Long-Term Trend of Soybean Yield Potential in South-Central Nebraska

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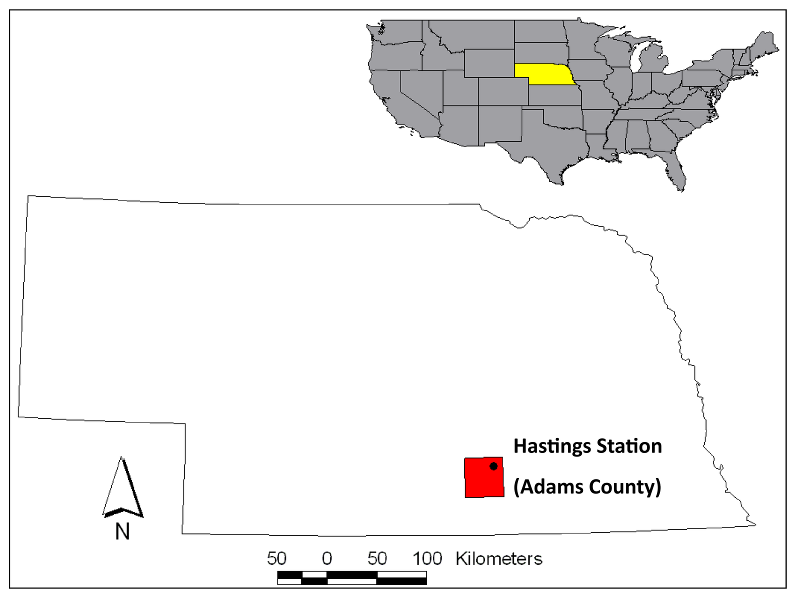
Rationale

Soybean [Glycine max (L.) Merr.] production in the USA was first recorded in 1924. In Nebraska, soybean production was reported in 1938, irrigation introduction the late 1950s, and yield increase over time (NASS, 2013).

This study quantifies the magnitude and trends in soybean yield response (planting dates and maturity groups, MG) to primary climatic variables in South-Central Nebraska.

Location, Soils & Climate



Common soil is Hastings silt loam of fine, smectitic, mesic Udic Arguistolls; 18.4 cm water holding capacity within 0-100 cm depth, and a well-drained soil (NRCS, 2013).

Figure 1. Study location within Adams county of South-Central Nebraska

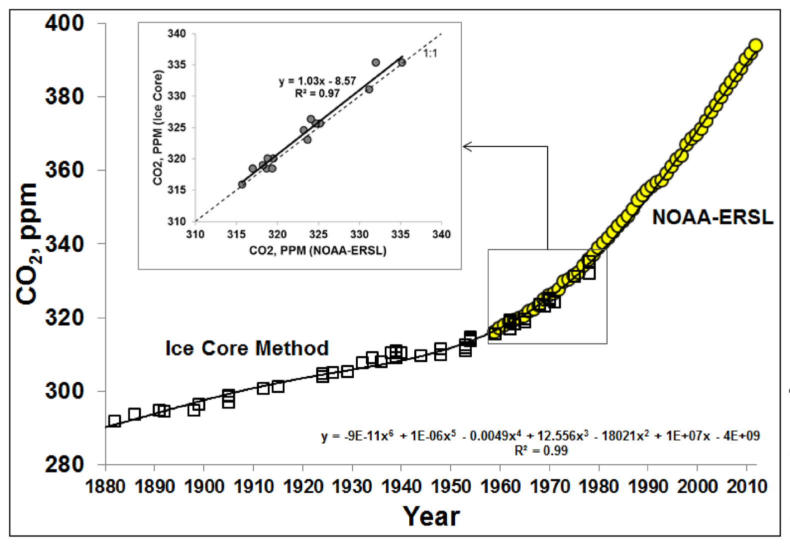


Figure 2. Yearly CO_2 (ppm) recorded in Mauna Loa, Hawaii (NOAA-ERSL) and in Law Dome Antarctic summit (Etheridge *et al*., 1996). Polynomial fit was used specifically to predict CO_2 levels in years with missing observations.

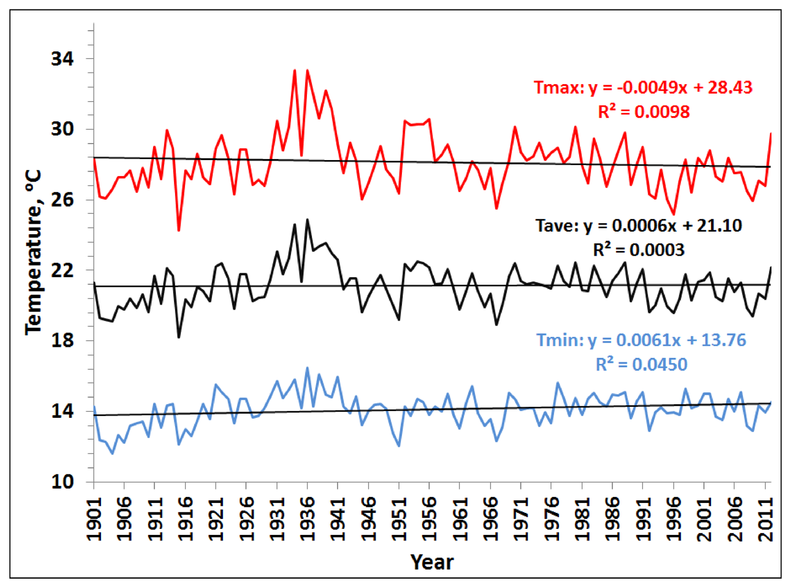


Figure 3. Growing season (May—September) averages of maximum (Tmax), average (Tave) and minimum (Tmin) air temperatures.

Methods

Daily climatic data obtained from the High Plains Regional Climate Center for the period of 1987 through 2012 were processed. From 1901 to 1986, the NWS Coop weather station daily Tmax, Tmin, and precipitation data were used. All the other climate variables (solar radiation, relative humidity, potential ET, et.) were estimated using the methodology developed by Irmak et al. (2012).

Yearly soybean yield potential was simulated for hypothetical maturity groups: 2.0, 3.0 and 4.0 using SoySim model (Setiyono *et al*., 2010). This was carried out using both the yearly CO_2 rise (Figure 1) and using 1901 CO_2 ppm as benchmark year.

Results

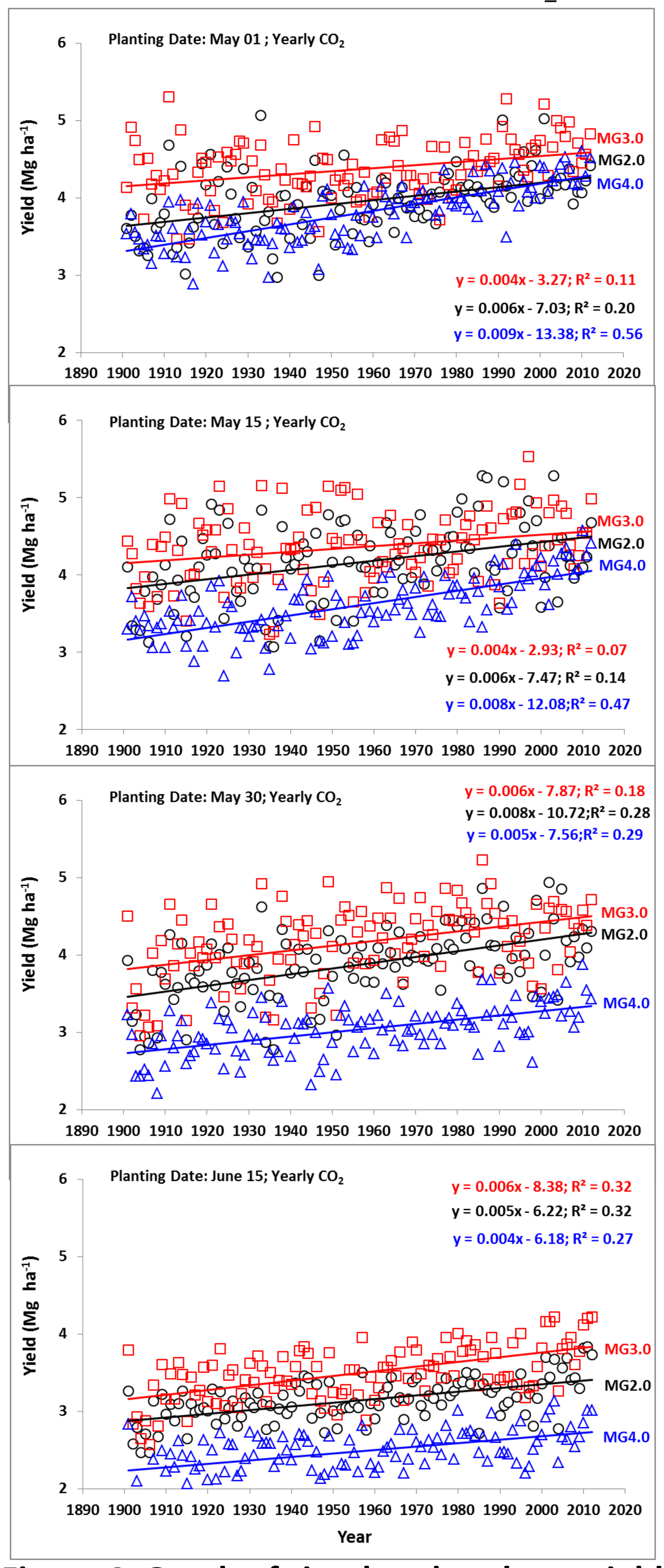


Figure 4. Graph of simulated soybean yield potential (simulated with the SoySim crop model) *versus* year (1901-2012) for the selected planting dates (May 1, 15, 30; June 15) and three hypothetical cultivars of MG 2.0. 3.0, and 4.0. Year-specific weather data and year-specific atmospheric CO_2 ppmv values were used as SoySim inputs.

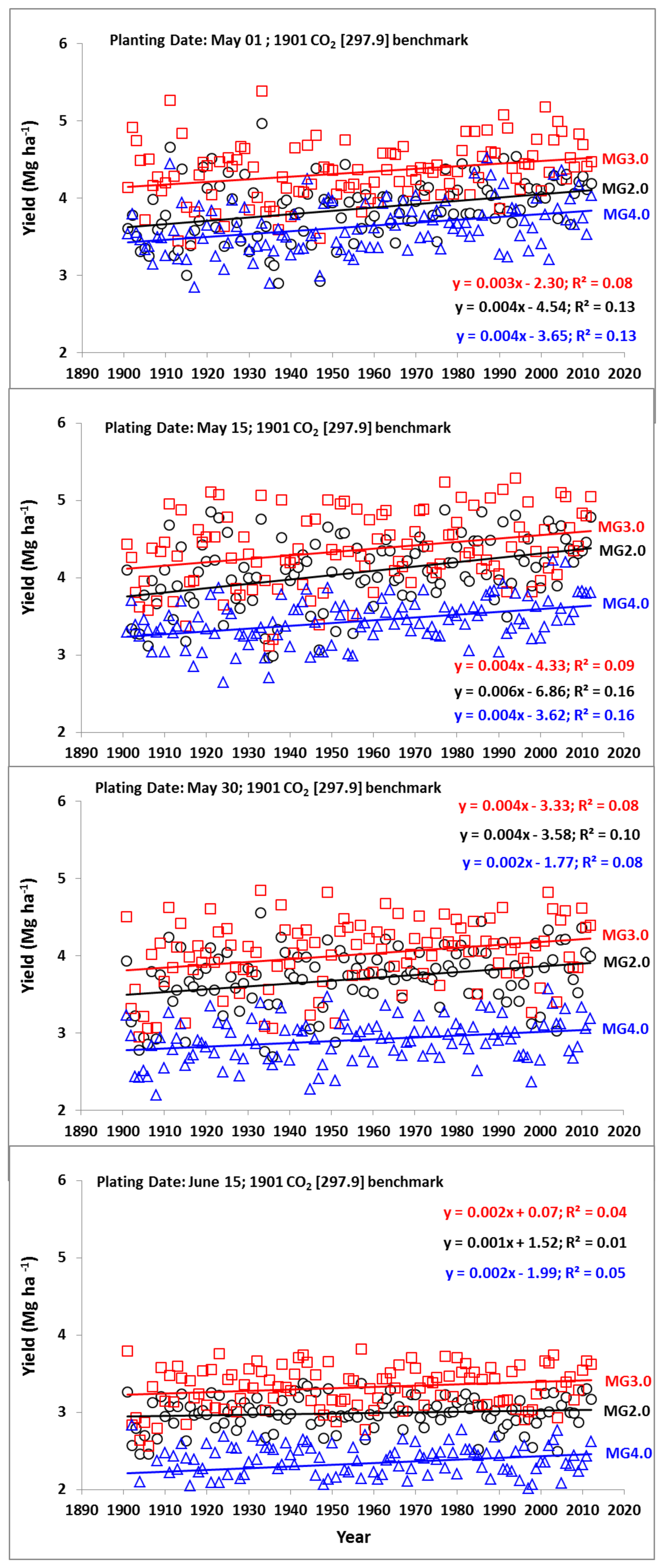


Figure 5. Same graph as in Figure 4, BUT with the atmospheric CO_2 ppmv value of 297.9 held constant in SoySim for each subsequent year of simulated yield potential.

Table 1. Best, worst, mean, median, and 75% & 25% percentile of soybean yield potential (1901-2012) simulated with four planting dates, three cultivar maturity groups (2.0, 3.0, and 4.0) and year-specific seasonal crop weather data and year-specific atmospheric CO_2 values.

MG	Planting Date	------------------------Yield, Mg ha^{-1}--------------------					
		Best	Worst	Mean	Median	75% Percentile	25% Percentile
2.0	May 01	5.06 (*1933*)	2.98 (*1937*)	3.95	4.00	4.18	3.69
	May 15	5.28 (*2003*)	3.07 (*1936*)	4.16	4.16	4.49	3.80
	May 30	4.93 (*2002*)	2.77 (*1936*)	3.87	3.91	4.14	3.62
	June 15	3.83 (*2011*)	2.46 (*1906*)	3.14	3.12	3.34	2.98
3.0	May 01	5.30 (*1911*)	3.47 (*1913*)	4.37	4.34	4.66	4.14
	May 15	5.53 (*1997*)	3.22 (*1935*)	4.36	4.37	4.66	4.03
	May 30	5.23 (*1986*)	2.95 (*1904*)	4.16	4.21	4.48	3.89
	June 15	4.22 (*2003*)	2.57 (*1906*)	3.49	3.48	3.75	3.26
4.0	May 01	4.60 (*2010*)	2.88 (*1917*)	3.80	3.82	4.08	3.50
	May 15	4.58 (*2010*)	2.68 (*1924*)	3.60	3.60	3.87	3.33
	May 30	3.87 (*2010*)	2.21 (*1908*)	3.03	3.07	3.22	2.82
	June 15	3.13 (*2003*)	1.79 (*1906*)	2.48	2.50	2.67	2.30

Results (continued)

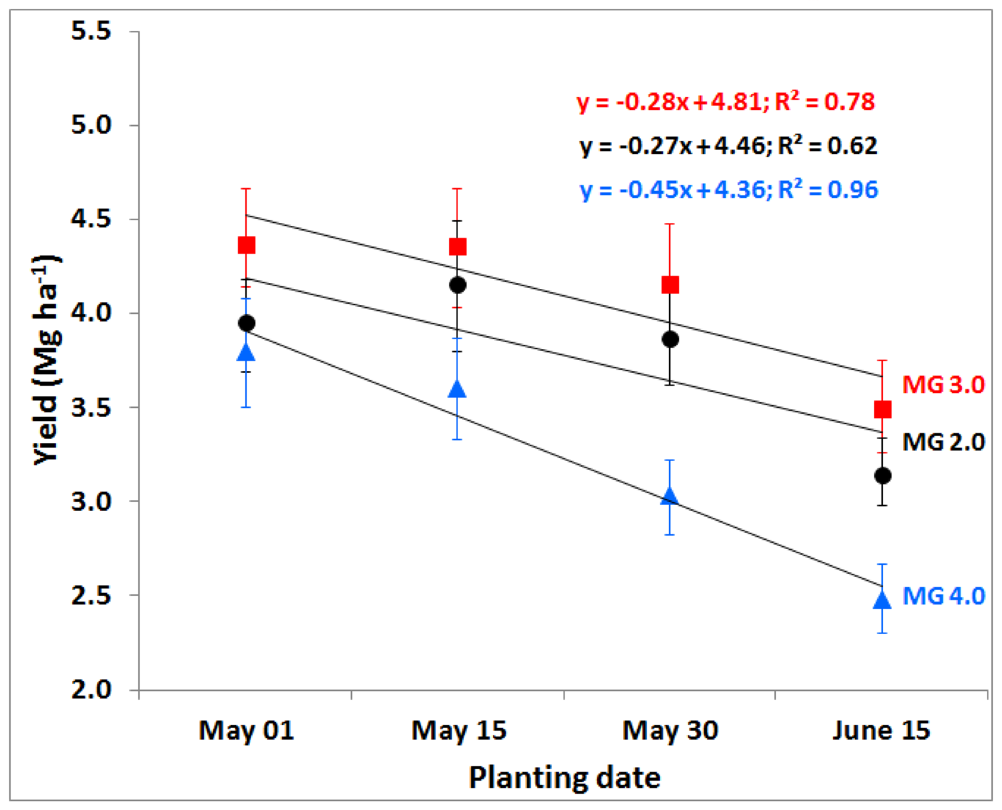


Figure 6. Linear regression of simulated soybean yield potential for cultivars of differing three maturity groups (MG) *versus* the four selected planting dates using year-specific season crop weather data and year-specific atmospheric CO_2 values. Symbols denote the mean yields (n=112 years) and error bars are 75% and 25% percentiles.

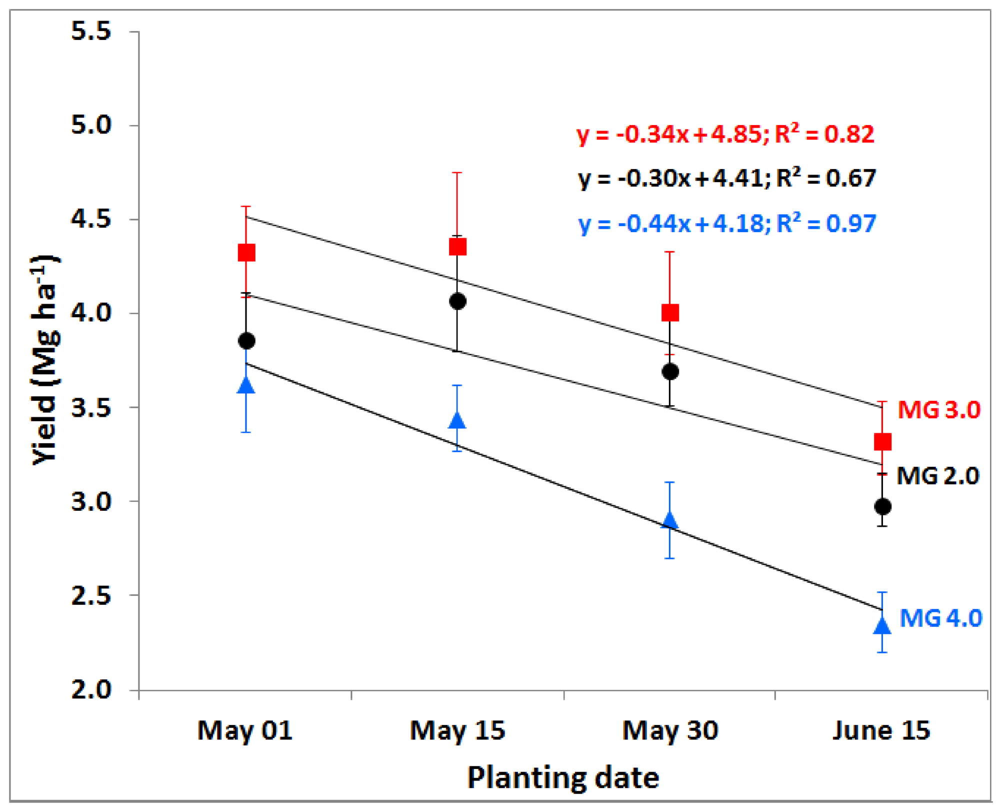


Figure 7. Same graph as in Figure 6, BUT with the atmospheric CO_2 ppmv value of 297.9 held constant in SoySim for each subsequent year of simulated yield potential.

Summary

- MG 3.0 soybean cultivars considered by breeders to be best adapted for South Central NE production, and the poster figure results confirm that notion (with or without using year-specific atmospheric CO_2 levels or a 1901 level for all years).
- The response of soybean yield potential to the rise in atmospheric CO_2 level ranged form 1 to 5 kg ha^{-1} yr^{-1} (0.01 to 0.07 bu acre^{-1} yr^{-1}), which is close to the 5 kg ha^{-1} yr^{-1} estimate inferred by Specht et al. (1999).
- Soybean yield potential was enhanced in each MG when the planting date was advanced from mid-June to early May, linearly so in the case of MG 4.0 cultivars, though it plateaued at the earliest plant date with MG 2.0 and 3.0 cultivars.
- The yield *vs.* regression coefficients in Figure 4 are somewhat greater than the corresponding ones in Figure 5, and suggest that there is a synergistic interaction between earlier planting and steady rise in atmospheric CO_2.

References

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