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Factors Causing Corn Yield Increases in the United States

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FACTORS CAUSING CORN YIELD INCREASES IN THE UNITED STATES

By

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Corn is a vital commodity in both production and the trade market. Being one of the most abundant crops grown in the United States, it is crucial that we understand what factors of corn production are most important. Most of the research found up until now is mainly on how weather affects the average corn yields. Looking at the other factors, like biotech acres planted, row width, and plant population per acre, give the public and farmers the knowledge they need to make important decisions about what they consume or grow. Since there is such a big debate on whether or not biotech or genetically modified crops should be produced, it is a good thing to know if these traits have a significant effect on corn yield. This research, with variables other than just weather, is to show exactly just how much they affect the average bushels per acre.

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CHAPTER 1

INTRODUCTION

In the past 51 years, corn yields have been on the rise in the United States. Corn, also known as maize in some countries, is the most abundant row crop grown in the U.S. and one of the oldest crops in the world. According to the Genetic Science Learning Center at the University of Utah (2013), corn has been estimated to be over 10,000 years old, and it was developed in what is now known as Mexico. Farmers that helped develop the corn we know today found that there are different varieties of corn and began to crossbreed different species in order the grow the more desirable traits such as varieties that tasted better, grew in size and was easier to grind (Genetic Science Learning Center 2013). Farmers would then save the kennels of the most desirable and plant them in the next growing season. This practice is still used today. Corn is crossbred to bring out desirable traits such as types and amount of starch, ability to grow in different climates and soil, length and number of kernel rows, kernel size, shape and color, and resistance to pests (Genetics Science Learning Center 2013). All of these traits have contributed to the growth of corn yields. Instead of farmers working on the breeding of different varieties and species, it is a scientist in labs working to grow more efficient and sustainable corn plants.

According to the United States Department of Agriculture (USDA) Foreign Agriculture Service (FAS), in 2016 the world production of corn was about 42,343 million bushels (1,075,550 thousand metric tons) of corn. The U.S. accounts for about 36 percent of the world production, the largest producer in the world, with China being second at about 20 percent of the world production.

Once harvested, Corn is used to produce many products. The most significant use of corn is in the U.S. is feed for animals. Most of the feed for animals is directly from the field to the animal, but there is a small amount of animal feed that is a byproduct of other corn products. For example, the corn meal created from ethanol production is used to make dog food. Next largest product made from corn is ethanol for blending with motor gasoline. Corn from the U.S. is used to make about eight majors products and is exported all around the world.

Understanding how the factors of growing corn affect the yield outcome at the end of the season is essential for many reasons. In a growing world, we must use our land in the most efficient way. Getting more bushels per acre out of the land is vital to feed the increasing population as well as helping farmers understand what some of the best tools are to produce corn. When farmers know what tools to use to grow the most efficient crop, it's saved them valuable time and money. Overall, optimized corn production is important for both consumer and farmer.

CHAPTER 2

REVIEW OF LITERATURE

Corn yield increase is a widely researched topic. Most research focuses on weather factors that affect corn yields. While weather is a large part of the outcome of yield at the end of the season, this research looks a little further at how biotech, plant population, and row width play a part in the U.S. corn yield. Understanding how factors other than weather help improve corn yield because it gives farmers something to control since the weather is such an unpredictable element. For example, knowing how biotech can help when there is a drought can help farmers make the most efficient decisions when choosing what to plant in the spring.

Sheppard (2009) discusses how yield trends in Illinois are changing. The researcher of this paper conducts similar research with both corn and soybeans. The article states, "In the future, this research will help farmers choose the best management techniques and help geneticists engineer the best seed to fit the climate" (Sheppard 2009, 1). Which is the purpose of this research as well, to provide information to farmers, scientist, and consumers. Sheppard (2009) mentions that technology in agriculture such as biotech and precision agriculture can help make crop production more manageable against the more unpredictable variables like weather. She states, "Many experts believe improvements in the biotechnology for seed genetics today are responsible for the higher corn yield" (Sheppard 2009, 1). Biotechnology is a part of why yield trends are on the rise, but there are other non-weather variables that help the average U.S. corn yield increase. As the demand for food and product commodities rises, it is essential as ever to have accurate yield predictions and efficient farming systems.

Another article that was helpful in this research was one by Tannura, Irwin and Good (2008). They compare how each month of the corn growing season in the U.S. Corn Belt affects the yield at harvest. From their research, they were able to determine "unfavorably dry weather during the summer month decreased corn yields more than favorable wet weather increased it" (Tannura, Irwin, and Good, 2008). Their comparison looked at both precipitation and temperature of May, June, July, and August. They found that "in each state, moderately higher-than-average precipitation throughout June through August would be expected to produce the highest yields" (Tannura, Irwin, and Good, 2008, 19). This information is helpful when predicting how the weather would affect yield because it is such an uncontrollable variable in growing any crop. To know that a warm and dry spring could potentially be beneficial to yields is information that farmers want and need to know to make decisions for the rest of the growing season.

CHAPTER 3

DATA

This research is designed to help explain the U.S. corn yield data over the past 51 years. Information was collected from websites and reports from National Agriculture Statistics Service (NASS), National Oceanic Atmospheric Administration (NOAA), and USDA's Economic Research Service (ERS) and USDA *Acreage Reports*. Using these sources, information was collected on precipitation, temperature, percent of biotech acres planted, row width and plant population which will all be used to explain the outcome of U.S. corn yield.

The U.S. corn yield data from the end each year is collected by the National Agriculture Statistics Service's Quickstats database. The data gathered can be seen in figure 2 in the appendices. The average corn yield data will be the dependent variable of this research, using the other data collected to explain further why the average corn yield in the U.S. has been on the rise in the past 51 years.

Using the NOAA Climate at a Glance database, data was gathered that represents the U.S. Corn Belt weather data. The information on temperature and precipitation for the growing season of corn is from plant to harvest, which depending on the area can start as early as April and end in October. Both of the temperature and precipitation data is from 1966 to 2016, which is the last 51 years. Using all of the possible growing season months in this research will show what months are the most crucial for corn production. From this data, we can remove the months that are less significant and focus on the months that have more of an impact.

The U.S. Department of Agriculture's releases an *Acreage Report* every November which provides the data for average row width and plant population per acre. With this raw data, by state, the average was calculated that would represent the average row width and the plant population per acre for the U.S. The information for average row width and plant population per acre was collected from 1966 – 2016.

Another service under the USDA is the ERS. Here is where the data for the percentage of biotech planted is recorded. Unfortunately, the only data to be found for the U.S. percent of biotech planted for corn is only available for 2000 – 2016. The reason for this is because biotech or genetically modified plants are a newer and more accepted practice among farmers. Although it is known that biotech was released for farm use in 1996 we were unable to find data on how much was applied to field. A trend technique was used to predicted how many biotech acres were planted from 1996 – 1999. It is essential to include this data even though it is not over the 51 years like the rest of the information because there is controversy over biotech plants and whether or not it is necessary to grow these seeds. Incorporating it into the research will show if biotech is significant to corn production or harmful.

All of this data has a vital role in the average corn yield for the U.S. Knowing what variables are more significant than others will help farmers make necessary production decisions on whether somethings are worth the labor and money. Efficient farming will benefit both the farmer and consumer.

CHAPTER 4

METHODS

In this research, there will be 18 variables to compare and find the relationship between the dependent variable, U.S. corn yield. To conclude the variables, a regression model will be used, more specifically ordinary least squares multiple linear regression (OLS). This model will find the relationship between the variables and how each factor will affect the dependent variable which is the U.S. Corn Yield. Using the IBM SPSS software and OLS multiple linear regression methods will see the best fit line for each variable.

To use the OLS regression model, five assumptions need to be made to use the estimator. The five assumptions are linear parameters, random sample; the conditional mean should be zero, no perfect collinearity and homoscedasticity. Assumption one, linear parameters, the dependent variable can be calculated as a linear model with the independent variable and the error term. Assumption two, random sample, means that the data should not have any biases making the data completely random. Assumption three, a zero-conditional mean, suggests that the mean of the error term is zero using the values of the independent variables. Assumption four, no perfect collinearity, implies that there is no linear relationship between the independent variables. Lastly, assumption five, homoscedasticity, is that the error term has the same variance and are not correlated with each other. To perform an OLS multiple linear regression, all five of these assumptions must be made. If all the following assumptions are followed, this research should have an equation below:

(1) U.S. Corn Yield = $\beta 0 + \beta 1$ (average row width) + $\beta 2$ (percent biotech acres) + $\beta 3$ (plant population per acre) + $\beta 4$ (April temperature) + $\beta 5$ (April precipitation) + $\beta 6$

(May temperature) + β7 (May precipitation) + β8 (June temperature) + β9 (June precipitation) + β10(July temperature) + β11 (July precipitation) + β12 (August temperature) + β13 (August precipitation) + β14 (September temperature) + β15 (September precipitation) + β16 (October temperature) + β17 (October precipitation) + β18 (Trend) + εi

In the equation 1, the dependent variable is the U.S. Corn Yield, and there are 19 independent variables with an error term. The expected sign for average row width (β1) would be negative because as the row width increases the overall yield is expected to decrease. With a larger width between the rows, there are going to be fewer plants grown when means a less concentrated acre and the farmers are not using the land efficiently. The rows between the plants cannot be too big, but they cannot be too close together either. Percent of biotech acres planted (β2) and plant population per acre (β3) are expected to have positive signs. Biotech seeds are protected with herbicide tolerant and insect resistant genes, and this will protect the corn from the threats of weeds and bugs which means that the yield of corn should increase. When plant population per acre increases, it is believed that average corn yield would also increase because there are more plants per acre and this would increase the bushels per acre.

The weather variables that associate with corn production have been heavily researched. Preseason precipitation was insignificant for Illinois and Indiana corn yields but was significant for Iowa corn yields (Tannura, Irwin and Good 2008). They also found that May precipitation was very significant for Indiana and Iowa corn yields but not as substantial for Illinois. The article agrees that June and July precipitation are significant to all three states. August precipitation was insignificant on yields in Illinois and Indiana, but it was substantial in Indiana

(Tannura, Irwin and Good 2008). The temperature during the growing season can have similar effects on corn as the weather. Too hot or too cold and it could harm the plant. Tannura, Irwin, and Good’s (2008) article state that their research found that May and June's temperatures were insignificant for all three states, but the temperature for July is significant in all three states to corn yields. Even more significant are the temperatures for August for all three states (Tannura, Irwin and Good 2008).

Table 1 lists the hypothesis tests for the research for this paper. More months are being tested than previous research paper just to see how months that surround the growing season have an impact on the average corn yields at the end of the season.

Table 1: Hypothesis Tests

Null Hypothesis	Alternate Hypothesis
H_o: $\beta_{AverageRowWidth} = 0$	H_a: $\beta_{AverageRowWidth} \neq 0$
H_o: $\beta_{PercentAcresBiotech} = 0$	H_a: $\beta_{PercentAcresBiotech} \neq 0$
H_o: $\beta_{PlantPopulationPerAcre} = 0$	H_a: $\beta_{PlantPopulationPerAcre} \neq 0$
H_o: $\beta_{AprilTemperature} = 0$	H_a: $\beta_{AprilTemperature} \neq 0$
H_o: $\beta_{AprilPrecipitation} = 0$	H_a: $\beta_{AprilPrecipitation} \neq 0$
H_o: $\beta_{MayTemperature} = 0$	H_a: $\beta_{MayTemperature} \neq 0$
H_o: $\beta_{MayPrecipitation} = 0$	H_a: $\beta_{MayPrecipitation} \neq 0$
H_o: $\beta_{JuneTemperature} = 0$	H_a: $\beta_{JuneTemperature} \neq 0$
H_o: $\beta_{JunePrecipitation} = 0$	H_a: $\beta_{JunePrecipitation} \neq 0$
H_o: $\beta_{JulyTemperature} = 0$	H_a: $\beta_{JulyTemperature} \neq 0$
H_o: $\beta_{JulyPrecipitation} = 0$	H_a: $\beta_{JulyPrecipitation} \neq 0$
H_o: $\beta_{AugustTemperature} = 0$	H_a: $\beta_{AugustTemperature} \neq 0$
H_o: $\beta_{AugustPrecipitation} = 0$	H_a: $\beta_{AugustPrecipitation} \neq 0$
H_o: $\beta_{SeptemberTemperature} = 0$	H_a: $\beta_{SeptemberTemperature} \neq 0$
H_o: $\beta_{SeptemberPrecipitation} = 0$	H_a: $\beta_{SeptemberPrecipitation} \neq 0$
H_o: $\beta_{OctoberTemperature} = 0$	H_a: $\beta_{OctoberTemperature} \neq 0$
H_o: $\beta_{OctoberPrecipitation} = 0$	H_a: $\beta_{OctoberPrecipitation} \neq 0$
H_o: $\beta_{Trend} = 0$	H_a: $\beta_{Trend} \neq 0$

CHAPTER 5

RESULTS

This research has 18 independent variables and a dependent variable of average corn yield. The results of the regression can be found in the coefficient summary, table 3, in the appendices. The interpretation of the coefficients are from the values listed in table 3. To begin, average row width (β1) has a coefficient of -7.313 which means for every 1-inch increase in row width the average corn yield will decrease by 7.313 average bushels per acre. Plant population per acre (β2) has a coefficient of 0.004 which means for every one corn plant increase per acre the average corn yield will increase by 0.004 average bushels per acre. Percent of biotech corn planted (β3) has a coefficient of 25.252; this means for every 1 percent increase in biotech acres plants there is a 25.252 increase in average bushels per acre. For the April temperature (β4) has a positive coefficient of 0.697 which means that for every 1-degree increase in the April temperature there is a 0.697 increase in average bushels per acre. April precipitation (β5) show that for every 1-inch increase in rainfall during April there is a 1.543 increase in average corn yield. For May temperature (β6), every 1-degree increase in the temperature there is a 0.271 decrease in average corn bushels per acre. Similar to May temperature, there is also a decrease in May precipitation (β7) that causes a decrease in the average corn yield. For every 1-inch increase in rainfall during May there is a 0.274 decrease in average bushels per acre. For every 1 degree increase in June temperature (β8), there is a 0.581 decrease in average bushels per acre. The coefficient for June precipitation (β9) means for every 1-inch increase in rainfall there is 1.678 decrease in average corn yield. For the July temperature (β10) has a negative coefficient of which says that for every 1-degree increase in the July temperature there is a 2.284 decrease in average bushels per acre. July precipitation (β11) show that for every 1-inch increase in rainfall during July there is a 1.678 increase in average corn yield. For August temperature (β12), every 1-degree increase in the temperature there is a 1.709 decrease in average corn bushels per acre. The August precipitation (β13) has the opposite effect on the average corn yield. For every 1-inch increase in precipitation during August there is a 1.347 increase in the average corn yield. For the September temperature (β14) has a positive coefficient of which means that for every 1-degree increase in the September temperature there is a 1.105 increase in average bushels per acre. September precipitation (β15) show that for every 1-inch increase in rainfall during July there is a 0.931 decrease in average corn yield. For October temperature (β16), every 1-degree increase in the temperature there is a 1.157 increase in average bushels per acre. October precipitation (β17) has a negative coefficient which means that every 1-inch increase there is a 1.344 decrease in average corn bushels per acre. Lastly, the trend which accounts for the natural increase in technology from year to year. The trend (β18) coefficient means that for every unit increase in other factors there is 0.953 increase in average bushels per acre.

After the regression is run we use the t-statistics to determine which variables are significant. With a degree of freedom of 50, the level of significance of 0.05, and the t critical value was established at -2.009 and 2.009. From the output generated by SPSS, it calculates the t-statistic for each variable. From the t-statistics and the critical values, the significant variables were able to be determined. Three of the variables from this model are significant and rejected the null hypothesis. These variables were a percent of biotech acres planted, July temperature, August temperature, and October temperature. The July and August temperature has a significant negative effect on the average corn yields. Whereas the percent of biotech planted, and October temperature has a positive impact on the average corn yield.

The SPSS output also computes the R-squared variables which are important for interpreting this research. Table 4 shows the value of the R-squared to be 0.958. This means that 95.8% of the of the variation in U.S. corn yields can be explained by average row width, percent of biotech planted, plant population per acre, April temperature, April precipitation, May temperature, May precipitation, June temperature, June precipitation, July temperature, July precipitation, August temperature, August precipitation, September temperature, September precipitation, October temperature, October precipitation, and technology trend. This R-square is high but not perfect, which means that the data explains the yield well.

The F-test is calculated in the SPSS output and is related to the R-squared variable. F-test is computed when R-square is equal to zero. There are two different degrees of freedom, the numerator (18) and the denominator (32). The degrees of freedom with the level of significance (0.05) is used to calculate the F-test critical value which is 1.94. With this information, the F statistic is calculated as 40.786, and since R-squared is equal to zero the hypothesis is rejected. This further explains and confirms the percent that the R-square give in the output. That 95.8% of the average corn yield is explained by the research variables.

A reduced model was estimated as shown in table 5. Removing April temperature, April precipitation, May temperature, May precipitation, June temperature, and June precipitation allowed the analysis to focus more on the later months of the growing season which have been shown to be more crucial to growing corn. From this model, the results show that more variables are rejected. Percent of biotech acres planted, plant population, July temperature, August temperature, and October temperature are all rejected. The July and August temperature has a significant negative effect on the average corn yields. Whereas the percent of biotech planted, plant population per acre and October temperature have a positive impact on the average corn yield.

As shown in Table 6 in the appendices, SPSS computes R-squared to be 0.953. This means that 95.3% of the of the variation in U.S. corn yields can be explained by average row width, percent of biotech planted, plant population per acre, July temperature, July precipitation, August temperature, August precipitation, September temperature, September precipitation, October temperature, October precipitation, and technology trend. This R-square is high but not perfect, which means that the data explains the yield well.

When calculating the F-test, there are two different degrees of freedom, the numerator (12) and the denominator (38). The degrees of freedom with the level of significance (0.05) is used to calculate the F-test critical value which is 2.00. With this information, the F statistic was calculated as 64.867, and since R-squared is equal to zero the hypothesis is rejected. This further explains and confirms the percent that the R-square give in the output. That 95.8% of the average corn yield is explained by the research variables.

Both model 1 and 2 have negative coefficients, and this is because the agronomy and technological variables are accounted for in this research. If average row width, percent of biotech acres, and plant population were to be removed from the research, the trend coefficient would expect to be positive. Other research that only uses weather variable would have a positive trend. Since the technological variables are included in this research, it takes away from the trend which in other analysis naturally included the technological variable in the trend.

CHAPTER 6

DISCUSSION

In this paper, 51 years of data is looked at and analyzed to give a better understanding as to how factors of U.S. corn production affect its yield at the end of the season. The data gathered is from 1966 to 2016, which was chosen because it is the most recent 51 years. With technological advances, we can put some of the growth factors back in control of the farmers, whereas only having weather variables in corn production gives the farmer no control over his business and livelihood.

This research was conducted using multiple linear regression, and with the analysis of the 18 variable weather and technological factors, three were significant to U.S. average corn yield. Percent of biotech acres planted, July, August, and October temperature are significant to corn yield. July and August temperature are significant in a negative way, but Percent of biotech acres planted, and October is significant in a positive way to the corn yields. Biotech can help prevent weeds, insect, and drought damage, which supports the plant survival during the season which contributes to the yield numbers. The trend variable was added to the research to account for the natural increase of both knowledge and technology that happens from year to year.

This research was conducted in the entire U.S. as the area of studying, mainly using Corn Belt data as its focus. This research should help farmers and producers plan how they are going to combat unpredictable variables such as weather with other variables like biotech and plant population per acre. With this information, farmers can take these results to their farm and implement changes or improvements to current production plans.

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APPENDICES

APPENDIX

Table 2: 1966-2016, United States Corn Yield Data

Year	Average Yield (Bushels per Acre)	Average Row Width (Inches)	Percent of Acres Biotech	Plant Population (Plants per Acres)
1966	73.1	38.50	0	15,138
1967	80.1	37.98	0	15,600
1968	79.5	37.24	0	16,875
1969	85.9	37.04	0	15,900
1970	72.4	37.00	0	16,544
1971	88.1	36.79	0	16,031
1972	97.0	36.66	0	16,969
1973	91.3	36.63	0	16,713
1974	71.9	36.30	0	17,087
1975	86.4	36.20	0	16,653
1976	88.0	35.98	0	17,531
1977	90.8	35.81	0	18,198
1978	101.0	33.21	0	18,470
1979	109.5	35.33	0	18,790
1980	91.0	34.95	0	19,290
1981	108.9	34.71	0	18,960
1982	113.2	34.47	0	20,000
1983	81.1	34.38	0	19,900
1984	106.7	34.09	0	19,990
1985	118.0	33.73	0	20,500
1986	119.4	33.68	0	20,860
1987	119.8	33.54	0	21,340
1988	84.6	33.48	0	20,610
1989	116.3	33.30	0	20,760
1990	118.5	32.95	0	21,050
1991	108.6	32.82	0	22,080
1992	131.5	32.78	0	22,020
1993	100.7	32.53	0	23,457
1994	138.6	32.43	0	23,457
1995	113.5	32.43	0	24,064
1996	127.1	32.29	1	24,229
1997	126.7	32.20	5	24,564
1998	134.4	31.73	10	25,329
1999	133.8	31.73	20	25,393
2000	136.9	31.47	25	25,594
2001	138.2	31.23	26	26,121

2002	129.3	31.07	34	25,650
2003	142.2	31.03	40	26,529
2004	160.3	28.19	47	25,770
2005	147.9	30.67	52	25,515
2006	149.1	30.62	61	26,005
2007	150.7	30.61	73	26,265
2008	153.3	30.38	80	26,660
2009	164.4	30.33	85	27,180
2010	152.6	30.25	86	26,700
2011	146.8	30.19	88	26,935
2012	123.1	30.23	88	25,130
2013	158.1	30.03	90	27,785
2014	171.0	30.08	93	28,350
2015	168.4	29.94	92	28,240
2016	174.6	30.00	92	27,925

Table 3: Coefficients Summary

Coefficients Summary						
Model		**Estimated Coefficient**	**Coefficients Standard Error**	**Elasticity**	**t-Statistic**	**Hypothesis Test Outcomes**
1	Constant (Average Yield)	479.332	238.256	----	2.012	
	Average Row Width	-7.313	5.489	-2.042	-1.332	Fail to Reject
	Percent acres biotech	25.252	11.400	0.049	2.215	Reject
	Plant Population	0.004	0.002	0.742	1.850	Fail to Reject
	April Temperature	0.697	0.519	0.294	1.343	Fail to Reject
	April Precipitation	1.543	1.610	0.042	0.958	Fail to Reject
	May Temperature	-0.271	0.490	-0.138	-0.553	Fail to Reject
	May Precipitation	-0.274	1.195	-0.009	-0.229	Fail to Reject
	June Temperature	-0.581	0.775	-0.342	-0.749	Fail to Reject
	June Precipitation	-1.379	1.056	-0.050	-1.306	Fail to Reject
	July Temperature	-2.284	0.695	-1.425	-3.288	Reject
	July Precipitation	1.678	1.261	0.053	1.330	Fail to Reject
	August Temperature	-1.709	0.654	-1.036	-2.613	Reject
	August Precipitation	1.347	1.098	0.040	1.227	Fail to Reject
	September Temperature	1.105	0.592	0.597	1.866	Fail to Reject

	September Precipitation	-0.931	1.373	-0.024	-0.678	Fail to Reject
	October Temperature	1.157	0.512	0.509	2.262	Reject
	October Precipitation	-1.344	1.469	-0.029	-0.915	Fail to Reject
	Trend	-0.953	1.252	-0.208	-0.761	Fail to Reject

Table 4: Model Summary

Model Summary				
Model	**R**	**R^2**	**Adjusted R^2**	**Standard Error of the Estimate**
1	0.979	0.958	0.935	7.41337

Table 5: Coefficients Summary

Coefficients Summary						
Model		**Estimated Coefficient**	**Coefficients Standard Error**	**Elasticity**	**t-Statistic**	**Hypothesis Test Outcomes**
2	Constant (Average Yield)	531.067	202.488	----	2.623	
	Average Row Width	-9.135	4.820	-2.551	-1.895	Fail to Reject
	Percent acres biotech	27.749	9.798	0.054	2.832	Reject
	Plant Population	0.004	0.002	0.742	2.241	Reject
	July Temperature	-1.856	0.612	-1.158	-3.032	Reject
	July Precipitation	1.577	1.111	0.050	1.420	Fail to Reject
	August Temperature	-2.038	.557	-1.235	-3.661	Reject
	August Precipitation	1.284	.953	0.038	1.347	Fail to Reject
	September Temperature	0.970	0.500	0.524	1.938	Fail to Reject
	September Precipitation	-0.427	1.238	-0.011	-0.345	Fail to Reject
	October Temperature	0.993	0.468	0.437	2.120	Reject
	October Precipitation	-1.079	1.279	-0.023	-0.844	Fail to Reject
	Trend	-1.326	1.079	-0.289	-1.228	Fail to Reject

Table 6: Model Summary

Model Summary				
Model	**R**	**R2**	**Adjusted R2**	**Standard Error of the Estimate**
2	0.976	0.953	0.939	7.18151

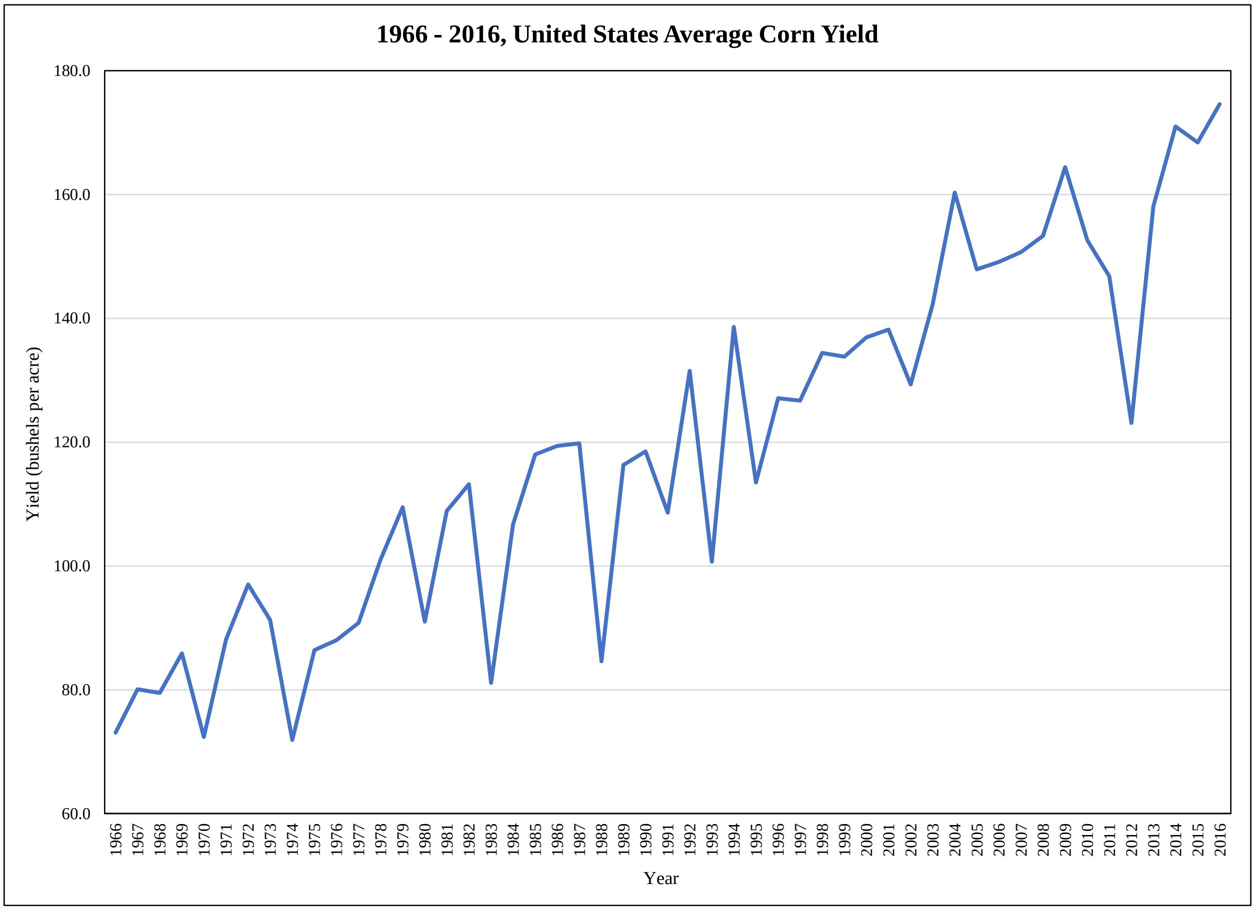

Figure 1: 1966 – 2016, United States Average Corn Yield

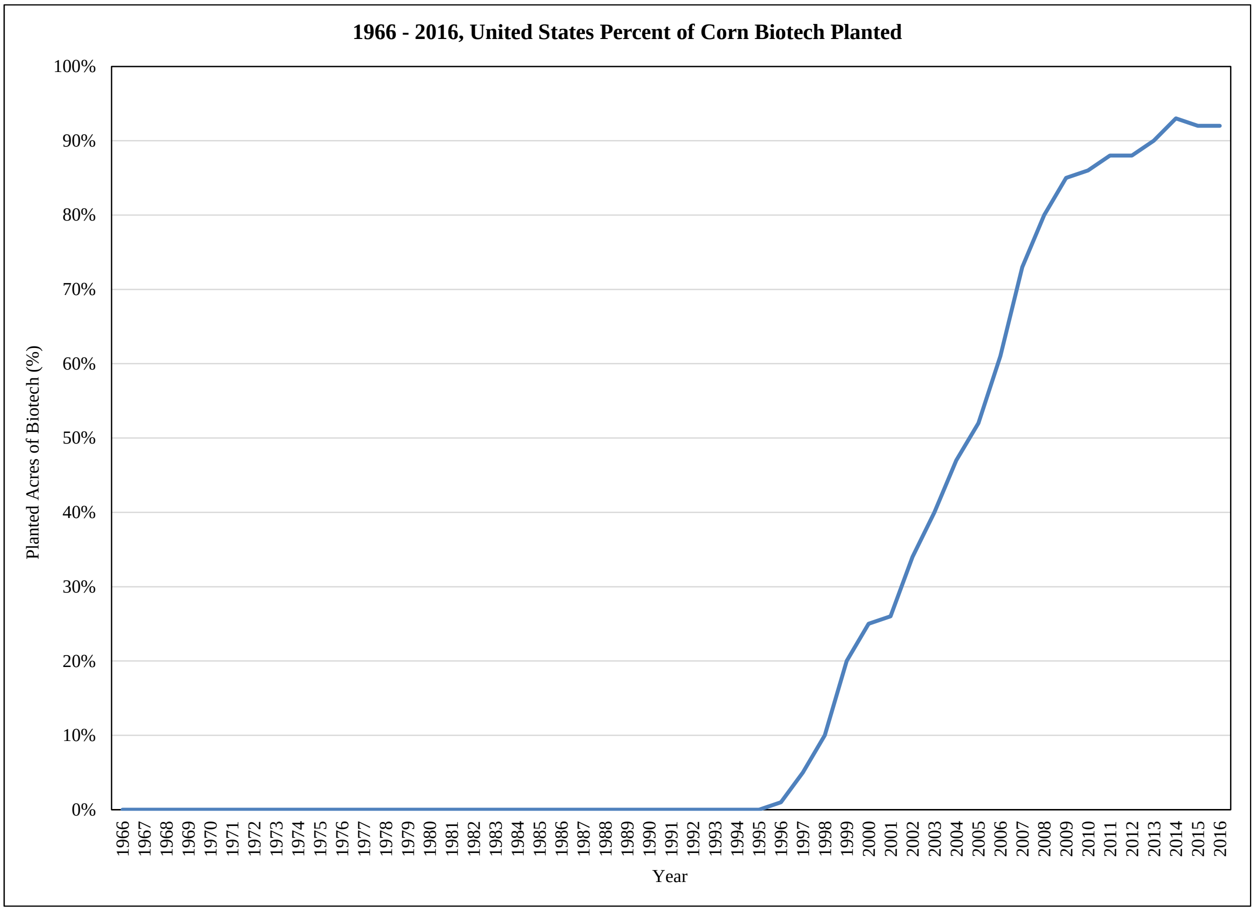

Figure 2: 1966 – 2016, United States Percent of Corn Biotech Planted

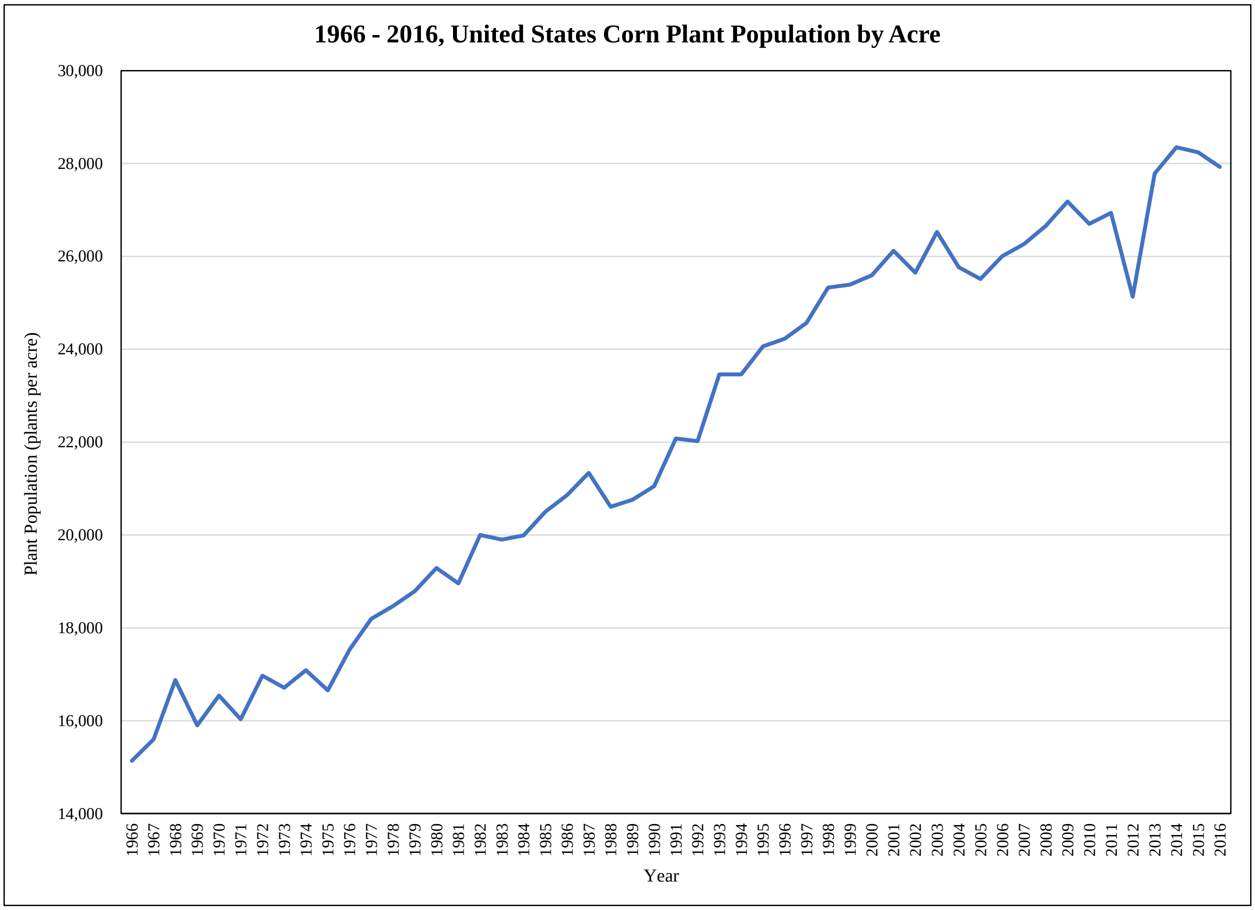

Figure 3: 1966 – 2016, United States Corn Plant Population by Acre

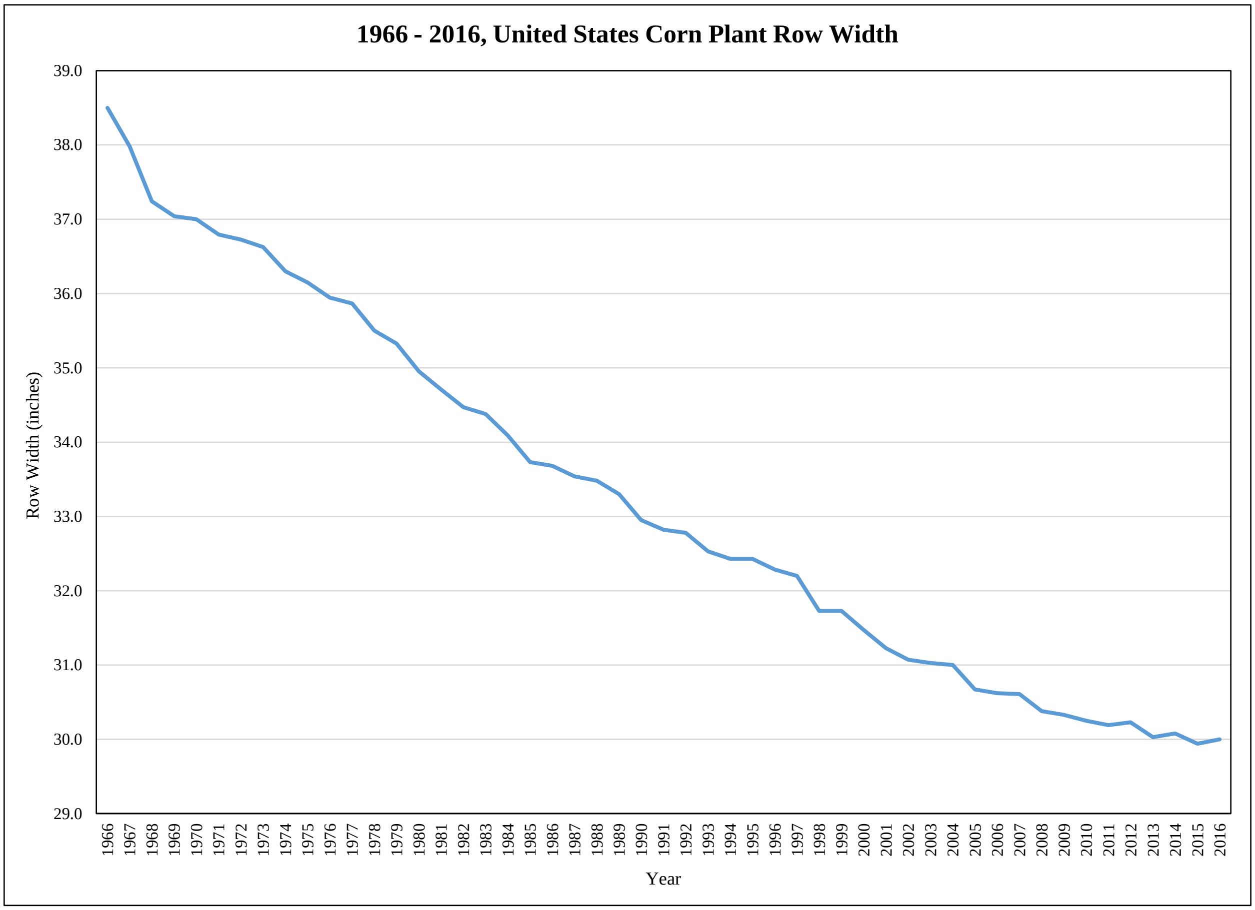

Figure 4: 1966 – 2016, United States Corn Plant Row Width

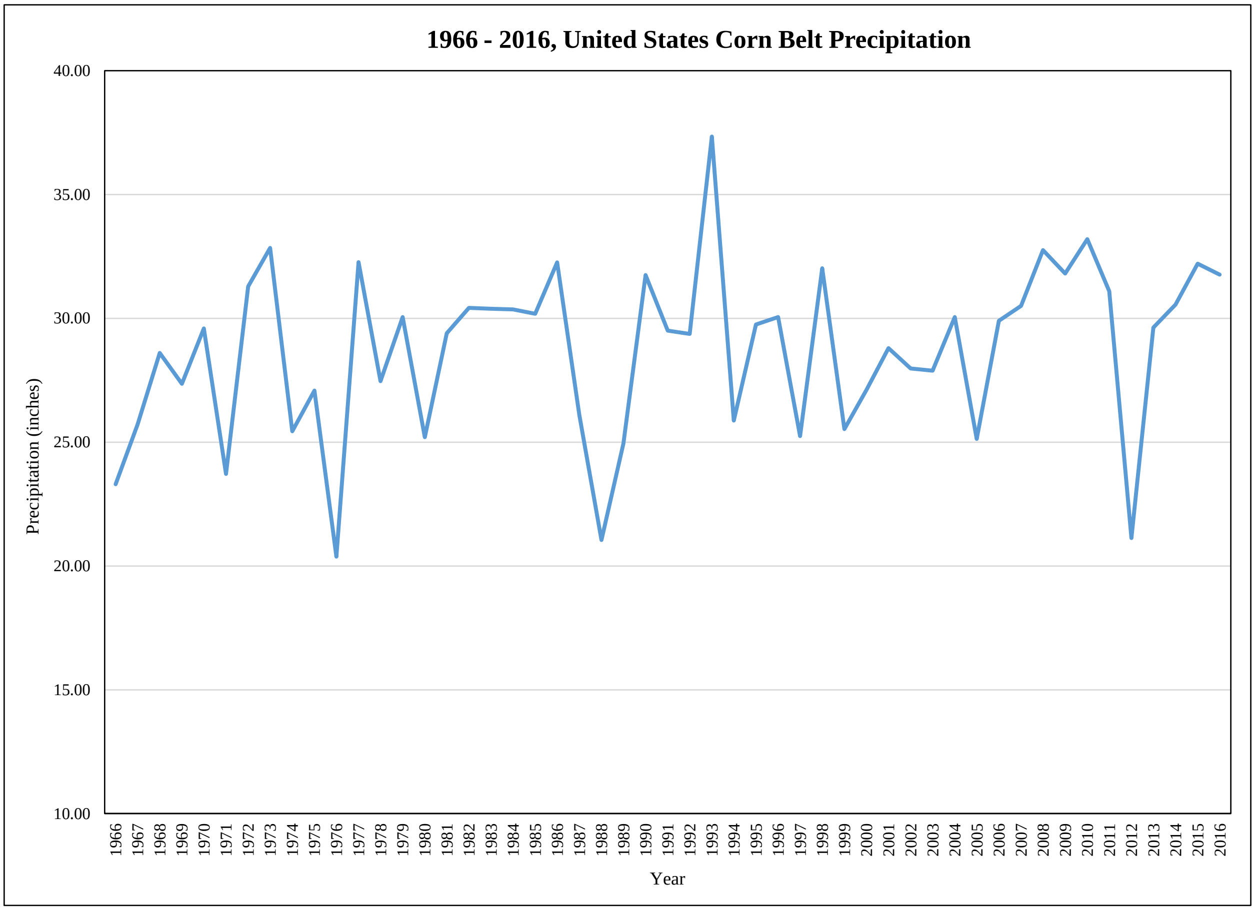

Figure 5: 1966 – 2016, United States Corn Belt Precipitation

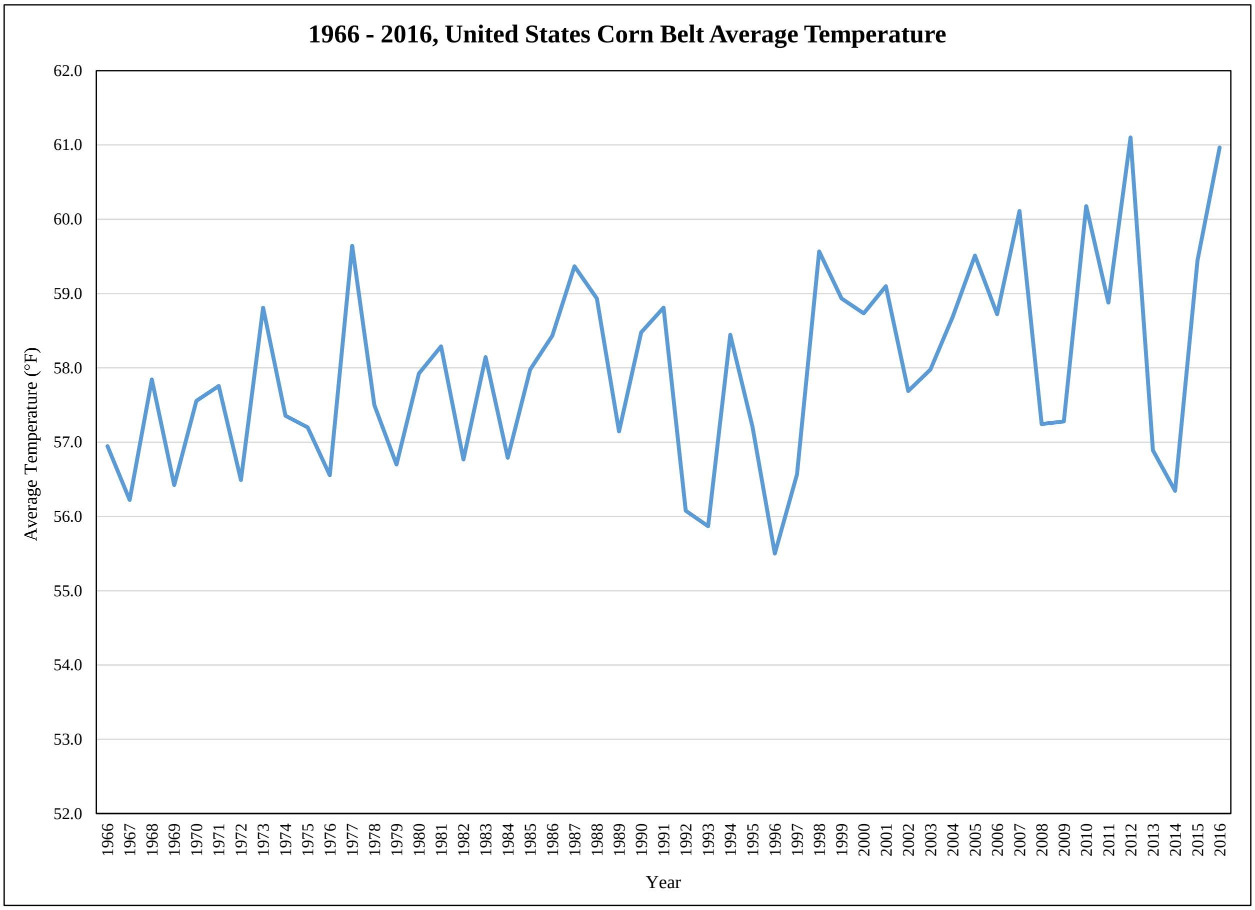

Figure 6: 1966 – 2016, United States Corn Belt Average Temperature

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