A Study of Climate Change Impact on Alabama Crops

Gracen M. Bridges [1] and Ruiqing Miao [2]

[1] Undergraduate Student, Department of Agricultural Economics and Rural Sociology, Auburn University
[2] Associate Professor, Department of Agricultural Economics and Rural Sociology, Auburn University

The purpose of this research is to investigate the impact of climate change on yields of corn, cotton, peanuts, and soybeans in Alabama using a large panel data set over 1950–2019. Many studies have focused on the negative impact of climate change overall (e.g., Schlenker and Roberts, 2009), but not specifically for the state of Alabama. This researched aims to fill the research gap.

We collect the county-level data for corn, cotton, peanuts, and soybeans from the National Agricultural Statistics Service (NASS) of the U.S. Department of Agriculture (USDA). Historical climate data are obtained from Schlenker and Roberts (2009). The future climate data are obtained from the Multivariate Adaptive Constructed Analogs under Global Climate Model HadGEM2 under and representative concentration pathways 8.5. The summary statistics of our data are presented in Table 1.

Table 1. Summary Statistics of Dataset for Corn, Cotton, Peanut, and Soybean Yields and Climate Analyses from 1950 - 2019.

(67 counties, 4,690 observations, 1950 - 2019)				
Variables	**Mean**	**SD**	**Min**	**Max**
Cotton Yield (lb/acre)	479.57	227.32	75.00	3433.00
Corn Yield (bushel/acre)	57.26	37.73	5.00	212.50
Peanut Yield (lb/acre)	1435.51	1010.56	200.00	4945.00
Soybean Yield (bushel/acre)	23.01	7.66	2.00	55.30
GDD (8–29˚C)	2721.47	166.45	2094.22	3122.54
GDD (8–30˚C)	2755.92	174.90	2099.73	3175.33
GDD (8–32˚C)	2799.86	189.05	2102.70	3248.97
Overheat degree days (>29˚C)	101.13	43.31	3.77	262.02
Overheat degree days (>32˚C)	22.75	17.78	0.01	114.92
Overheat degree days (>30˚C)	66.69	34.16	1.04	206.12
Precipitation (mm)	693.73	169.12	205.92	1454.10

Note: GDD = growing degree days.

We performed two sets of regression analyses: the Ordinary Least Squares (OLS) and the Fixed Effects Model. Equation (1) represents the OLS regression and equation (2) represents the Fixed Effects Model.

$$y_{it} = \beta_0 + \beta_1 * \text{GDD} + \beta_2 * \text{OverheatGDD} + \beta_3 * \text{Precipitation} + \beta_4 * \text{TimeTrend\_t} + e_{it} \quad (1)$$

$$y_{it} = \beta_0 + \beta_1 * \text{GDD} + \beta_2 * \text{OverheatGDD} + \beta_3 * \text{Precipitation} + \beta_4 * \text{TimeTrend\_t} + u_i + e_{it}, \quad (2)$$

where the β's are coefficients to be estimated, u_i is the county fixed effects, and e_{it} is the error term.

Table 2. Determinants of Corn, Cotton, Peanut, and Soybean Yields from 1950 - 2019

(67 counties, 4,690 observations, 1950 - 2019)			
	Growing degree days	**Overheat degree days**	**Precipitation**
Corn OLS	0.070105 ***	-0.425802***	0.011277**
Corn Fixed Effects	0.0119193***	-0.1758275***	0.0206787***
Cotton OLS	0.3662***	-4.75926***	-0.01217
Cotton Fixed Effects	0.0670559***	-2.2336307***	-0.0022338
Peanut OLS	3.4965***	-21.2426***	0.3152*
Peanut Fixed Effects	0.967659***	-10.242291***	0.607305***
Soybean OLS	0.0126819***	-0.116113***	0.0063104***
Soybean Fixed Effects	0.00207851**	-0.02618623***	0.0077019***

Note: Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05

From Table 2 we can see that the coefficients of GDD for the crops are positive numbers which mean the yield will increase as the GDD increases. The overheat GDD coefficients being negative means it will have an adverse effect on yield, by decreasing yields. The coefficients of precipitation are positive for all crop analyses except cotton. The coefficients of precipitation are positive, it will increase yields. Cotton fixed effects model show a negative precipitation coefficient, which will decrease the yield. The precipitation values for the corn fixed effects and OLS models are insignificant.

After performing the two methods of analyses, the coefficients are then used to predict yields under future climate scenarios. The yields were determined by using four variables: GDD, overheat GDD, precipitation, and year. We predicted the yields for 2050. After predicting the yields, we then calculate the percentage of yield changes based on the 2000-2019 average crop yields.

[1]Corresponding Author: gmb0046@auburn.edu

The historical yields from Figures 1 and 2 were calculated by taking the average crop yield between 2000 – 2019. The future climate yields were calculated using Equation (2). Figure 1 includes the historical and future yields for corn and soybeans, measured in bushels per acre. Figure 2 includes the historical and future yields for cotton and peanuts, measured in pounds per acre. We find that if there were no technology improvement, climate change by 2050 will decrease corn yield by 54% when compared with the average corn yield over 2000-2019, will decrease soybean by 76%, will decrease cotton by 74%, and increase peanut yield by 10%.

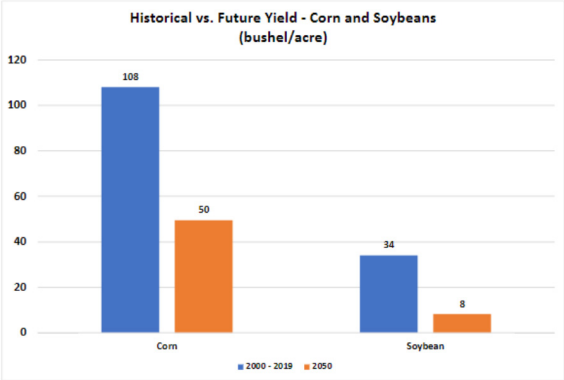

Fig. 1. Historical vs. Future Yield for Cotton and Peanuts measured in bushels per acre.

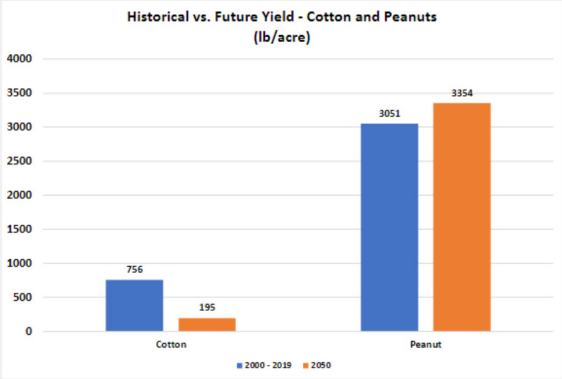

Fig. 2. Historical vs. Future Yield for Cotton and Peanuts measured in pounds per acre.

Statement of Research Advisor

Gracen Bridges showed immense initiatives when working on this project. She collected the county-level crop yield data and merged the yield data with weather data. She also conducted the statistical analysis and prepared the final report and this highlight. Under this project Gracen showed outstanding work ethic and skills associated with data processing, statistical analysis, and technical writing.

- Ruiqing Miao, College of Agriculture

References

[1] Schlenker, W. and Roberts, M. J. (2009). Nonlinear temperature effects indicate severe damages to US crop yields under climate change. Proceedings of the National Academy of Sciences, 106(37):15594–15598.

[2] Torres-Reyna, O. (n.d.). (2023) Getting started in fixed/random effects models using R/rstudio. Available at: https://www.princeton.edu/~otorres/Panel101R.pdf (accessed August 1, 2022).

[3] Wooldridge, J. M. (2021). Introductory Econometrics: A Modern Approach. Cengage. Retrieved May 15, 2022.

Authors Biography

Gracen Bridges is a senior-year student pursing a B.S. degree in Agricultural Business and Economics at Auburn University. She has played a key research role on how climate change affects four Alabama Crops.

Ruiqing Miao is an associate professor in the Department of Agricultural Economics and Rural Sociology of the College of Agriculture. His research focuses on the interaction between agricultural production and its environment, aiming to understand and quantify 1) agriculture's impact on land use, water use, water quality, and biodiversity, and 2) how agricultural production is affected by farmers' behaviors, public policies, agricultural innovation, technology adoption, and climate change.