

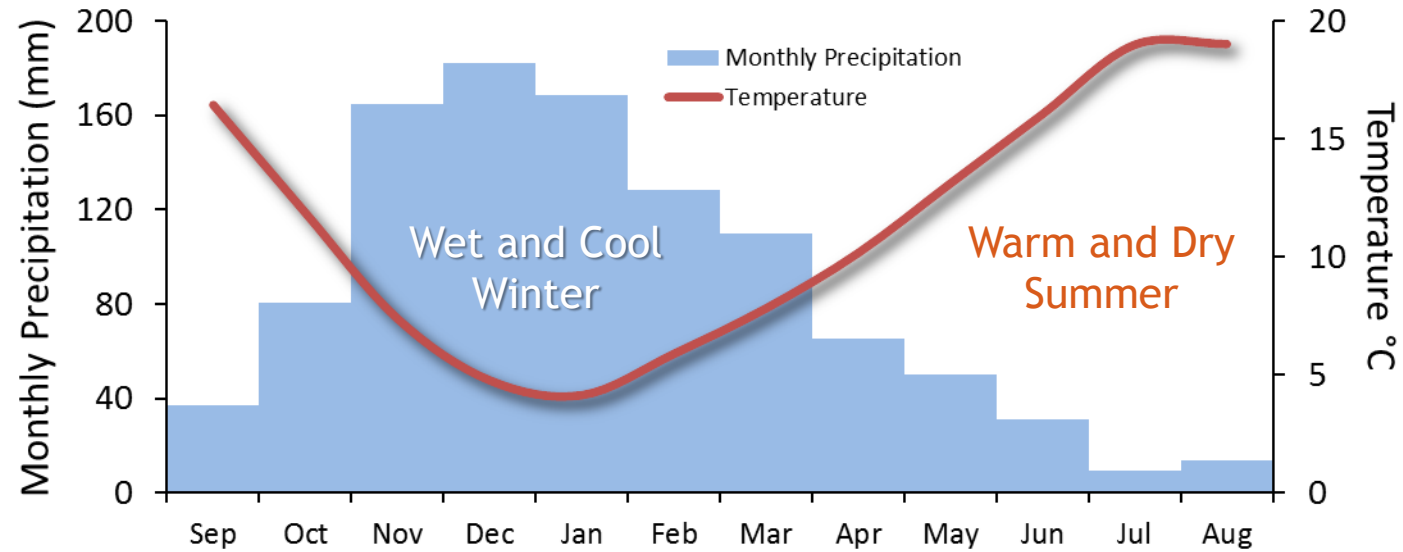


Weather Effects on Yield in Perennial Grass Seed Crops

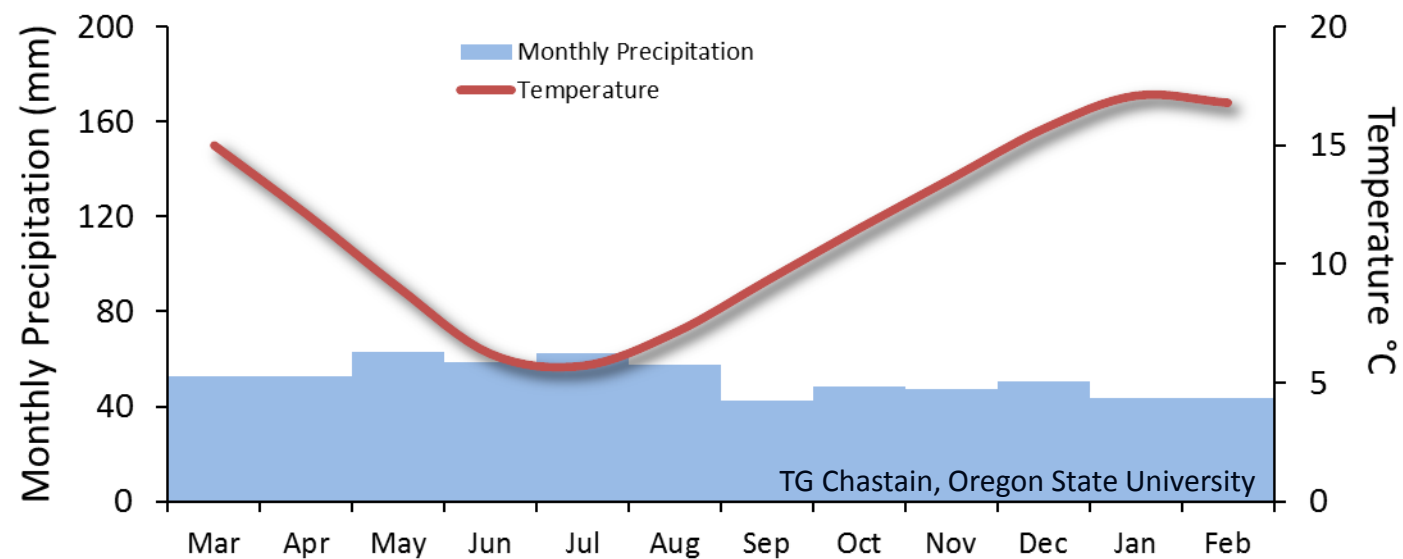
Thomas G Chastain
Oregon State University

Climate and Seed Production

Corvallis
Oregon

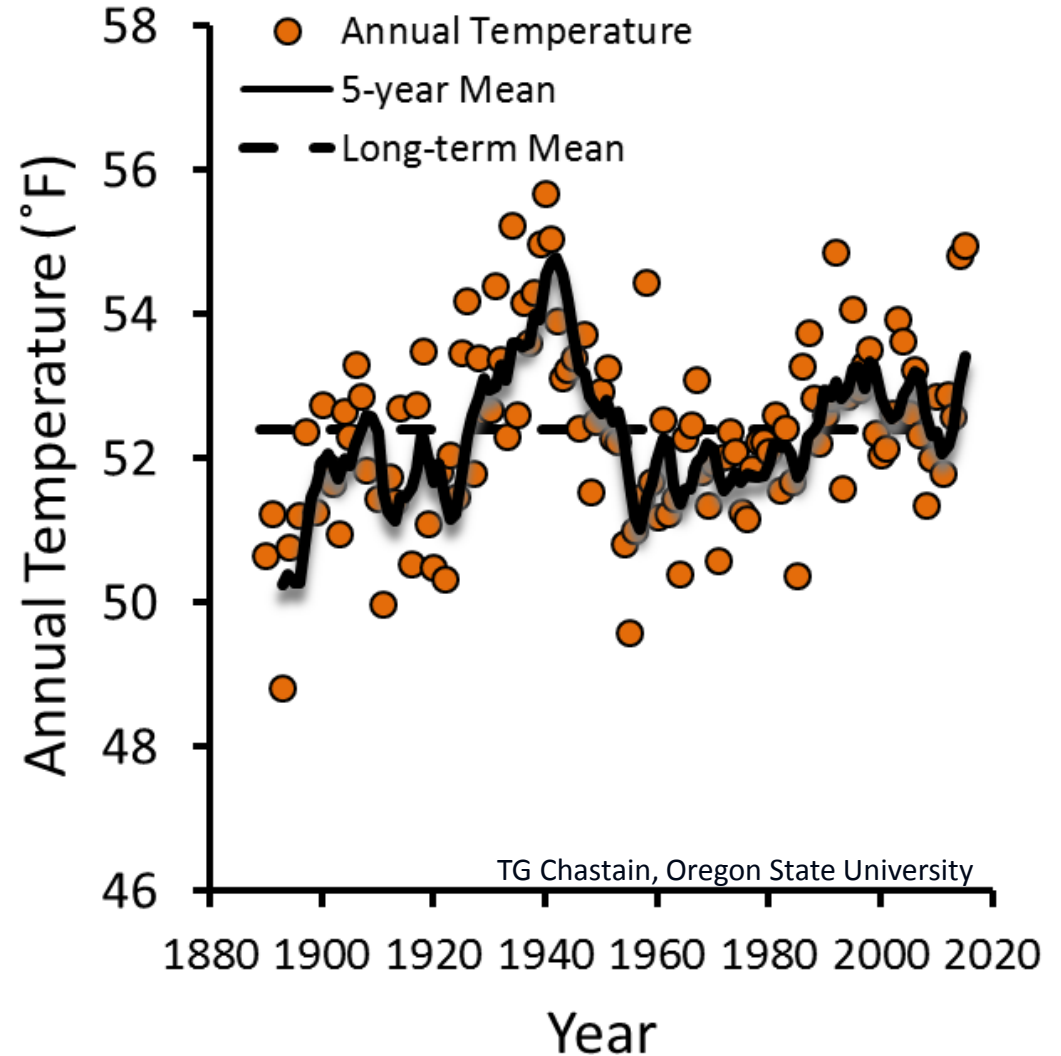


Christchurch
New Zealand



Climate and Seed Production

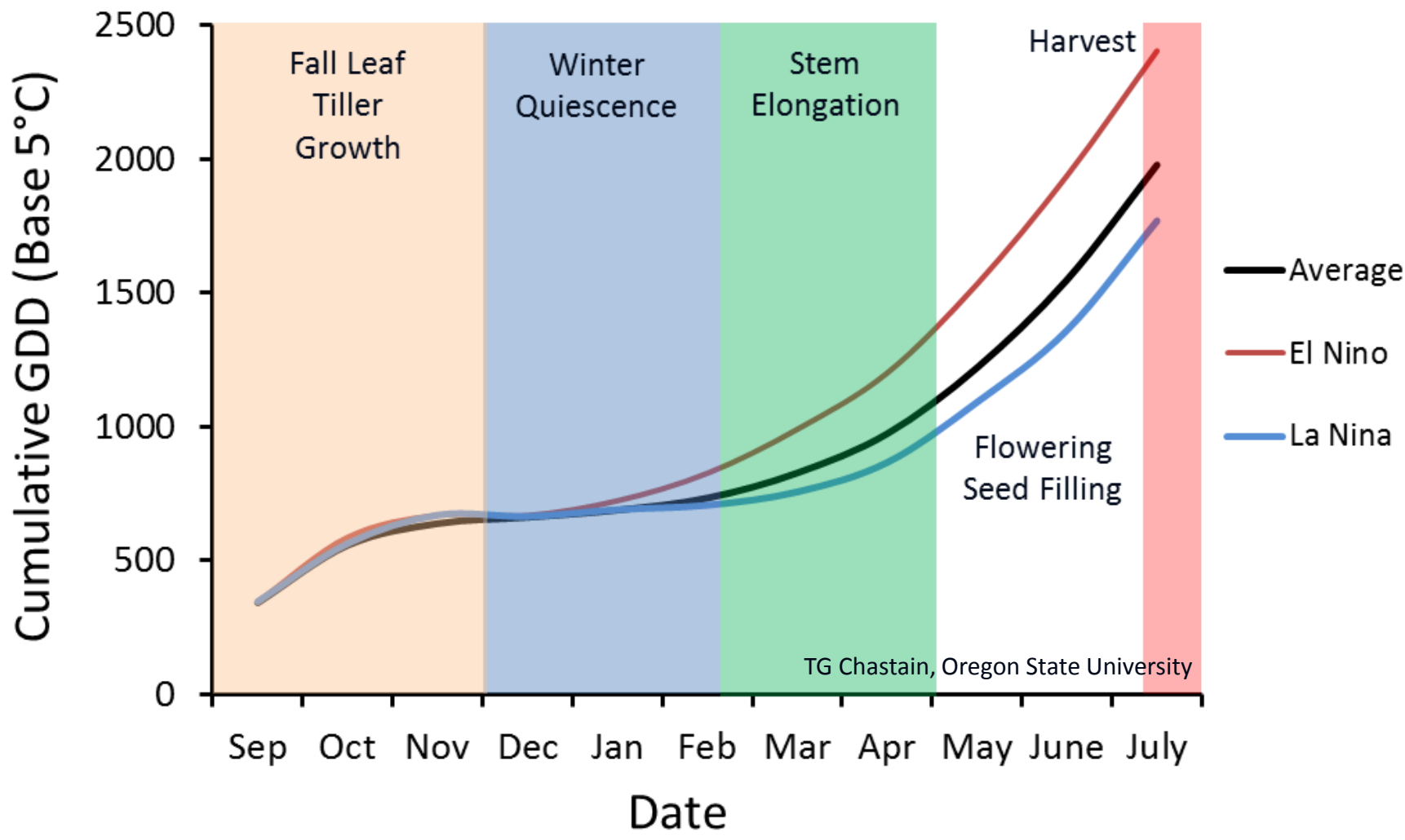
- Short-term warm and cool periods are related to weather phenomenon known as El Niño and La Niña.
- Oregon is currently under the influence of a strong El Niño (2015/16) and is comparable to past events in 1982/83 and 1997/98.
- Longer term warm and cool periods are present in the long-term temperature record.



Annual temperature, Corvallis Oregon.
Data source: NOAA

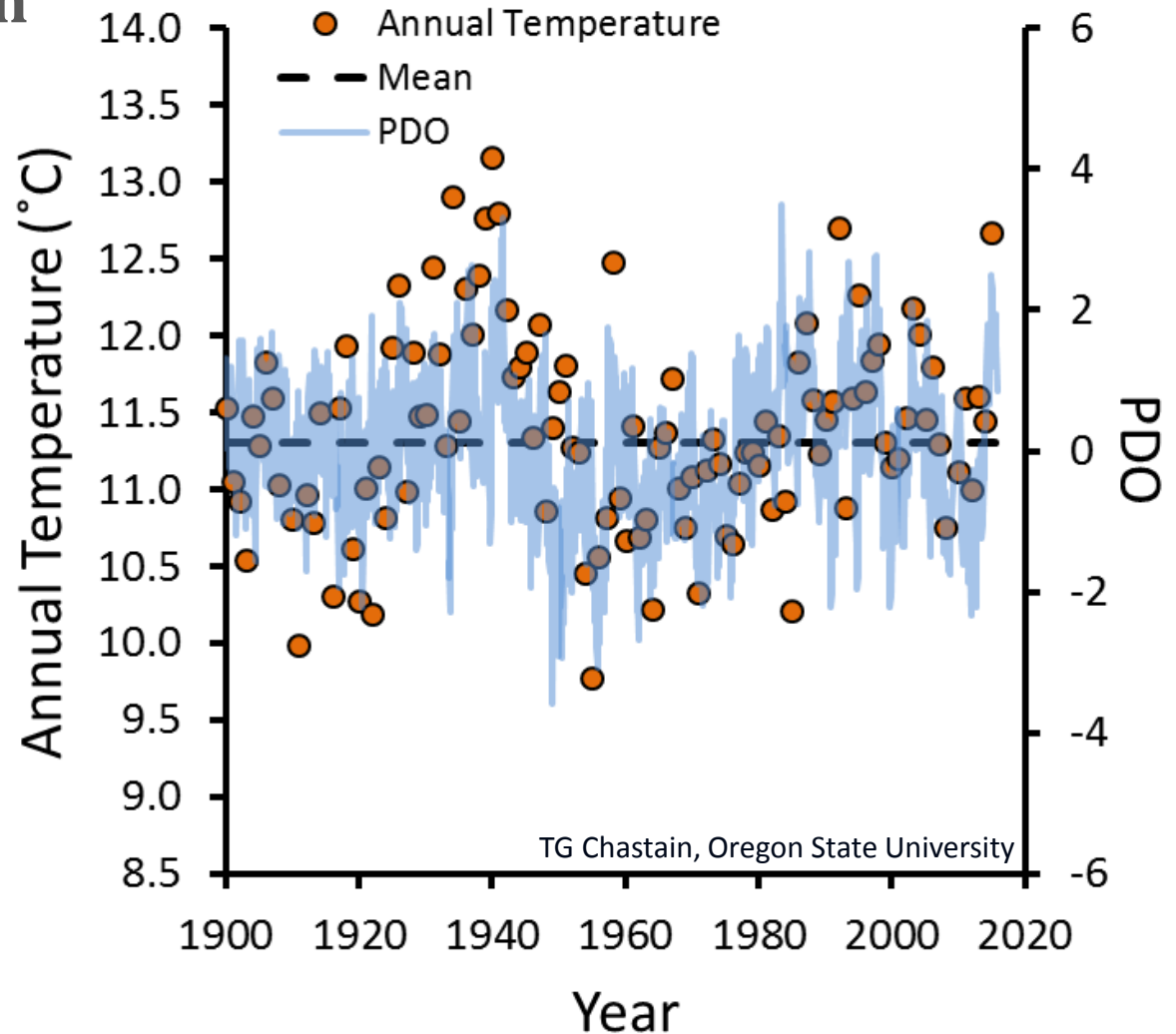
Climate and Seed Production

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



Climate and Seed Production

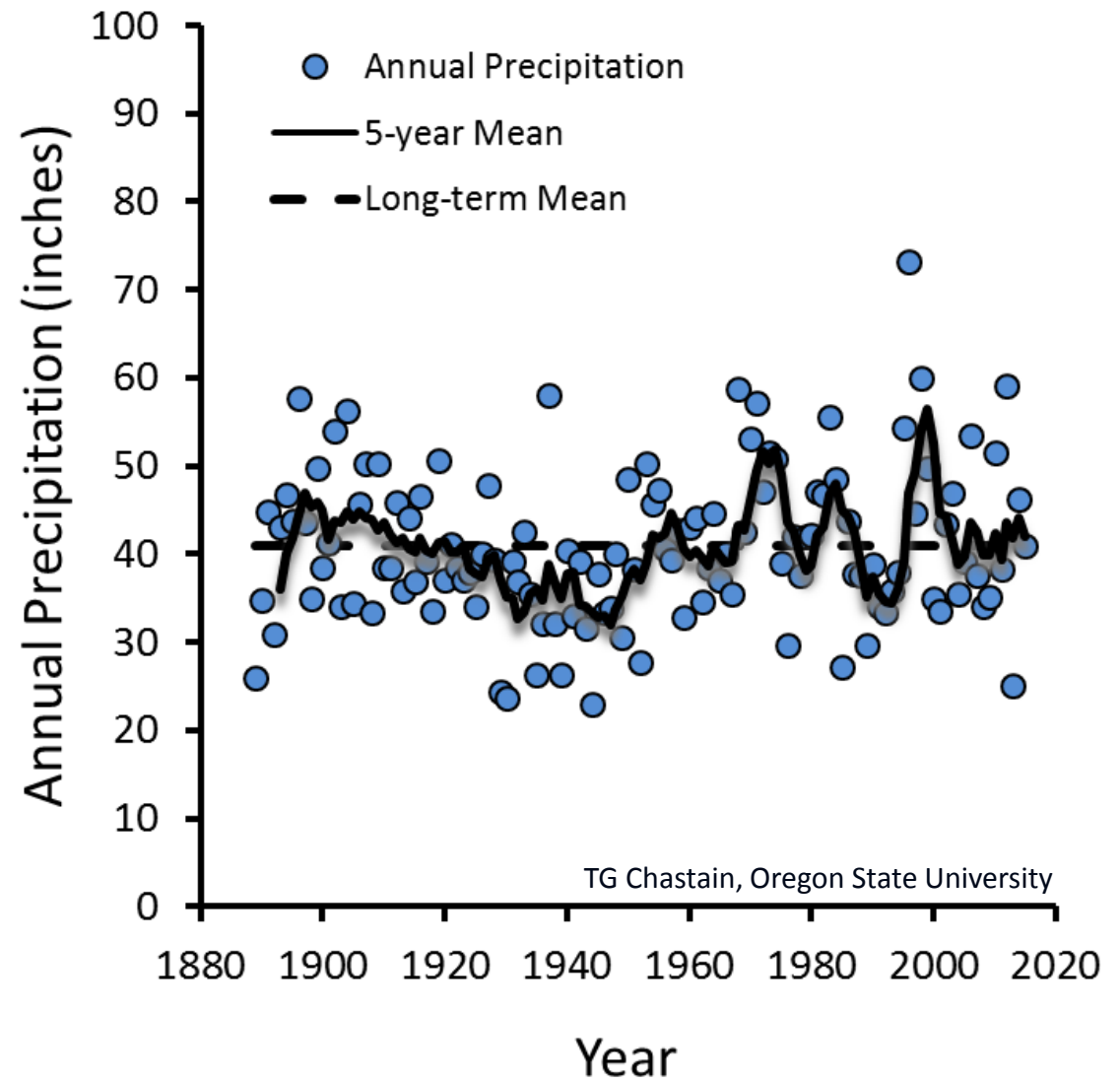
- Long-term warm and cool periods follow the phases of the Pacific Decadal Oscillation (PDO), an index of sea surface temperatures in the Pacific Ocean.
- These warm and cool periods have impacts on crop production such as extending or contracting the growing season.



Annual temperature, Corvallis Oregon, PDO.
Data sources: NOAA, University of Washington

Climate and Seed Production

- Dry and wet periods are evident in the long-term record.
- These periods are related to El Niño and La Niña phenomena and phasic changes in PDO.



Annual precipitation, Corvallis Oregon
Data source: NOAA

Seed Yield

- Yield is most influenced by two components: **seed number** and **seed weight**.

$$\text{Yield} = \text{Seed number} \times \text{Seed weight}$$

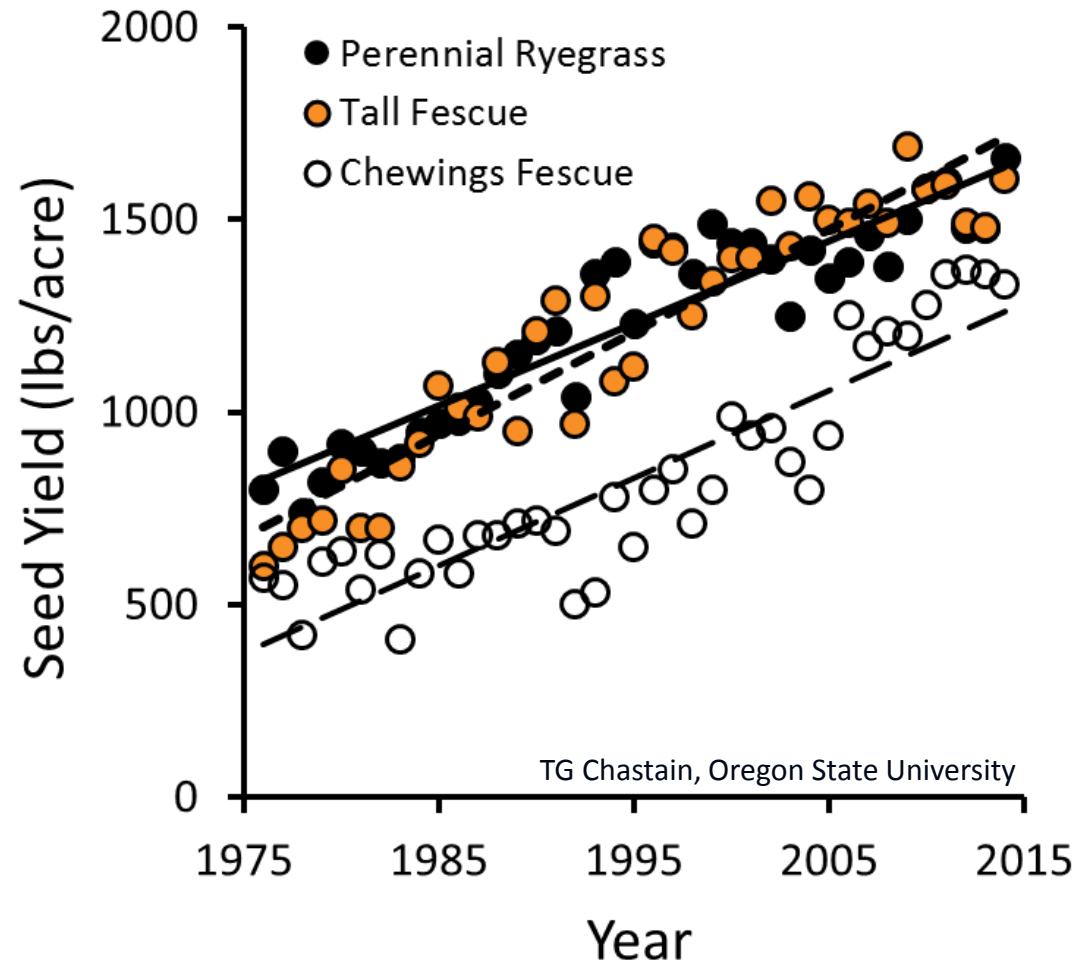
- **Seed number** is affected by pollination success, seed set and losses due to abortion and shattering.
- **Seed weight** is affected by rate of seed filling and length of seed filling period.
- Seed number varies more than weight and as a result makes larger contributions to yield.
- Both components are affected by weather during flowering and seed filling in spring.

Perennial ryegrass spike (TG Chastain photo)



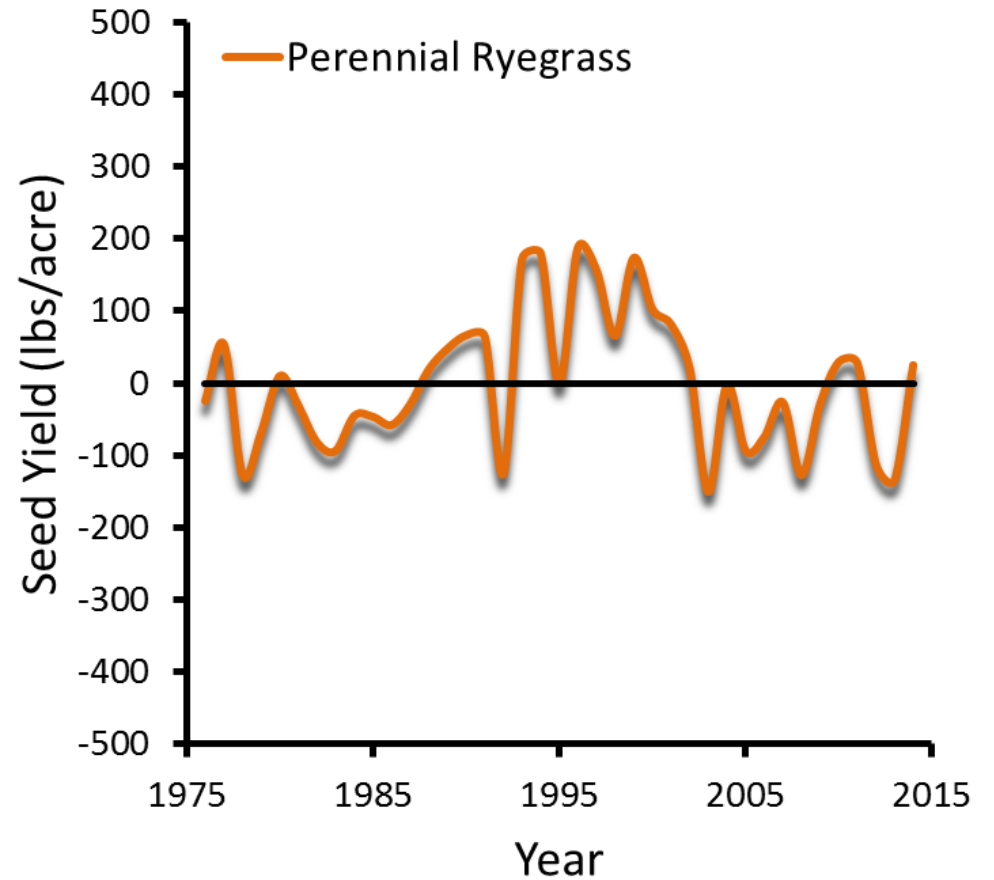
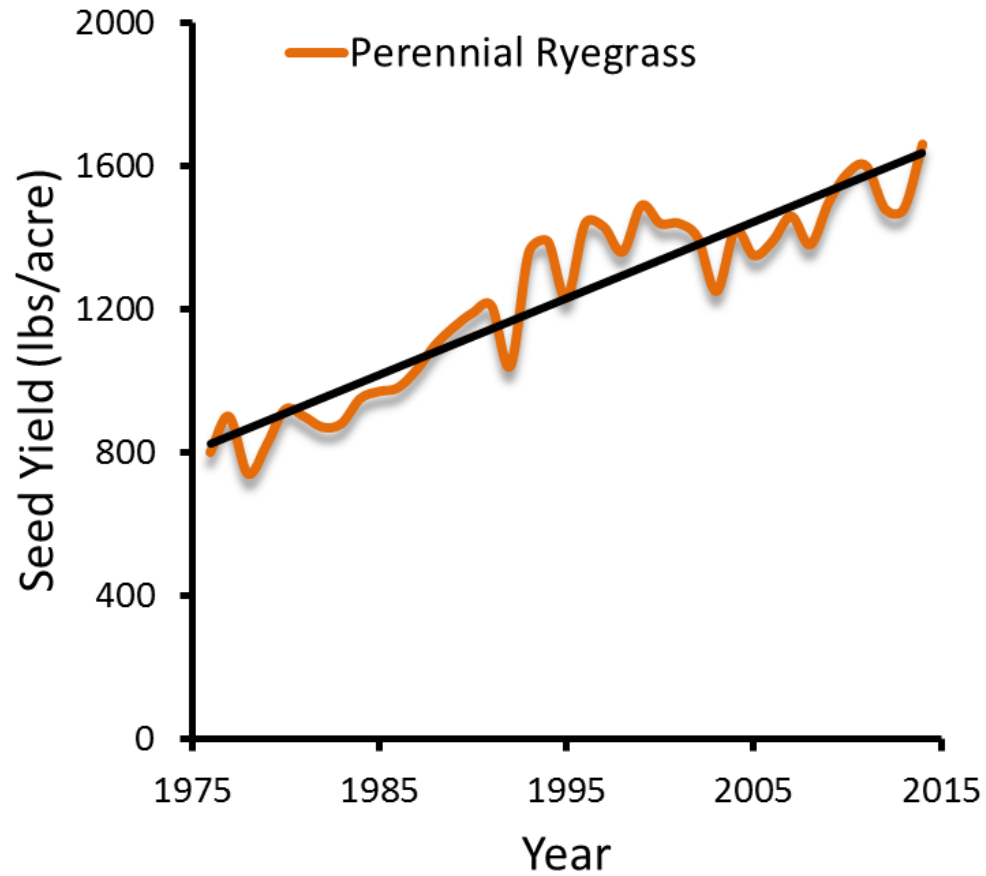
Weather and Seed Production

- Grass seed crop yields have increased over time and there is year to year variation.
- Is there a specific effect of weather on this variation in seed yield?
- Analysis of long-term yield data reveals no effect of annual precipitation on variation in yield – driest years have the same yields as the wettest years.



Trends in Willamette Valley grass seed yields (TG Chastain, 2015).

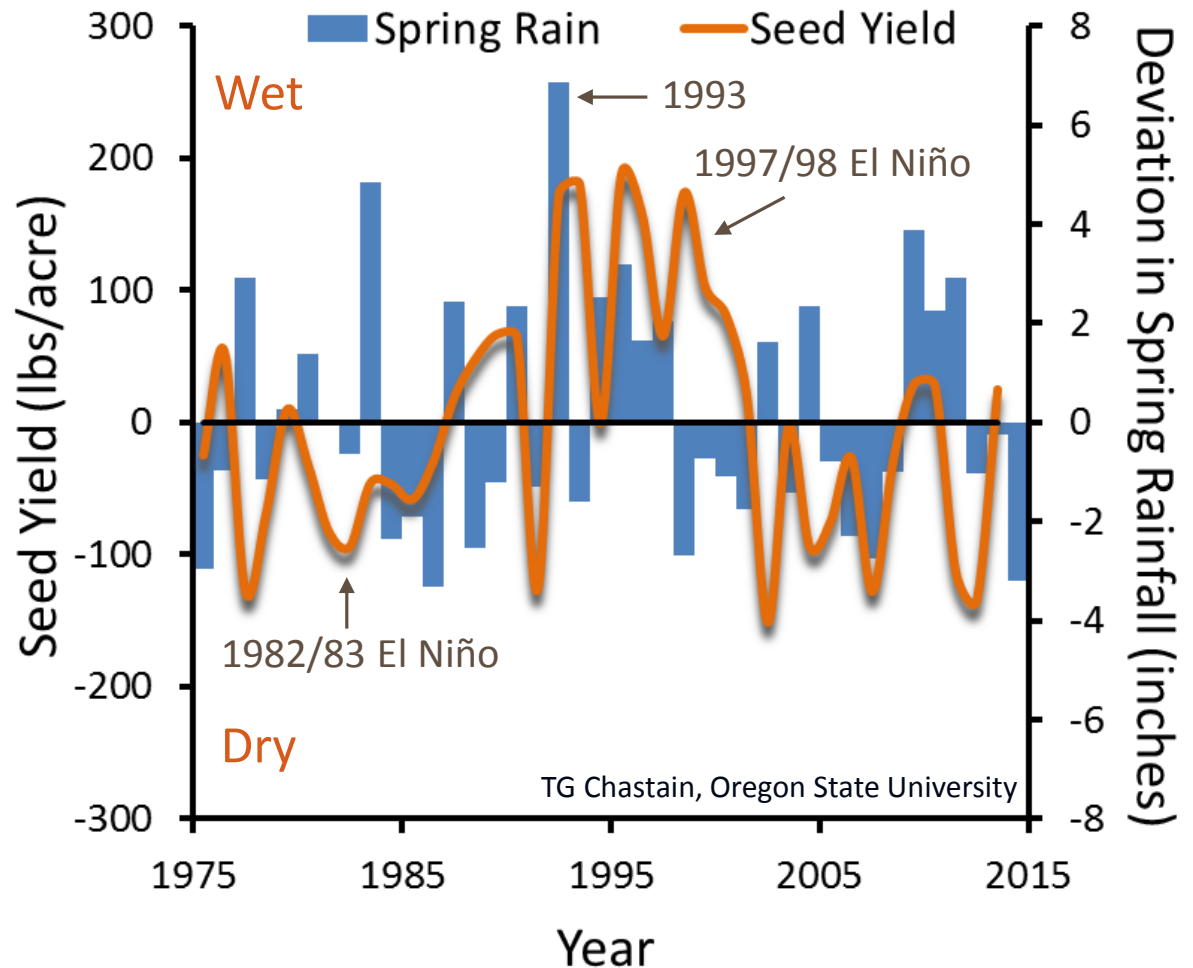
De-trending Seed Yields



Spring Rainfall and Seed Yield

- Spring rainfall in years with yield losses averaged 6.35 inches.
- Spring rainfall in years with yield gains averaged 7.29 inches.
- Strong El Niño events have mixed effects on yield – 1982/83 reduced yield while 1997/98 increased yield.
- Spring rainfall explains only a small part of the annual variation in yield.

Spring rainfall effects on perennial ryegrass seed yield



Spring Irrigation in Perennial Ryegrass

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

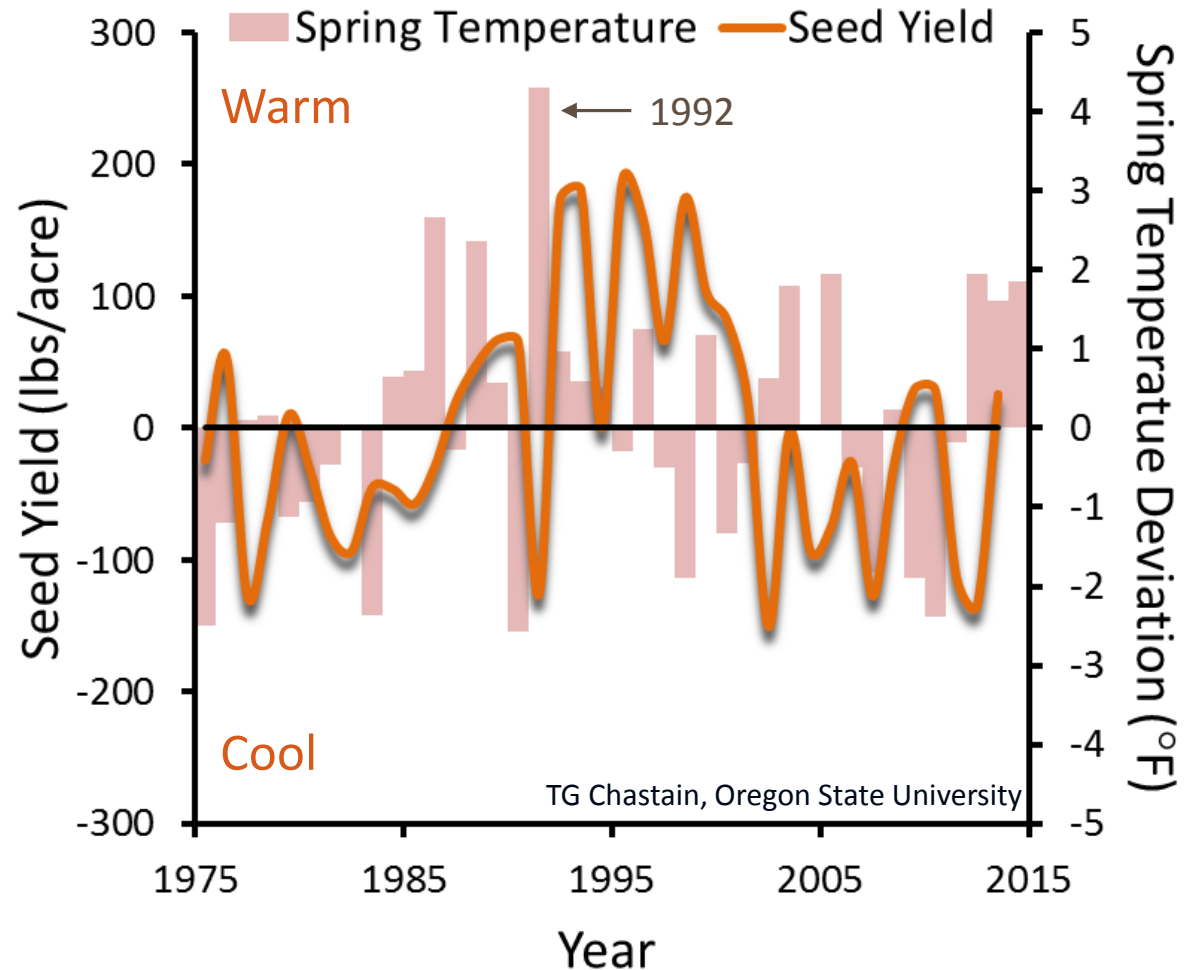


Irrigation system (TG Chastain photo)

Spring Temperature and Seed Yield

- Spring temperatures in years with yield losses averaged 56°F.
- Spring temperatures in years with yield gains averaged 55°F.
- Yield was decreased by 4 lbs/acre for each additional GDD accumulated in spring.
- Excessive heat coupled with drought reduced yield in 1992, a weak El Niño event.

Spring temperature and perennial ryegrass seed yield



1992 – How bad was it?

Weather Ranking	Year	Spring	May	June
Rainfall - Driest				
Period of Record	11th	56th	1st	75th
Last 50 years	4th	18th	1st	11th
Temperature - Warmest				
Period of Record	6th	2nd	3rd	4th
Last 50 years	2nd	1st	1st	1st

- 1992 - seed yields of perennial ryegrass and tall fescue were down by 11% and 15%, respectively.
- 1993 – seed yields of perennial ryegrass and tall fescue were up by 15% and 13%, respectively. No carry over effect.

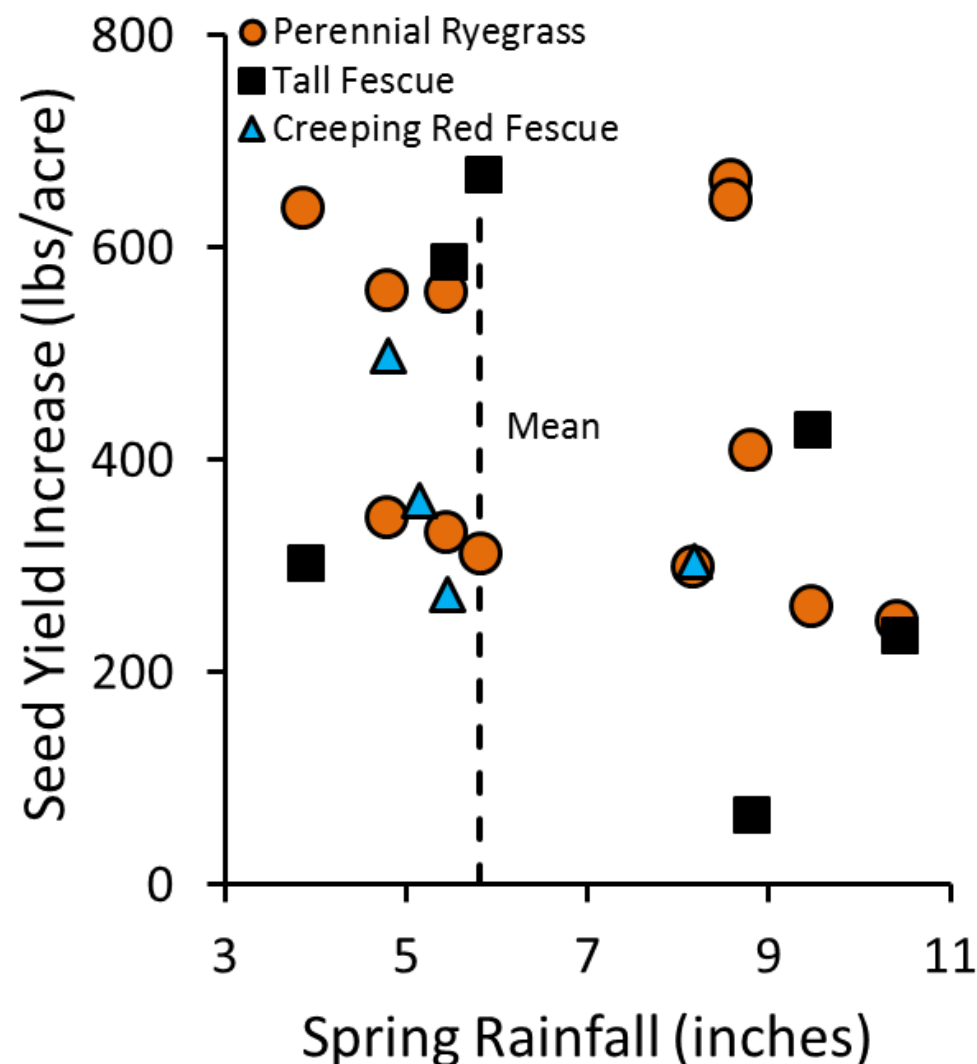
Extreme Spring Temperature and Seed Yield

Month	Maximum Temp		Minimum Temp	
	Low Yield	High Yield	Low Yield	High Yield
----- °F -----				
May	87	81	34	34
June	91	87	40	39

- Years with high seed yield tend to have lower maximum temperatures in May and June than years with low seed yield.
- The extreme low temperatures in May and June have no effect on seed yield.

Spring Rainfall and PGR

- Yields of grass seed crops were improved by TE PGR (Palisade) in both dry and wet spring seasons.
- Nevertheless, the magnitude of yield increase by PGRs tends to be greater in dry springs than in wet springs with lowest increases noted in wettest springs.
- Yield improvement by PGRs is not solely due to lodging control.



Effect of spring rainfall on seed yield increase by TE PGR (Chastain et al., 2014; Zapiola et al., 2014; Chastain et al., 2015).

Spring Rainfall and PGR

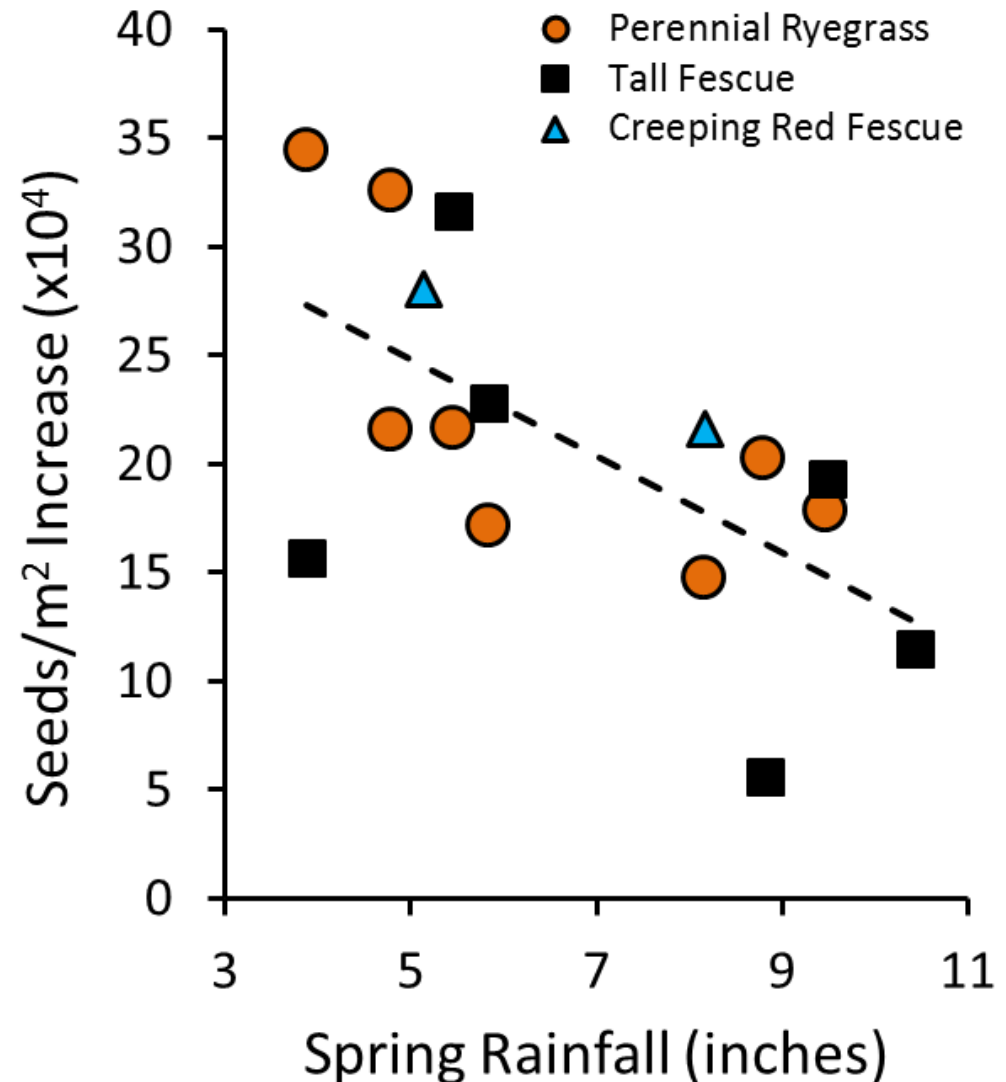
Spring rainfall effects on seed yield responses to TE PGR applications in grass seed crops

Crop	Season	Rain† inches	Temp °F	Yield increase lbs/acre
Perennial ryegrass	Wet	9.02	54.6	420
	Dry	5.04	54.8	456
Tall fescue	Wet	9.60	54.0	247
	Dry	5.59	54.8	521
Creeping red fescue	Wet	6.82	55.1	289
	Dry	4.97	56.2	431

†April to June precipitation and temperature at OSU's Hyslop Farm.
Data source: Chastain et al., 2014; Zapiola et al., 2014; Chastain et al., 2015.

Spring Rainfall and PGR

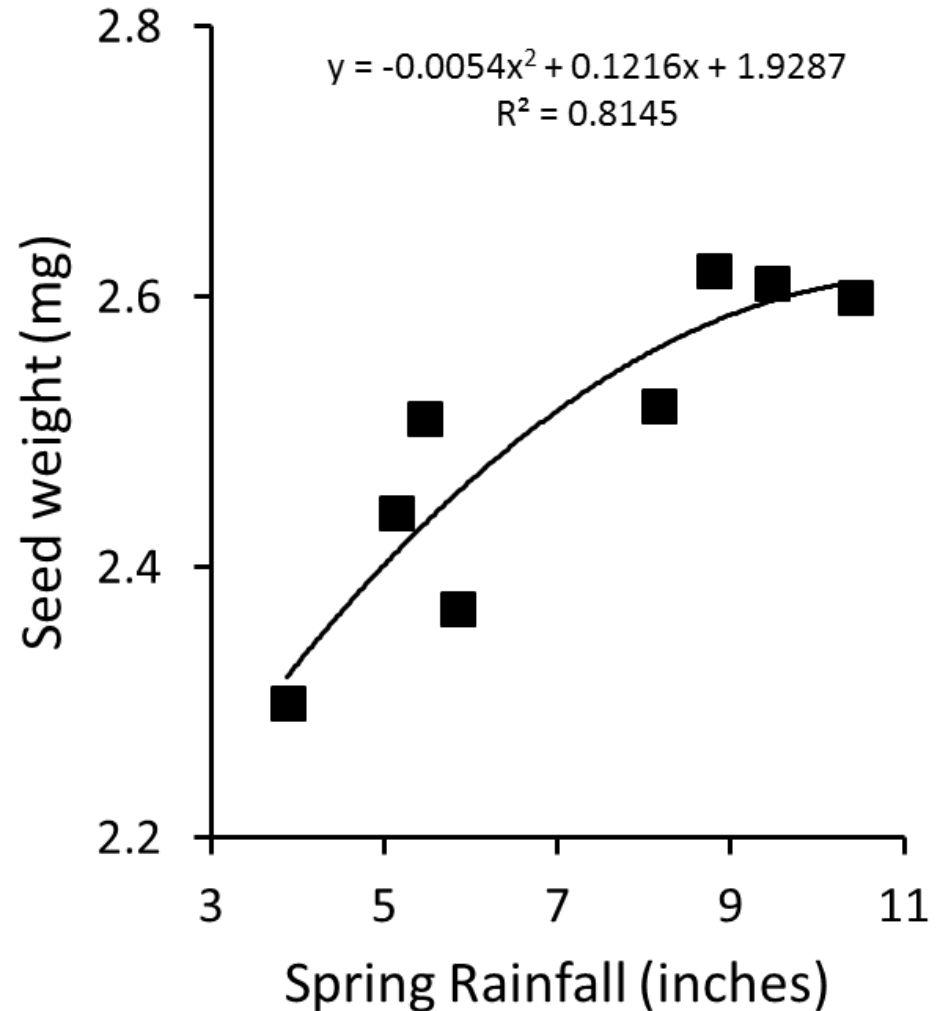
- TE PGR stimulates a bigger increase in seed number in dry springs and a smaller increase in seed number in wet springs.
- This difference in seed number increase due to PGR might be responsible for the yield responses to PGR in dry and wet seasons.



Effect of spring rainfall on seed number increase by TE PGR (Chastain et al., 2014; Zapiola et al., 2014; Chastain et al., 2015).

Spring Rainfall and PGR

- Seed weight increases with spring rainfall and with the application of spring irrigation.
- This takes place whether TE PGR is applied or not.



Effect of spring rainfall on seed weight in tall fescue (Huettig et al., 2013; Chastain et al., 2014; Chastain et al., 2015).

Weather Effects

- Too much rainfall in spring increases lodging and reduces pollination, both cause reduced seed yield. PGRs ameliorate these effects by reducing lodging.
- Too little rainfall and heat in spring produces low yields because of poor seed set and seed filling.

Perennial ryegrass floret

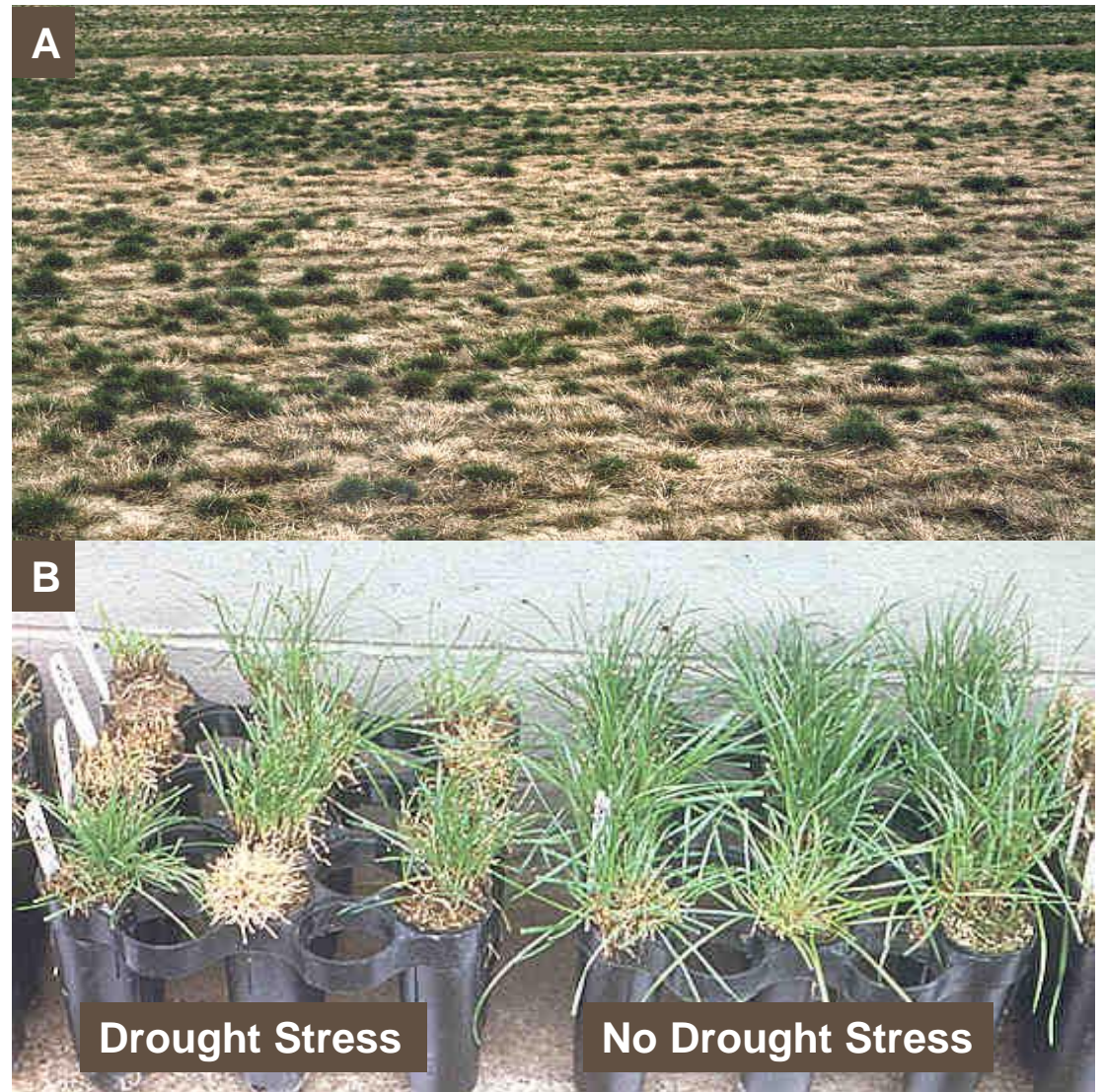
Anther

Filament



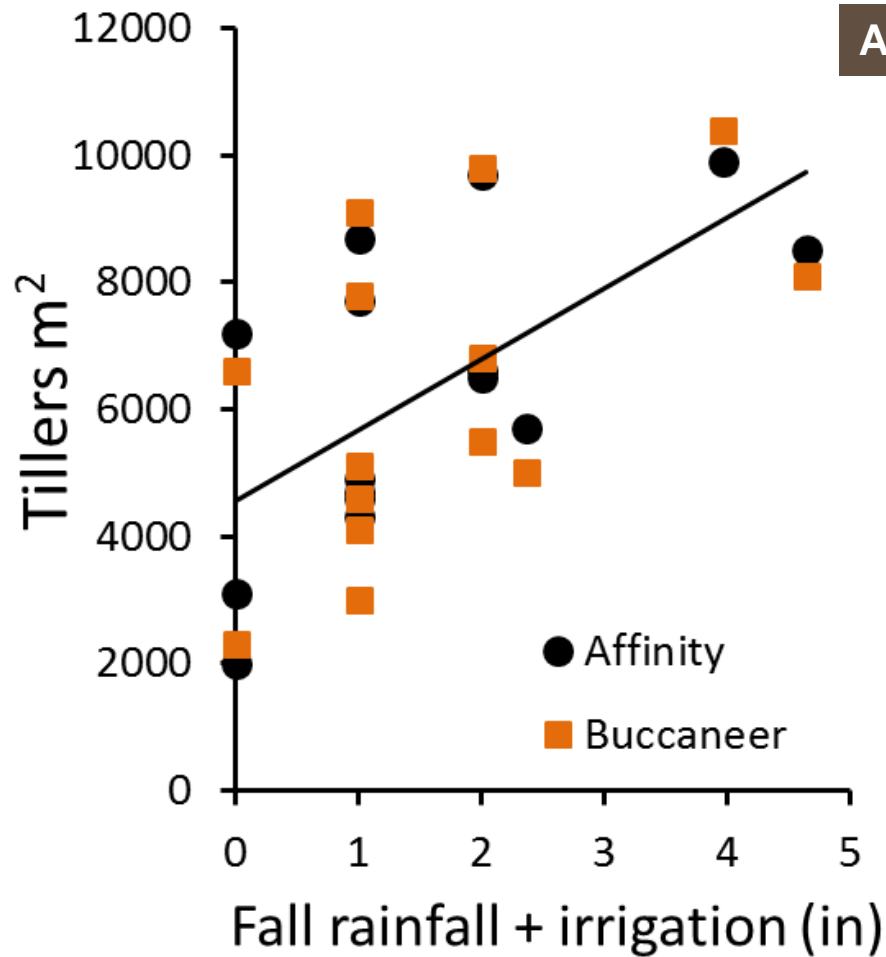
Drought and Stands

- Summer and fall drought contribute to stand loss in perennial ryegrass. Dead plants are interspersed among living plants in top photo (A).
- When perennial ryegrass is exposed to drought stress, some of plants die and some survive in a pattern similar to that observed in the field (B).
- Some genotypes within exhibit greater drought tolerance than others.



TG Chastain photos

Fall Irrigation and Stands



(a) Fall tiller production in perennial ryegrass and water, (b) regrowth in irrigated perennial ryegrass, (c) non-irrigated.



Weather effects on seed yield

- Spring weather is more likely to affect yield than other seasons. Spring irrigation can offset losses from low rainfall.
- PGRs reduce lodging caused by high spring rainfall and increases yields. PGRs increase yield in dry conditions even with low incidence and severity of lodging.
- Post-harvest irrigation can preserve stands but there is no documented evidence that yields are improved.
- Weather influences yield but good agronomic practices have a bigger effect.



Tall fescue seed (TG Chastain photo)