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Factors that Affect Hard Red Spring Wheat Yields in the United States

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By

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Submitted in Partial Fulfillment of the Requirements for the
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TITLE: FACTORS THAT AFFECT HARD RED SPRING WHEAT YIELDS IN THE UNITED STATES

MAJOR PROFESSOR: Dr. Dwight R. Sanders

Hard Red Spring wheat is the second most common wheat class produced in the United States. With HRS wheat being important to the wheat industry the amount of land being farmed for HRS is on the decline. So it is essential for farmers to maintain production when decreasing the amount of land being farmed. Weather has a huge impact on wheat yields, there has been research on the impacts of weather and yields. This paper should help farmers see the impact the weather has on HRS wheat yields. Using multiple linear regression, this paper finds what specific weather variables and what months impact HRS wheat yields, which include April temperatures and July temperatures.

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CHAPTER 1

INTRODUCTION

Hard Red Spring Wheat is the second most produced wheat class that is harvested in the United States for the past decade (USDA). HRS wheat production has been on the decline for the past few years, for the reasons that the amount of acres being farmed has been decreasing and crop production hasn't been increasing . One problem wheat farmers have when it comes to production is to grow the highest yielding crop possible. Many factors come in to play for wheat farmers to produce a high yielding crop. Some of the factors can be manipulated by farmers, while and others are environmental factors. These factors that farmers can change themselves could be row spacing, which that is the distance between each row that is planted. The spacing between rows have had different effects on the wheat yields. Some have found that closer row spacing are from each other increases the yield while other studies have found no effect on the yield (Chen, et al., 2008). Another factor that is commonly practiced by farmers is nitrogen application and when to apply the nitrogen. Nitrogen has different effects on wheat and when used at different times during the wheats life cycle nitrogen can affect the yield. These affects could be influence the quality of the plant and or increase the yield (Chen, et al., 2008). One of the biggest influences on HRS wheat yields though is something farmers have no control over which is the weather impacts. This study will look at the different affects row spacing and nitrogen will have on yields but only through literature analysis. Due to lack on data we were not able to do a statistical study on the impacts of row spacing and nitrogen application. This study focuses on the weather conditions through running a multiple linear regression to see the impact that temperature and precipitation has on HRS wheat yields.

Many HRS wheat farmers not only want to see high yields but also they look at the amount of protein their crops has. The protein in wheat is very important to the final product of wheat. “Mature wheat grains contain up to 8-20% protein” (Dupont, Altenbach, 2003, 136). Millers and wheat processors prefer their wheat to have a higher protein which is a result for better quality wheat. The reason millers prefer higher protein is because HRS can be mixed with lower protein wheat when they are mixed the two wheats can have the protein content suitable for bread production (USDA). The trouble some wheat producers face is that higher wheat yield doesn’t necessarily mean a higher protein content. However, Luis Lopez-Bellido et al. (2001) finds that there is no significant evidence of a negative correlation between a wheat yields and protein content. There are different methods producers use to try to increase the protein percentage, for this study we will be focusing methods pertaining to wheat yields rather than yields and protein content.

Hard Red Spring wheat is often used for bread production and is grown in the upper Greater Plains of the United States. Different wheat classes, such as Hard Red Winter, Soft Red Winter, White wheat, and Durum wheat, are grown all across United States for the reasons of seasonal differences in geographical locations and the return a farmer will get when planting certain wheat classes (USDA). Due to the scope of this study HRS wheat is being focused on and not winter wheats or other spring wheat. To study the weather effects on HRS will gives us a more accurate study on the impacts of the weather on HRS. Wet seasons have a greater impact on wheat yields than dryer seasons specifically excess rain seasons (Lopez-Bellido, et al., 2001). This paper should help see the effect precipitation has on wheat yields. Precipitation isn’t the only environmental factor that effects the yields, temperatures is also a very important factor that effects the yield.

Hard Red Spring wheat in the United States is grown in the spring to summer seasons. Together precipitation and temperature has a strong impact on wheat yields. A study that was done in the Mediterranean the researchers concluded that temperature is important during the grain filling stage which affects the yield (Lopez-Belido, et al., 2001). Where extreme high temperatures can result in hurting the grain filling stage (Dupont, Altenbach, 2003). This is because high temperatures reduces the length of that stage. Research has been done to see that "High temperatures affected all stages of grain development" (Altenbach, et al., 2003, p 18). Which will result in a lower quality crop but also a lower yielded crop. Different studies show that temperature is important through mostly all stages of growth but through this study we will be able to statistically show what months are most impacted by temperatures. As much as weather is important to wheat production there are factors that affect wheat yields that farmers can manipulate themselves.

Though wheat producers do not have any control on the weather, which has a strong influence on the yield they can control other factors that can increase production. Row spacing is a simple factor that farmers can manipulate themselves. The common spacing for rows is 10 cm, 15 cm, and 30 cm apart from each other. Many studies have found that less spacing in between rows, 15 cm, results into a higher yield rather than farther apart, 30 cm (Chen, et al., 2008). In this study, we will not be running a regression using row spacing in our statistical analysis due to lack of data on row spacing and their outcome. With more accurate data collecting through USDA or other agricultural data sites we might be able to statistically see how row spacing affects the yield. Row spacing is just one factor affecting wheat production a farmer can manipulate but another popular practice is to use nitrogen in their wheat production process.

Application of nitrogen in wheat production has different effects on the yield in the growth phases of the grains. Depending on which growth phase the grain is in nitrogen application can have different effects on the plant. Nitrogen applied in the early stages of growth leads to an increase in plant biomass densities. Nitrogen applied during the spike development stage, which is one of the later stages in wheat growth, results in a higher yield(Chen, et al., 2008). Nitrogen is one factor that is a farmer can use to increase their wheat production. It is something to test and see the statistical impact that nitrogen has on HRS wheat yields but due to lack of data that's been collected we will not be able to test the statistical importance that nitrogen has on wheat yields. While this paper focuses statistically the impact weather has on yields it's important to know that nitrogen application can have a positive impact on wheat yields.

Hard Red Spring wheat is planted in the months of April and May and harvested in August and September. With such a short growing this paper will cover monthly average precipitation and temperatures of the states that grow HRS wheat to the average yield of HRS. A multiple linear regression, which will be explained in the methods aspect of the paper, will be ran to see if there is a statistically significant impact on yields by month based on average precipitation and temperatures. We will most likely see a positive correlation with higher average rainfall and yields. We hope to see that temperatures have a stronger impact on yield in the later months of the season. Our findings with this study should help HRS wheat farmers to know how much monthly precipitation and temperatures can affect the yields so that they can predict how their yields are going to be at the end of the season.

CHAPTER 2

REVIEW OF LITERATURE

Hard Red Spring wheat accounts for 20% of the wheat production in the United States (USDA, 2018). It's important for HRS wheat producers to have large yields but also high protein content. In order to trade in the world market, wheat producers needs a protein content of 14 percent in HRS wheat. The United States is known to have high protein content due to our mild seasons and fertile soil and that makes it a challenge for producers to grow a high yielding crop with strong protein content (Ransom et al. 2014). Some studies show that high yields doesn't necessarily mean high protein content. So it's a challenge for farmers to try and grow a high yielding crop with high protein content. Many studies have been done to see what factors of production can help HRS wheat producers grow a high-quality crop but this study looks at what factors affect the yield.

Chen, Neill, Whichman, and Westcott (2008) did a study on the response of row spacing, seeding rate, and nitrogen fertilization on HRS wheat. They did a two-year study at the Central Agricultural Research Center of Montana State University. The study consisted of planting HRS wheat using different three independent variables. The variables they included were four seeding rates; 108, 215, 323, and 430 seeds per square meter. Row spacing the second variable, was set at 15 cm and 30 cm. The final variable tested was the amount and timing of nitrogen introduced in the crop growth cycle. Specifically they used "FA1, 100% at seeding; FA2, 50% at seeding and 50% at tiller formation; and FA3, 50% at seeding and 50% at shoot elongation" (Chengci et al., 2008, p 1297). FA represents fertilizer application at different periods. In this study they found that there is an increase in yield for 15 cm row spacing compared to 30 cm row spacing. They found that nitrogen does not affect the grain yield, and that late application, the heading stage, has decreased the protein content compared to the other timings of nitrogen application. The findings of this study should help HRS wheat producers know what factors of production that they can manipulate to increase their crop's yield.

When doing a study on HRS wheat it is important to know the different phases of growth for the grain. Dupont and Altenbach wrote a review on the "Molecular and biochemical impacts of environmental factors on wheat grain development and protein synthesis". In this review, they go through the process of grain development which wheat producers could know at what time in the growth periods are important for the final product. The first phase of the grains is for the endosperm to develop which begins at the point of fertilization, and is followed by a period of cell development during which starch and protein reserves collect. The amount of starch and protein is determined by the amount of endosperm cells and that helps the early grain fill stage. Water being absorbed into the cell dictates the final size of the cells. Following cell expansion and water accumulation the starch and protein replace cell water and the kernel begins to dehydrate. "Late in development, the formation of a waxy layer of chalaza impedes inputs of sugars and amino acids into the grain… protein and starch deposition cease and the grain reaches maximum dry weight…" (Dupont, Altenbach, 2008, p. 134). Dupont and Altenbach explain that it is important to acknowledge that environmental conditions are impactful at the molecular level of the grains. Local climate conditions affect the grain during the grain filling phase. Both authors explain that the optimum temperature for maximum yield is between 15 and 20 degrees Celsius, which is 59 to 68 degrees Fahrenheit. Temperatures above 20 degrees Celsius or 68 degrees Fahrenheit might cause the grain fill phase to shorten which leads to a smaller yield. Understanding how climate and timing of grain development can help producers better plan, plant and harvest more successfully so that they can see a greater return in their production.

Since heat is grown all over the world farmers must overcome a variety of environmental challenges depending on their specific geographic location. Lopez-Bellido, Lopez-Bellido, Castillo, and Lopez-Bellido (2001) did a study over a 6-year period on the effects of environmental challenges and nitrogen fertilization on the quality of HRS wheat in the Mediterranean. During this study, they find that wheat yields vary from dry season to wet seasons. In their findings, they find that water stress heavily influences a greater protein content where as if they have a moderate amount of precipitation to low precipitation then reduces the protein content. They also find that timing of nitrogen application can affect the yield and protein content. One thing that's important in their study is that they found "no evidence of the significant negative correlations between yield and grain protein content" (p. 204). Wheat producers ultimate goal is to maximize yield with high protein content, this is why it's important to know that high yields does not necessary mean a lower protein content.

CHAPTER 3

DATA

The data collected for this research is to help identify the effects that temperature and precipitation have on United States HRS wheat yields. HRS wheat yields information came from the United States Department of Agriculture Economic Research Service (USDA). The weather information was found using National Oceanic and Atmospheric Administration (NOAA). The information that was found should help the research of what weather factors affect HRS wheat yields.

Hard Red Spring wheat yields are recorded by the USDA at the end of every year. The years of data that USDA has on HRS wheat yields range from 1986 to 2017. That limits the research but can statistically be valid. The data collected can be found in Table (1) which shows the average yields in the U.S. to its corresponding year. The yields unit of measurement is bushels per acre. U.S. HRS wheat yields will be the dependent variable in this research which in theory we will be able to see what factors affect the yield.

There are different environmental variables that can affect wheat yields. *NOAA Climate at a Glance* is where the information was found to represent the independent variables in this study. NOAA was able to collect data that was specifically the geographical area that grew HRS wheat which validates and strengthens the argument in the empirical study of this research. The independent variables that will be used in this study will be the average temperatures and monthly precipitation of each month during the HRS growing season. That data is aggregated data because it's the average for each month throughout the U.S. that HRS is grown.

The data collected should help this study identify the months with weather conditions have the strongest impact on the yields. Through this study farmers will be able to predict how much rain in a particular month that affect the yield as wells as what average temperatures will affect the yield. Due to the lack of data for other variables that can affect yields, such as nitrogen application and row width. This study will cover how much precipitation and average temperatures changes affect the yields.

CHAPTER 4

METHODS

This study will be done using Ordinary Least Square method which is a regression that shows the effects of independent variables on a single dependent variable. The dependent variable is HRS wheat yields and the independent variables are monthly average temperatures and monthly precipitation. There will be 12 independent variables that represents the average monthly temperatures of each crop growing season month, April through September, as well as the average precipitation in each growing season month. The years that the data represents is 1986 through 2017. Since this is a study of the whole United States production of HRS wheat the data collected is aggregated.

In order for OLS regression model to be used in this study, five assumptions must be addressed before running it. The first assumption is that of collecting a random sample. This means that the data should show no bias making the data completely random. The second assumption is linear parameter, meaning that the dependent variable is calculated as a linear model with the independent variables and error terms. The third assumption is conditional mean being zero which means that the mean of the error term is zero using the values of the independent variables. The fourth assumption is no perfect collinearity means that the amount of error is independent of the level of the independent variable. The final assumption is homoscedasticity, means that the variance of the error is the same at all levels of the independent variable. If all five assumptions are met than OLS multiple linear regression method can be applied. The equation that is used in the study is:

(1) U.S. HRS Wheat Yield = $\beta 0$ + $\beta 1$ (April Precipitation) + $\beta 2$ (May Precipitation) + $\beta 3$ (June Precipitation) + $\beta 4$ (July Precipitation) + $\beta 5$ (August Precipitation) + $\beta 6$

(September Precipitation) + β7 (April Temperatures) + β8 (May Temperatures) + β9 (June Temperatures) + β10 (July Temperatures) + β11 (August Temperatures) + β12 (September Temperatures) + β13 (Trend) + ε_i

In equation 1, the dependent variable is U.S. Hard Red Spring Wheat yields with 13 independent variables with an error term. Precipitation should have a positive correlation with HRS wheat yields, which hypothesized the later months should have a stronger correlation with precipitation and yield. However, too much rain or no rain should damage the crop and have a negative correlation with HRS yield. As hypothesized temperature should have a positive correlation with yield. With the area of HRS wheat being grown in the northern part of the U.S. the higher the average temperature the better the yield will be.

After running the regression, this study uses different approaches to interpret the effect that the independent variables have on our dependent variable, HRS wheat yields in the U.S. The independent variables will have a coefficient for each variable which mean an increase of each independent variable leads to a change in the yield, dependent variable. Each coefficient will have its own t-statistic which allows us to say with confidence how the independent variable affects the dependent variable. We will also analyze the R-squared in the regression which tells us how much of the variation in the dependent variable, HRS wheat yields, is explained by the independent variables. We will also analyze the F-statistic, which tells us that the R-squared is statically significant or not. Lastly this study will look at the elasticities to see the magnitude of influence of the independent variables has on our HRS wheat yields. The hypothesis test for this study is expressed in Table 1, H_o represents our Null Hypothesis and H_a represents our alternative hypothesis. In OLS multiple linear regression we want to reject our null and accept our alternative hypothesis.

Table 1: Hypothesis Tests

Null Hypothesis	Alternative Hypothesis
H_o: $\beta_{AprilPrecipitation} = 0$	H_a: $\beta_{AprilPrecipitation} \neq 0$
H_o: $\beta_{AprilTemperatures} = 0$	H_a: $\beta_{AprilTemperature} \neq 0$
H_o: $\beta_{MayPrecipitation} = 0$	H_a: $\beta_{MayPrecipitation} \neq 0$
H_o: $\beta_{MayTemperatues} = 0$	H_a: $\beta_{MayTemperature} \neq 0$
H_o: $\beta_{JunePrecipitation} = 0$	H_a: $\beta_{JunePrecipitation} \neq 0$
H_o: $\beta_{JuneTemperatures} = 0$	H_a: $\beta_{JuneTemperature} \neq 0$
H_o: $\beta_{JulyPrecipitation} = 0$	H_a: $\beta_{JulyPrecipitation} \neq 0$
H_o: $\beta_{JulyTemperatures} = 0$	H_a: $\beta_{JulyTemperature} \neq 0$
H_o: $\beta_{AugustPrecipitation} = 0$	H_a: $\beta_{AugustPrecipitation} \neq 0$
H_o: $\beta_{AugustTemperature} = 0$	H_a: $\beta_{AugustTemperature} \neq 0$
H_o: $\beta_{SeptemberPrecipitation} = 0$	H_a: $\beta_{SeptemberPrecipitation} \neq 0$
H_o: $\beta_{SeptemberTemperature} = 0$	H_a: $\beta_{SeptemberTemperature} \neq 0$
H_o: $\beta_{Trend} = 0$	H_a: $\beta_{Trend} \neq 0$

CHAPTER 5

RESULTS

This study ran a regression using equation (1) through the software *Eviews* which is discussed in the methods chapter. The results from the regression can be found on Table (2) of the appendix. The estimated coefficient tells us the relationship between the yield and the independent variables. For instance, our β1 (April Precipitation) coefficient is 0.3117 which means that for every 1-inch increase in precipitation in the month of April results in an increase of 0.3117 bushels per acre (yield) for HRS wheat. So β2 (May Precipitation) is 0.7697 which means that for every 1-inch increase of precipitation in the month of May results in an increase of 0.7697 bushels per acre for our yield. We see that the month of June, July and August has a negative coefficient, β3 (June Precipitation) is -1.1699. Meaning that for every 1-inch increase of precipitation in the month of June results in a decrease of 1.1699 bushels per acre. Similar β4 (July Precipitation) is -1.5781 which is defined as for every 1-inch of increase in precipitation in the month of July results in a decrease of 1.5781 bushels per acre. β5 (August Precipitation) is -0.0211 which means that for every 1-inch of increase in precipitation in the month of August results in a decrease of 0.0211 bushels per acre. β6 (September Precipitation) on the other hand is 1.8058 which means for every 1-inch of increase in precipitation in the month of September results in an increase of 1.8058 bushels per acre. After running this regression, we can see the precipitation can have a negative or positive correlation with yields.

Precipitation is important to consider when trying to predict your yield for the year, but temperature is another weather variable which is why this study included it in the regression. The coefficients are read similarly as before with precipitation, but the unit of measurement is different. For example, β7 (April Temperature) is 0.898 which means for every 1-degree Fahrenheit increase in April's average temperature results in an increase of 0.898 bushels per acre. β8 (May Temperature) is 0.105 and that means that for every 1-degree Fahrenheit increase of May's average temperature results in an increase of 0.105 bushels per acre. β9 (Junes Temperature) is -0.6221 meaning that for every 1-degree Fahrenheit increase of June's average temperature results in a decrease of 0.6221 bushels per acre. β10 (July Temperature) is -1.7321 which means that for every 1-degree Fahrenheit increase of July's average temperature results in a decrease of 1.7321 bushels per acre. β11 (August Temperature) is 0.2879 which means that for every 1-degree Fahrenheit increase of August's average temperature results in an increase of 0.2879 bushels per acre. β12 (September Temperature) is 0.5982 which means that for every 1-degree Fahrenheit increase of September's average temperature results in an increase of 0.5982 bushels per acre. For the final variable β13 (Trend) which represents the natural increase of yields from technology growth over the years. β13 (Trend) is 0.6233 which means that for every unit in other factors results in an increase of 0.6233 in bushels per acre. As seen with precipitation, temperature can have a positive and negative effect on HRS yields.

After running the regression and examining the coefficients it's important to look at the t-statistic to see if the coefficient is statistically significant. In this study, we are using 95% confidence level, we compare our computed t- statistic to the 95% confidence level with 30 degrees of freedom. In order for us to reject our null hypothesis, our computed t-statistic must fall outside the range of -2.042 and 2.042. We can see on Table (2) that we have 3 variables that can be used to reject the null hypothesis. April Temperature has a t-statistic of 2.68, July Temperature has a t-statistic of -3.36, and our trend has a t-statistic of 6.6. This means that the temperatures observed during the months of April and July as well as our trend variable has a significant impact on the yield. As seen in Figure (1) the relationship between the average monthly temperatures of April and July compared to the average yield. Since July has a negative correlation the higher the temperatures in July results in a lower yield for the corresponding year. After examining the t-statistic it's important to then look at the R-squared to see if the whole the whole regression equation is statistically significant.

When statistically testing the whole regression you want to look at the R-squared. The R-squared tells us how much variation in our dependent variable can be explained by our independent variables. The R-squared in this regression is found in Table (3) and is 0.82. Meaning that April's precipitation, April's temperature, May's precipitation, May's temperature, June's precipitation, June's temperature, July's precipitation, July's temperature, August's precipitation, August's temperatures, September's precipitation, September's temperatures, and the trend explains 82% of the variation in U.S. HRS wheat yields. The data doesn't explain all of the variation of the yield, the remaining 18 % could be in influence by nitrogen application and row spacing. So with 95% confidence weather variables and the trend variable explains 82% of the variation in HRS wheat yields.

The F-statistic is also important to analyze when running a multiple linear regression. We look at the F-statistic to see the validation of our R-squared, the F-statistics is computed when the R-squared is equal to zero. The degrees of freedom for the F-statistic is (12,29) which when we compare our computed F-statistic to the F-statistic with relation to the degrees of freedom we can see if we reject the R-squared. We would reject the R-squared if our computed F-statistic was smaller than 2.1 and the computed F-statistic is 6.1281. This means that our R-squared is valid and we can see with 95% confidence that our independent variables explains 82% of the variation in U.S. HRS wheat yields.

CHAPTER 6

DISCUSSION

In this study, we looked over a 31-year period ranging from 1986 to 2017. We looked at the effects weather had on HRS wheat yield in the United States by running a multiple linear regression. With information outlined in this study, farmers will be able to better predict what quality of yields to expect with respect to local climate conditions foreseen during the growing season. This study, found that April and July's temperatures are statistically significant in affecting yields. This study shows that a colder April will have a negative impact on the yield indicating that a warmer spring will be better for production. A warmer spring might be benefit the yield but a hotter summer can harm the yield, a hot July might result in a lower yielded crop. Which moderate temperatures is ideal for farmers to produce a high yielding crops. While weather is important for crop production, a farmer has no influence it and instead must look at factors that they can control to help their crop when the weather conditions are not ideal.

Weather is not the only factor that can affect HRS yields, these are factors of production a farmer cannot control. As founded the weather variables statistically tells us 82% of the variation in HRS wheat yields meaning that 82% of the yield is influenced by the weather variables and the trend variable. The remaining 18% could be influence by controlled variables, such as nitrogen application and row width. These variables weren't test because there wasn't enough data to be found that would make them statistically significant.

Suggestions for future researchers on HRS wheat yields would be that to find a way to test the controlled variables as mention to see if they do have a significant impact on the yield. That could be done by doing your own controlled experiment by getting grants and testing the affects nitrogen and row spacing would have on the yields. Another idea to help further the studies on HRS wheat yields could be to collect accurate data from farmers and to see what practices they use and see those effects on the yields.

This study should help farmers predict the outcome of their wheat production by analyzing the weather for their season. This study should help influence other researchers to look into HRS wheat production and discover ways that farmer can increase their yields and production in the United States.

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APPENDICES

APPENDIX

Table 2: 1986-2017, United States Hard Red Spring Wheat Yields Data

Year	**Average Yield (Bushels per Acre)**
1986	33.2
1987	31.9
1988	17.8
1989	27.3
1990	36.0
1991	31.8
1992	41.1
1993	32.0
1994	30.3
1995	30.2
1996	33.6
1997	28.1
1998	33.8
1999	32.5
2000	37.0
2001	34.6
2002	27.9

2003	39.2
2004	42.2
2005	36.0
2006	32.2
2007	36.3
2008	39.9
2009	44.5
2010	45.1
2011	35.2
2012	43.9
2013	45.8
2014	46.3
2015	46.0
2016	46.3
2017	39.8

Table 3: Coefficients Summary

Coefficients Summary						
Model		**Estimated Coefficient**	**Coefficients Standard Error**	**Elasticities**	**t-Statistic**	**Hypothesis Test Outcome**
1	Constant (Average Yield)	87.12984	56.98747		1.52893	
	April Precipitation	0.311698	1.901843	0.044911	0.163891	Fail to Reject
	May Precipitation	0.76968	1.163336	0.085964	0.661614	Fail to Reject
	June Precipitation	-1.16994	1.536434	-0.030201	-0.761465	Fail to Reject
	July Precipitation	-1.578038	1.548371	-0.014744	-1.01916	Fail to Reject
	August Precipitation	-0.211049	2.010947	-0.090654	-0.10495	Fail to Reject
	September Precipitation	1.805822	1.480763	0.057989	1.219521	Fail to Reject
	April Temperature	0.897962	0.334998	1.085137	2.680496	Reject

	May Temperature	0.104995	0.443269	0.016194	0.236866	Fail to Reject
	June Temperature	-0.622057	0.390032	-1.131584	-1.594888	Fail to Reject
	July Temperature	-1.732097	0.515623	-2.455070	-3.359229	Reject
	August Temperature	0.287933	0.70596	-0.297142	0.407861	Fail to Reject
	September Temperature	0.598213	0.387022	0.955162	1.545685	Fail to Reject
	Trend	0.62326	0.094467	0.017710	6.597655	Reject

Table 4: Model Summary

Model	**R-Squared**	**Adjusted R-Squared**	**Standard Error of the Estimate**	**F-Statistic**
1	0.815698	0.682591	3.825557	6.128143

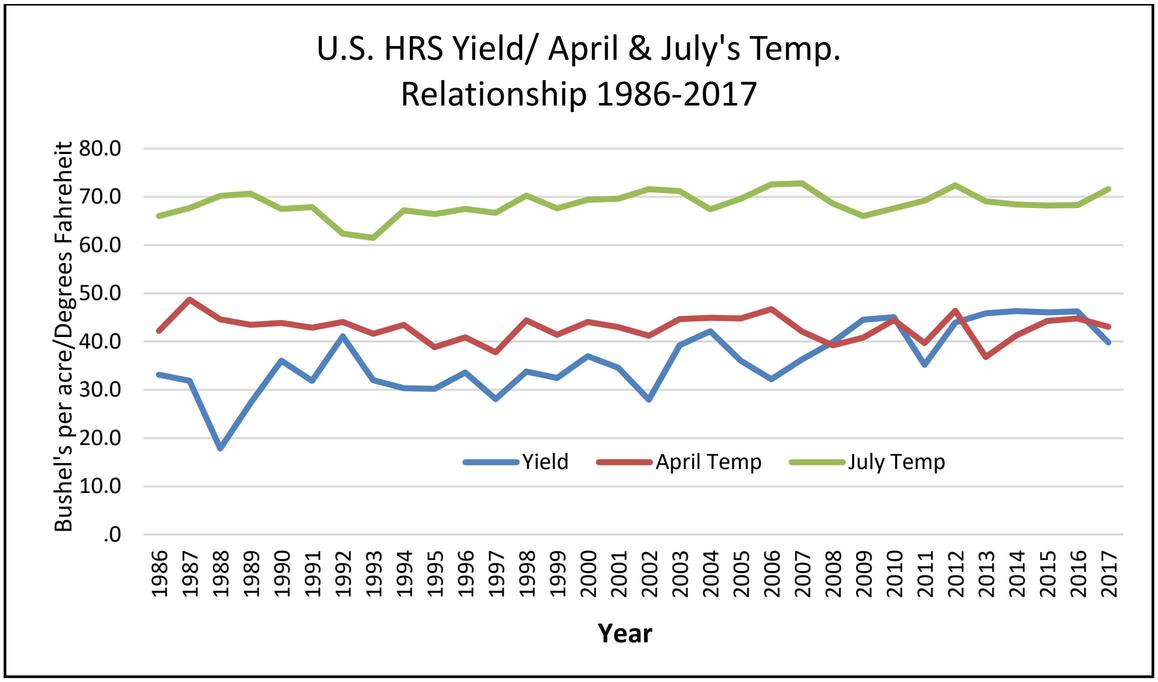

Figure 1: 1986 – 2017, U.S. HRS Yield/ April & July's Temp. Relationship

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