SIMULATING THE EFFECTS OF GROWING SEASON LENGTH AND IRRIGATION PRACTICES ON COTTON GROWTH AND YIELD

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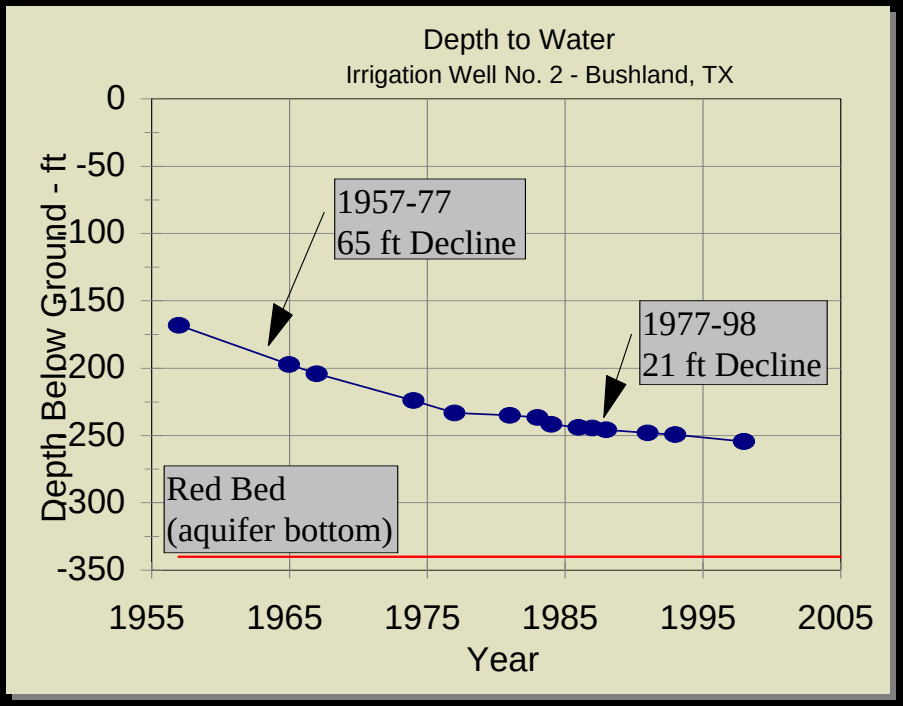
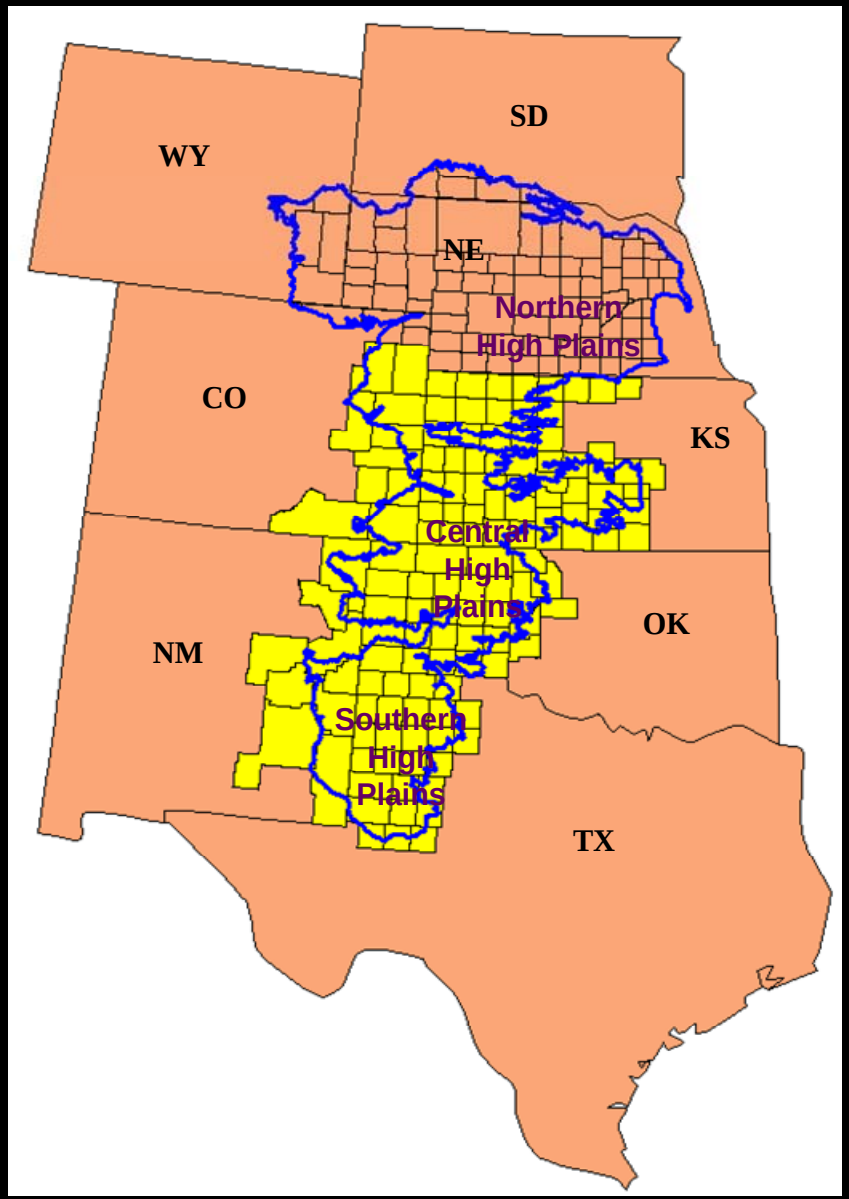
- Well capacity has declined with the decreasing water table.



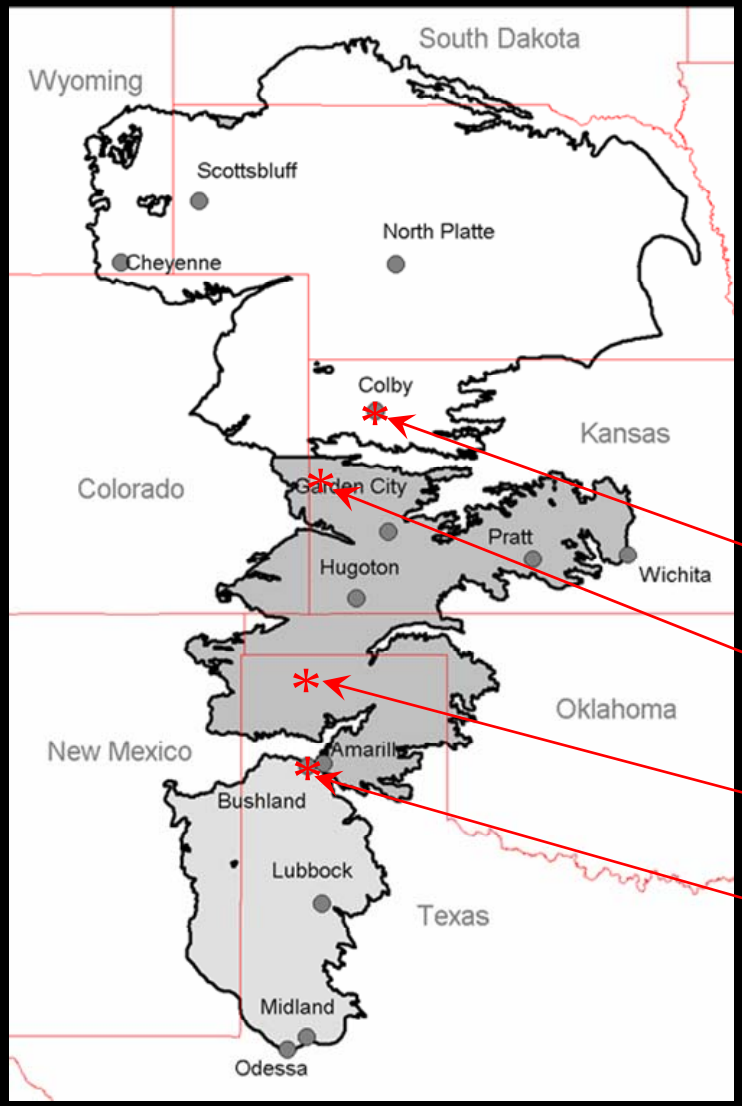


HYPOTHESES

- Deficit irrigation strategies to apply water for use during the early growing season for a limited period will promote the greatest yield or water use efficiency.

OBJECTIVES

- Use computer crop growth simulation with actual weather records to calculate annual cotton yield at various locations in response to:
  - emergence date,
  - irrigation capacity,
  - irrigation duration.



LOCATIONS

- Cotton yield and plant growth was simulated at:
  - Colby,
  - Tribune,
  - Stratford,
  - Bushland.

SIMULATIONS

- We simulated growth and yield of a stripper type cotton using GOSSYM version 4 from 1997.
- Input weather data from long-term (> 30 yrs) records at all locations included: daily solar irradiance, maximum and minimum air temperature, precipitation, and wind run.
- We simulated cotton planted in 0.76 m rows at 21 plants m^{-2} beginning 15 days before emergence on DOY 145, 152, and 159.

SOIL PARAMETERS

- Soil profile physical properties (density, texture, hydrology) were described for site specific soils based on NRCS data, measurements, and soils information supplied with the model.
- Initial profile soil water was 50% of plant available water content.
- Initial soil profile N (~ 50 kg/ha N) was supplemented with an additional 200 kg/ha N and 50 kg/ha P.

IRRIGATION PARAMETERS

- Irrigation Application Durations (4): 4, 6, 8, and 10 weeks beginning 37 days after emergence.
- Irrigation – Capacity Levels (4):
  - Irrigation = 2.5 mm d^{-1} (3 lpm/ha)
  - Irrigation = 3.75 mm d^{-1} (4.5 lpm/ha)
  - Irrigation = 5.0 mm d^{-1} (6 lpm/ha)
  - No – Irrigation = Rain only

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BUSHLAND COTTON LINT YIELD, kg ha^{-1}

Emerge D145 (222)	Irrigation Duration, Weeks			
Irrigation Capacity, mm/d	4	6	8	10
2.5	392	435	455	461
3.75	538	603	626	633
5	664	719	736	732
Emerge D152 (193)				
2.5	342	383	405	414
3.75	482	534	558	563
5	586	639	656	658
Emerge D159 (175)				
2.5	288	320	335	344
3.75	387	434	456	461
5	473	517	530	532

BUSHLAND WATER USE EFFICIENCY (WUE), kg m^{-3}

Emerge D145 (0.057)	Irrigation Duration, Weeks			
Irrigation Capacity, mm/d	4	6	8	10
2.5	0.087	0.092	0.092	0.088
3.75	0.118	0.124	0.120	0.114
5	0.140	0.140	0.134	0.125
Emerge D152 (0.051)				
2.5	0.078	0.083	0.084	0.081
3.75	0.109	0.112	0.109	0.103
5	0.127	0.128	0.122	0.115
Emerge D159 (0.047)				
2.5	0.067	0.072	0.071	0.069
3.75	0.090	0.094	0.092	0.087
5	0.106	0.107	0.101	0.095

COLBY COTTON LINT YIELD, kg ha^{-1}

Emerge D145 (235)	Irrigation Duration, Weeks			
Irrigation Capacity, mm/d	4	6	8	10
2.5	341	364	374	375
3.75	397	405	414	415
5	417	421	423	420
Emerge D152 (185)				
2.5	270	289	300	302
3.75	316	326	330	330
5	333	337	340	338
Emerge D159 (120)				
2.5	190	204	208	211
3.75	228	234	238	238
5	245	245	243	241

COLBY WATER USE EFFICIENCY (WUE), kg m^{-3}

Emerge D145 (0.069)	Irrigation Duration, Weeks			
Irrigation Capacity, mm/d	4	6	8	10
2.5	0.085	0.085	0.082	0.077
3.75	0.093	0.087	0.083	0.077
5	0.093	0.085	0.079	0.075
Emerge D152 (0.056)				
2.5	0.069	0.069	0.067	0.063
3.75	0.076	0.071	0.067	0.063
5	0.075	0.069	0.065	0.061
Emerge D159 (0.040)				
2.5	0.052	0.052	0.049	0.046
3.75	0.058	0.054	0.050	0.047
5	0.058	0.052	0.048	0.045

BUSHLAND - FRACTION OF OPEN BOLLS

Emerge D145 (0.86)	Irrigation Duration, Weeks			
Irrigation Capacity, mm/d	4	6	8	10
2.5	0.83	0.79	0.77	0.76
3.75	0.77	0.73	0.71	0.70
5	0.73	0.69	0.67	0.67
Emerge D152 (0.79)				
2.5	0.76	0.73	0.72	0.71
3.75	0.68	0.65	0.63	0.61
5	0.64	0.61	0.60	0.60
Emerge D159 (0.71)				
2.5	0.68	0.62	0.61	0.60
3.75	0.59	0.55	0.52	0.50
5	0.54	0.52	0.49	0.50

COLBY - FRACTION OF OPEN BOLLS

Emerge D145 (0.47)	Irrigation Duration, Weeks			
Irrigation Capacity, mm/d	4	6	8	10
2.5	0.43	0.41	0.39	0.39
3.75	0.38	0.36	0.36	0.36
5	0.36	0.36	0.36	0.37
Emerge D152 (0.37)				
2.5	0.34	0.32	0.32	0.32
3.75	0.29	0.28	0.28	0.28
5	0.28	0.28	0.29	0.29
Emerge D159 (0.28)				
2.5	0.24	0.22	0.21	0.21
3.75	0.20	0.19	0.19	0.19
5	0.20	0.19	0.19	0.19

SUMMARY

- Delayed cotton emergence decreased lint yields and WUE, and was worse where growing seasons were already limited.
- Cotton lint yield and WUE generally increased with increasing irrigation capacity, but irrigation later than 6 weeks often produced negligible yield benefits at higher irrigation capacities.
- Increasing irrigation produced greater yield, but also more unusable bolls.

CONCLUSIONS

- Cotton production in areas with short growing seasons (Kansas) diminish crop response to irrigation.
- We recommend for irrigated cotton in these areas:
  i. timely planting,
  ii. manage irrigated areas using higher application capacities, but do not extended applications later into the growing season.

HYPOTHESES

- Cotton requires progressively less energy to mature with increasing latitudes and, therefore, is a viable alternative crop for production north into Kansas.
- Deficit irrigation strategies to apply water for use during the early growing season for a limited period will promote the greatest yield or water use efficiency.

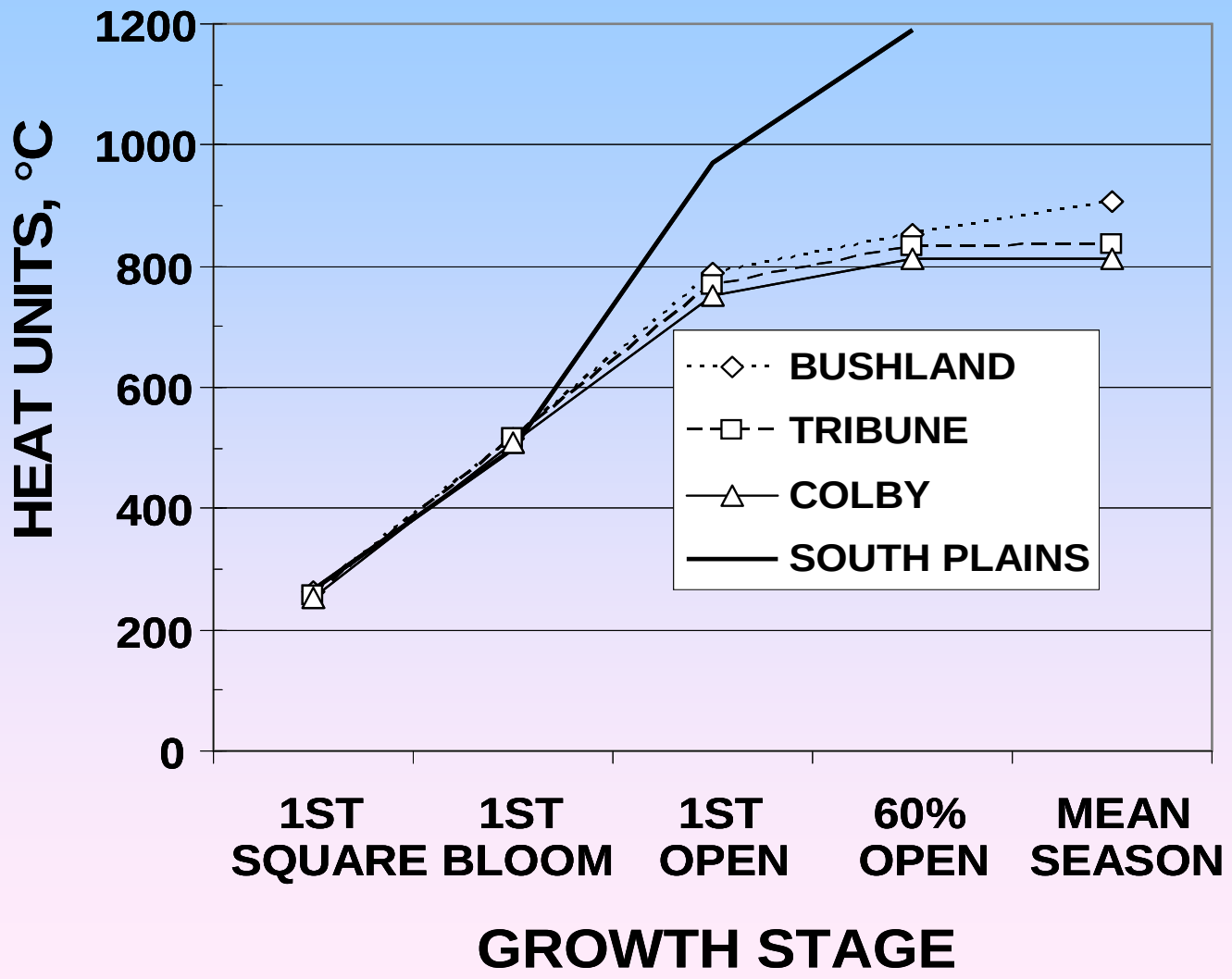
COTTON AND GROWING SEASON ENERGY

- Cumulative cotton growing season energy (HU) is calculated from daily maximum (Tmax) and minimum (Tmin) air temperatures (in °C) adjusted for a 15.6 °C base according to the equation:

$$HU = \sum (Tmax + Tmin)/2 - 15.6$$

- Cotton HU have been related to crop growth stage and yield. That simple model does not consider cotton growth under temperature extremes.

HEAT UNITS BY GROWTH STAGE AND LOCATION



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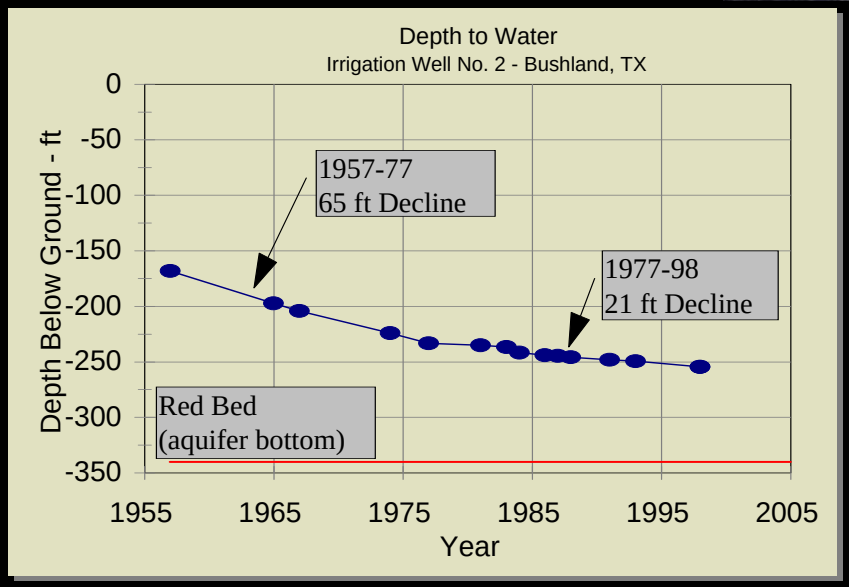

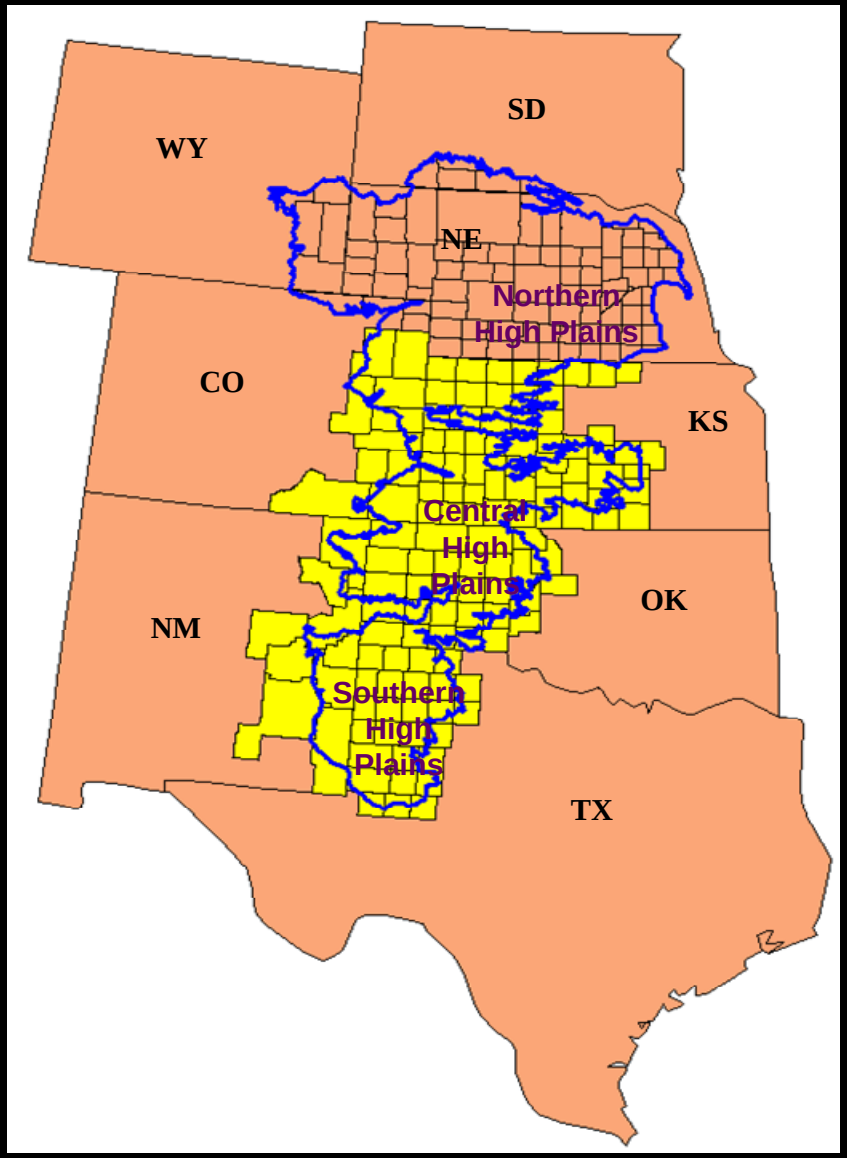

OGALLALA AQUIFER REGION

- Area – 41,320,000 ha
- Crop land – 41% of area
- Annual precipitation – 366 to 813 mm
- Major Crops – Corn, Sorghum, and Wheat