Evaluation of the Relationship and Impact of Climatic Factors on West Tennessee Corn and Soybean Yields from 1955 to 2013

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Abstract

This study was designed to determine if a relationship existed between corn (*Zea mays*) and soybean (*Glycine max*) yields and climate factors in West Tennessee from 1955 to 2013. Yield data was obtained from National Agricultural Statistics Service (NASS) annual crop surveys for the twenty one counties in United States Department of Agriculture (USDA) West Tennessee and Delta Districts. Climate data for was obtained from National Climatic Data Center (NCDC). Only climate data from April through October was used in calculations to more accurately reflect corn and soybean growing seasons. Correlations, linear regressions, and multiple regressions were developed to compare crop yields with climate factors for the year as well as three phases of the crop production process (planting, growing, and harvesting). Significant relationships were found to exist between corn yield and minimum temperature (r = 0.32; P = .01), precipitation (r = 0.29; P = .26), Palmer Z-Index (r = 0.26; P = .47), and one month Standardized Precipitation Index (r = 0.26; P = .049). Significant relationships were found between soybean yield and maximum temperature (r = -0.32; P = .01), precipitation (r = 0.43; P < 0.001), Palmer Drought Severity Index (r = 0.28; P = .03), Palmer Z-Index (r = 0.43; P < .001), and one month Standardized Precipitation Index (r = 0.46; P < .001). The study found that yields were dependent on multiple climatic factors due to the abundance of significant multiple regression models compared to linear regression models. However, West Tennessee corn and soybean yields were not statistically influenced by average temperature or climate factors during the planting stage of production. Overall, growing season temperature and precipitation factors were important and will continue to impact corn and soybean yields in West Tennessee.

Tennessee Agriculture

Agriculture is the largest economic industry in Tennessee. Tennessee is a diverse agricultural state with the Mississippi Delta in the west, rolling hills in the middle, and Appalachian Mountains in the east. The diversity of the landscape allows for several agricultural commodities to be produced. Tennessee's top agriculture commodities include beef cattle, grains, oilseeds, poultry, and forage.

The majority of Tennessee's corn is produced in West Tennessee. West Tennessee accounted for 66% (84.2 million bushels) of Tennessee's 128 million bushels of corn harvested in 2013. Likewise, the majority of Tennessee's soybean production is found in West Tennessee. West Tennessee produced 73% (51.2 million bushels) of Tennessee's 69.9 million bushels of soybeans harvested in 2013 (NASS, 2014).

West Tennessee Climate

West Tennessee has experienced diverse weather patterns over the last several years. Temperatures have remained consistent in Tennessee with an average growing season (April through October) temperature of 70.5°F (21.4°C). From 1955 to 2013, the lowest average growing season temperature was 67.5°F (19.7°C) in 1976. The highest average growing season was 73.6°F (23.1°C) in 2012. From 1955 to 2013, West Tennessee had an average of 29 inches of rain per growing season. The lowest year was 1956 with 19.6 inches, and the highest year was 2009 with 41.34 inches of rainfall. West Tennessee experiences both wet and dry conditions. It only rained 0.01 inches in October 1963. May 1983 had 12.02 inches of rain.

Tennessee is predicted to experience climate variability in the upcoming decades due to CO_2 in the atmosphere, rising oceanic temperatures, etc. Average temperature is predicted to increase by 3.5°C per year in Tennessee. Research predicts that precipitation may decrease as much as 3% or increase as much as 15% (Karetinkov et al., 2008).

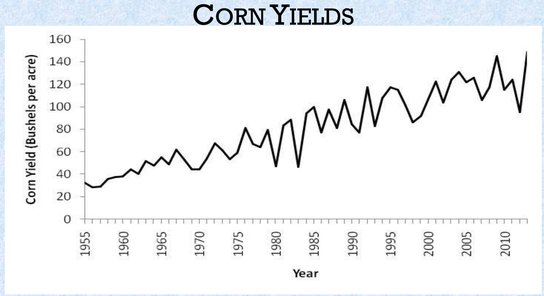
Study Area

From TNGenWebProject, Inc.

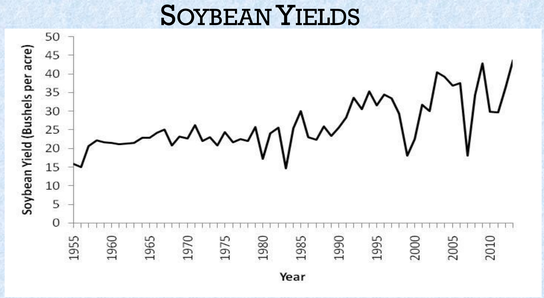
Climate Factors Studied

Mean Temperature (TAVG)
Minimum Temperature (TMIN)
Maximum Temperature (TMAX)
Precipitation (PCP)
Palmer Drought Severity Index (PDSI)
Palmer Z-Index (ZNDX)
One Month Standard Precipitation Index (SPI01)

Corn Yields



Soybean Yields



Season / Phase Definition

Growing Season (April through October)
Planting Phase (April through May)
Growing Phase (June through July)
Harvesting Phase (August through October)

Corn Yield and Climate Correlation

	Growing Season		Planting Phase		Growing Phase		Harvesting Phase	
Climatic Factor	Corr	p	Corr	p	Corr	p	Corr	p
TAVG	0.051	0.699	0.015	0.909	0.138	0.297	0.003	0.981
TMIN	0.324	0.012	0.071	0.595	0.381	0.003	0.210	0.111
TMAX	-0.165	0.211	-0.034	0.795	-0.127	0.338	-0.175	0.184
PCP	0.290	0.025	0.075	0.575	0.205	0.120	0.224	0.088
PDSI	0.116	0.381	0.000	0.998	0.109	0.411	0.164	0.213
ZNDX	0.259	0.047	0.062	0.640	0.171	0.195	0.235	0.073
SPI	0.256	0.0499	0.040	0.762	0.224	0.088	0.181	0.170

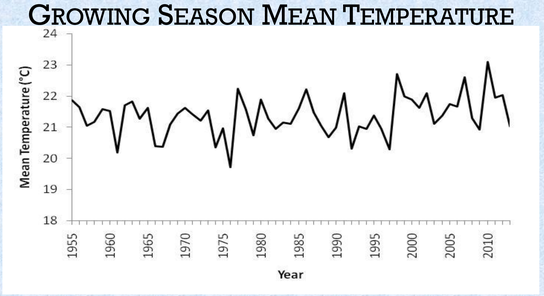
Corr: Correlation; p: p value

Soybean Yield and Climate Correlation

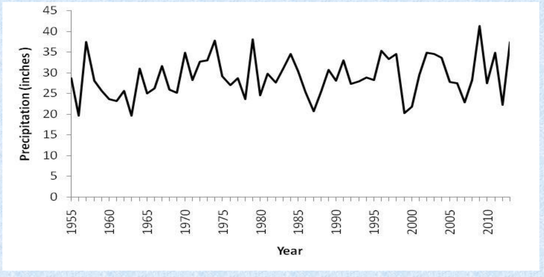
	Growing Season		Planting Phase		Growing Phase		Harvesting Phase	
Climatic Factor	Corr	p	Corr	p	Corr	p	Corr	p
TAVG	-0.087	0.513	0.040	0.763	0.008	0.955	-0.165	0.212
TMIN	0.246	0.060	0.083	0.530	0.235	0.074	0.158	0.232
TMAX	-0.326	0.012	-0.005	0.971	-0.218	0.097	-0.399	0.002
PCP	0.438	<0.001	0.100	0.452	0.286	0.028	0.371	0.004
PDSI	0.278	0.033	0.084	0.526	0.238	0.070	0.355	0.006
ZNDX	0.431	<0.001	0.086	0.519	0.256	0.051	0.428	<0.001
SPI	0.459	<0.001	0.740	0.578	0.318	0.014	0.384	0.003

Corr: Correlation; p: p value

Growing Season Mean Temperature



Growing Season Total Precipitation



R^2 Values for Simple and Multiple Linear Regression Models

	Growing Season	Planting Phase	Growing Phase	Harvesting Phase
Corn				
TAVG	<0.01	<0.01	0.02	<0.01
TMIN	0.10*	<0.01	0.15*	0.04
TMAX	0.03	<0.01	0.02	0.03
PCP	0.08*	0.01	0.04	0.05
PDSI	0.07*	<0.01	0.01	0.03
ZNDX	0.07	<0.01	0.03	0.06
SPI01	0.07*	<0.01	0.05	0.03
Multiple	0.43**	0.15	0.42**	0.31**
Soybeans				
TAVG	0.01	<0.01	<0.01	0.03
TMIN	0.05	<0.01	0.06	0.03
TMAX	0.07*	<0.01	0.05	0.16**
PCP	0.19**	0.01	0.08*	0.14**
PDSI	0.08*	0.01	0.06	0.13**
ZNDX	0.19**	0.01	0.07	0.18**
SPI01	0.21**	0.01	0.10*	0.15**
Multiple	0.46**	0.05	0.36**	0.39**

** significant at p < 0.05; ** significant at p < 0.01*

Conclusions

- Corn is positively related to minimum temperature
- Soybeans are negatively related to maximum temperature
- If temperature rises as predicted, corn yields could increase and soybean yields could decrease in West Tennessee
- Both corn and soybeans require adequate precipitation for optimum yield
- Short term drought conditions will affect corn and soybean production more than long term drought conditions
- Multiple factor prediction model should be used when information is available
- Lack of significant findings indicate that climatic factors will not affect corn yield until the crop is established.

References

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Data from USDA NASS Quick Stats and NOAA NCDA Climatic Data Online

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* Presenting author. Michael Vestal completed the research as a graduate student at the University of Tennessee at Martin.