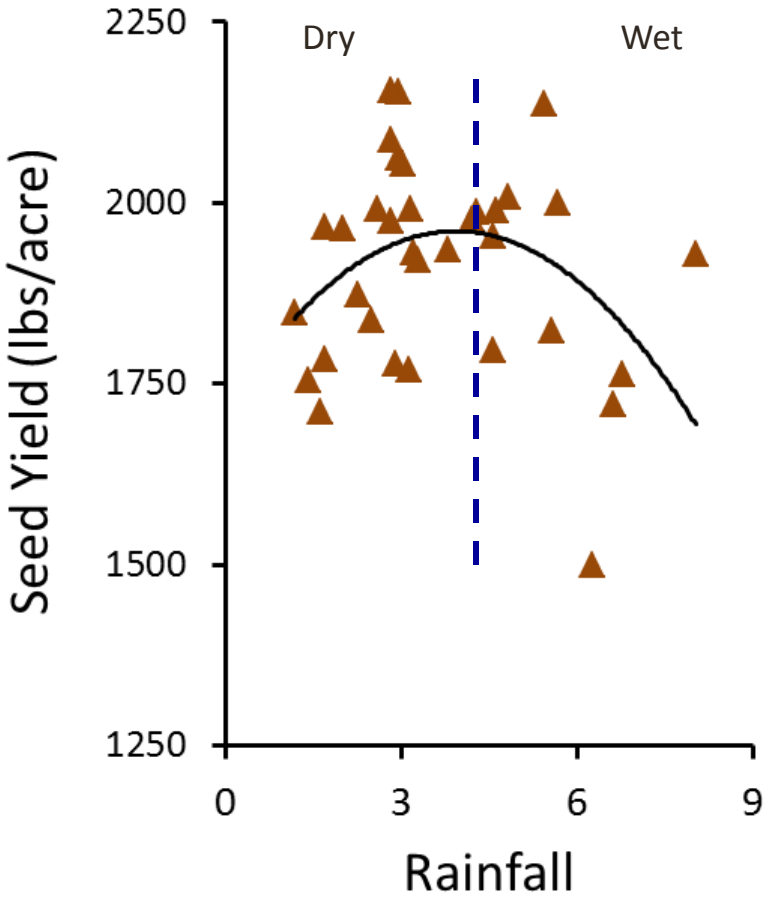
Weather Effects



May and June rainfall effects on seed yield in annual ryegrass

- Too much rainfall in spring increases lodging and reduces pollination, both cause reduced seed yield.
- Too little rainfall in spring produces poor yields because of poor seed set and seed filling.

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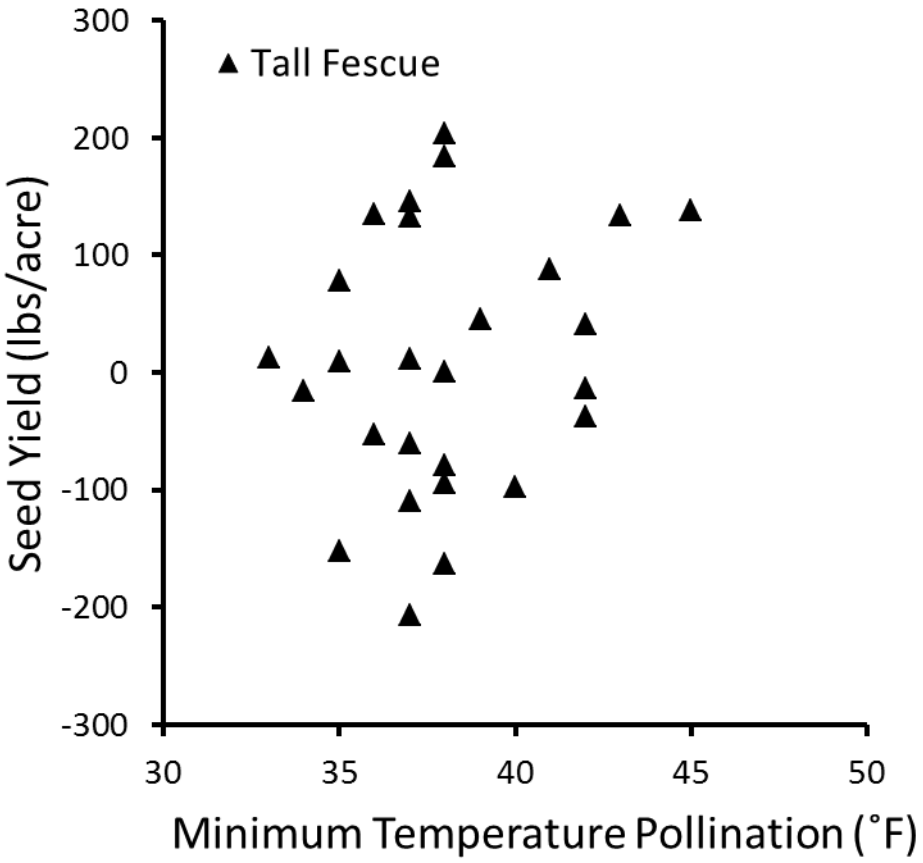
Weather Effects

- High rainfall reduces pollen in the air as evident in pollen counts. When growers encounter high rainfall in mid to late May and the first two weeks in June, especially if there are few or no dry periods, there is a possibility that pollination is reduced.
- Timing is also important as late-maturing crops may avoid rain problems unlike early-maturing crops if the rain comes early.
- Years with yield reductions from high rainfall in May and early June and the resulting loss in pollination occur about once every 5 years.

Weather Effects



- Work in England suggests that low minimum temperatures during pollination reduce seed yield in perennial ryegrass (Hampton and Hebblethwaite, 1983).
- However, no relationship is evident between low minimum temperature during pollination and seed yield in perennial ryegrass in the Willamette Valley.
- There is a trend toward higher seed yields with higher minimum temperatures in tall fescue in the Willamette Valley.

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Weather Effects

- Weather conditions can also have a strong effect on the development of important diseases in grass seed crops such as rust. Warm springs tend to have more rust than cool springs.

Tall fescue stem rust

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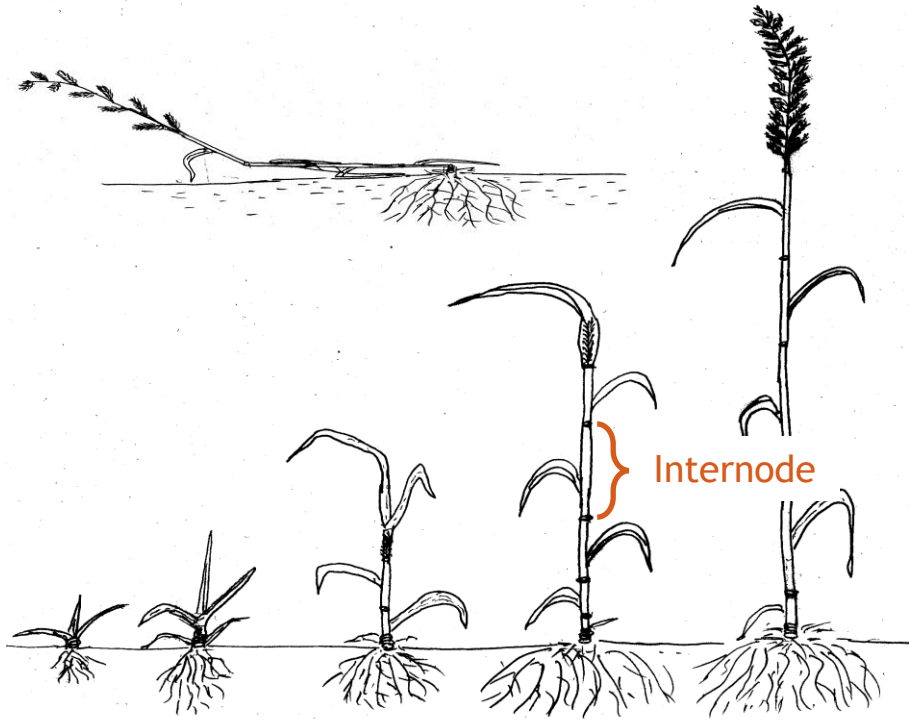
PGRs for Lodging Control in Grass Seed Crops



- Stem elongation results from activity of the intercalary meristem found above each node. Each internode elongates independently promoted by the hormone GA_1.
- Under certain conditions, the tiller cannot support the weight of the inflorescence and seed. 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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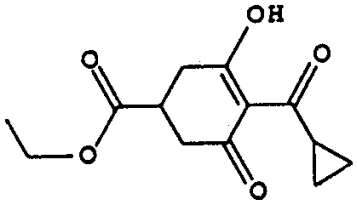
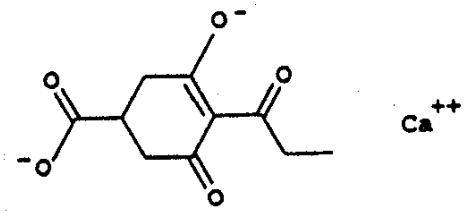
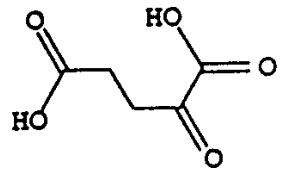
Acylcyclohexanedione PGRs



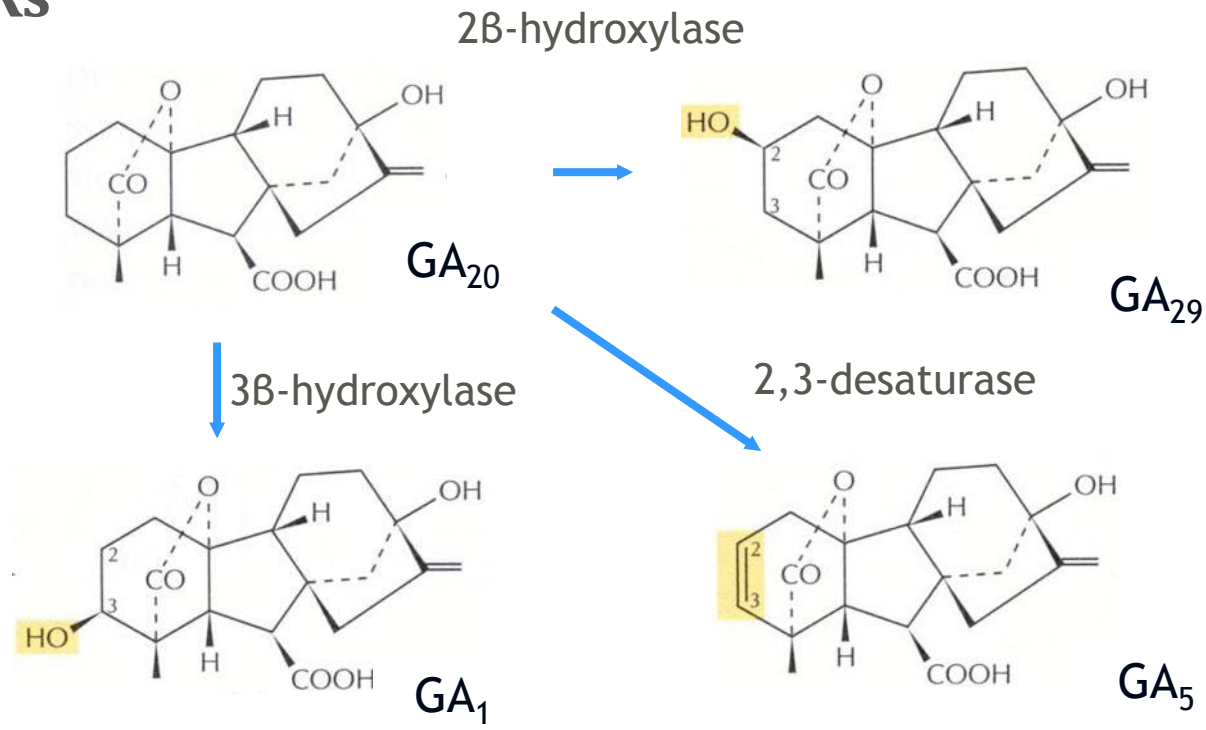
Trinexapac-ethyl (Palisade)



Prohexadione-calcium (Apogee)

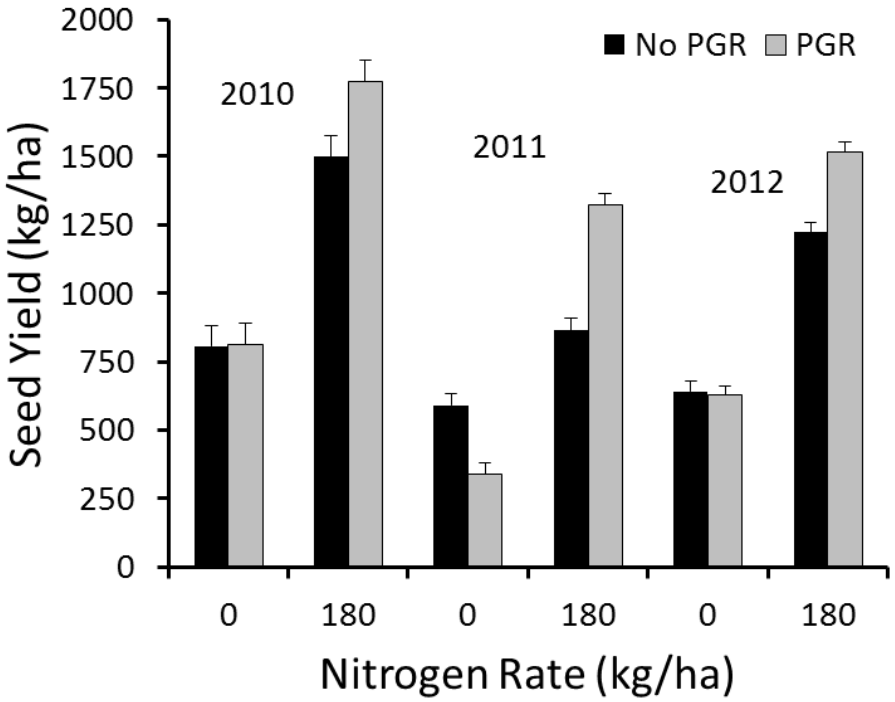


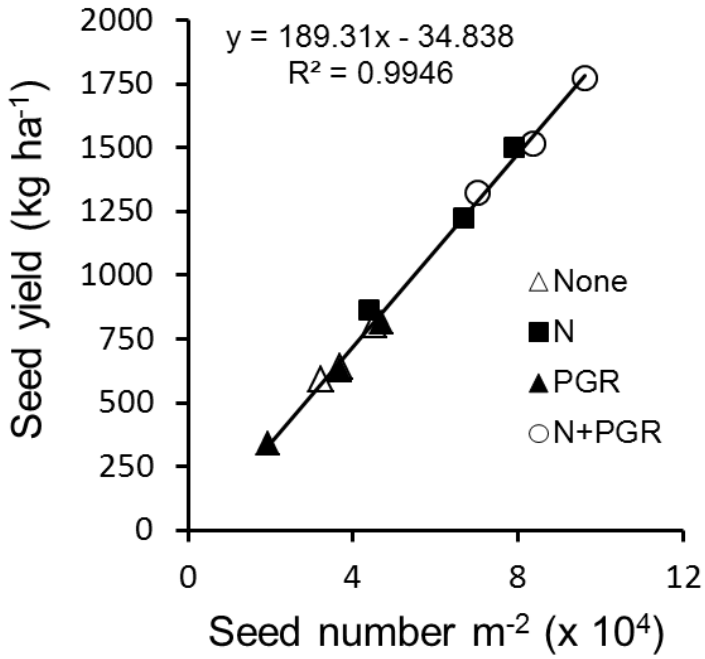
2-oxoglutaric acid



- 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.

Interaction of PGRs and Nitrogen





Pollination and Seed Yield in Grass Seed Crops

- Grass seed crops have low inherent efficiency in seed production. Many flowers are sterile, fail to pollinate or are not fertilized. As a result, fewer seed are produced than expected.
- Low pollination can reduce seed yield.
- Pollination of grass seed crops is affected by weather conditions (temperature and rainfall) but these conditions can also affect pests such as rust.
- Lodging reduces pollination but can be offset by plant growth regulator applications.

Tall fescue seed