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Irrigated Versus Non-Irrigated Corn Yields in Nebraska

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IRRIGATED VERSUS NON-IRRIGATED CORN YIELDS IN NEBRASKA

by

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Corn is the largest produced field crop in the United States(U.S). Corn is processed into many different varieties of foods.as well as products. Some of the main uses of corn, include, livestock feed, sweeteners, alcohol, and fuel ethanol. With many different uses it is important to produce mass amounts of corn. Corn is also one of the toughest crops, allowing it to be grown in many different climates and regions.

It is no secret that for any plant to grow as strong and healthy as possible, they must receive ample amounts of sunlight, nutrients, and of course, water. Without just one of these necessities, the plant could become sick or not be able to reach its full potential. People have known this to be true for centuries. In many different cultures around the world, farming has been a main source of food. For people in many cultures, they had to adapt and create ways to improve their crops regarding the harsh environments that they lived in. One of these techniques that was created and is still widely used today is irrigation. An irrigation system can help to provide water and nutrients to crops that may not receive enough naturally. Although these irrigation systems that are now used in today's world are much larger and more efficient in first world countries, especially the United States, the purpose remains the same.

The goal of this research was to determine if the use of an irrigation system can help to increase the yield of corn. This study used multiple regression models with independent variables that included precipitation, temperature, and trend. It was examined that weather has a greater

impact on non-irrigated corn yields than what it does on irrigated corn yields. This reduction in weather risk may justify the cost of irrigation for some producers.

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CHAPTER 1

INTRODUCTION

Farmers are always trying to get the most out of their crops, whether this be the crop that they are going to plant, what type of fertilizer or pesticides to use on the crop, or even when they should harvest their crops. There are many factors that go into growing any kind of produce. Some of these factors include bugs, temperature, precipitation, location, as well as what crop is being planted.

Chen (2021) states that The United States Department of Agriculture is an organization that provides information of agriculture, food, and natural resources. The USDA was founded by Abraham Lincoln in 1862. One thing specifically that the USDA does is collect data. This organization collects data for just about anything that has to do with agriculture. There are thousands upon thousands of data sets that can be found from the USDA. For this research, the data that will be used is corn, grain data that has been measured in bushels per acre. From this data, I collected data from the state of Nebraska. There were fifty-one years that were analyzed. These years were from 1968 till 2008. This data was also split into whether it was from an irrigated corn field or a non-irrigated corn field.

Another organization that was used to provide data for this research was the National Oceanic and Atmospheric Administration (NOAA). From the National Oceanic and Administration About Our Agency (2021) page, they state that the NOAA collects data from the environment, which includes, weather data, climate monitoring, fisheries management and many more. They also work to predict as well as understand changes in climates, weather, oceans, and coasts. The data that was found from the NOAA that will also be used for this research was temperature and precipitation data. This data was analyzed over the whole state of Nebraska. The

years that were analyzed were the same years that data was collected for irrigated and non-irrigated corn. These years were from 1968 through 2018. For a total of fifty-one years.

The Purpose of this research is to determine if having an irrigation system in place really makes a significant difference compared to crops that do not have an irrigation system in place and rely on only rainfall for their main source of water. When conducting this research there were a couple of things that I specifically focused on during the discussion. Some of these included variables that were in affect such as amount of precipitation throughout the growing months, average temperature throughout the growing months, and consistency from how much corn was yielded year in and year out. Also, something that was analyzed was the trend of corn.

With this research, I hope to give some insight to not only farmers that grow just corn, but to all types of farmers whether it be soybeans, cotton, rice or fruits on whether it would be worth their time and money to invest in some sort of irrigation system for their crops. Something that this research could show that would make farmers want to invest in this type of technology would be if an irrigation system helps crops to produce a significantly greater quantity. Another thing that could sway farmers would be if an irrigation system will make corn yields more consistent no matter what type of weather, they may experience throughout the year. If farmers would be able to get rid of those years where their crops do not produce near as much as what they may have in previous years, due to drought and hot temperatures, then this could be a good investment for farmers.

CHAPTER 2

REVIEW OF LITERATURE

There were many things that were interesting from the following articles. All these articles had to do with some sort of irrigation. In some of these articles they compared different types of irrigation systems as well as using different amounts of water on crops. The articles also compared other things such as changing the makeup of soil as well as trying to reduce water runoff. All these articles had something to do with trying to increase the amount that a crop can yield. These studies also give support to this research from similar studies and results.

Ayars (1999) conducted a study that showed the effects of subsurface drip irrigation for corn production in the state of Kansas. This study was examined on deep, well-drained, loess soil, silt loam soils, which is common in many western Kansas areas. With most Subsurface drip irrigation systems, a smaller volume of soil is watered which means crop rooting may be limited. However, from using SDI, they found that crops responded similarly to different frequencies. In this test they measured frequencies of one, three, five, and seven days per week. From this frequency they found that they all produced similar corn yields.

Another advantage of subsurface drip irrigation that they stated in their research is that this system allows farmers to better manage nitrogen fertilization. By doing this, the nitrogen goes directly to the center of the root system causing the roots to grow deeper, which can prevent stress on the plant, as well as not allowing weeds on the topsoil to germinate.

This study stated that using subsurface drip irrigation, they were able to use less water than other irrigation systems by nearly 25%. Typically, subsurface drip irrigation has much higher investment costs than other pressurized irrigation systems such as full-sized, center pivot

sprinklers. However, there are realistic scenarios where subsurface drip irrigation can compete directly with center pivot sprinklers for corn production in the Central Great Plains.

Vories (2009) looked at corn and other mid-south crops that are primarily surface, or center pivot irrigated. Historically, water for irrigation was plentiful and relatively inexpensive, so application efficiency was not a major concern. This paper investigates the response of corn to different drip irrigation management strategies. The soil in the study area was mixed, with fine sandy loam, loamy sand, and silty clay. This study was tested from 2002-2004.

There were three irrigation levels that they tested in this study. The first level was replacing 100% of daily water use by the plant. The second level that they tested was only replacing 60% of daily water use of the plant. The third and final level that they tested was using no irrigation and for the plant to only receive rainwater.

For the results in this study, they found that the only year that showed a significant difference was in 2002. In this year, the study suggested that replacing 60% of the estimated daily crop evapotranspiration with subsurface drip irrigation is sufficient for maximum corn yields. However, they stated in their research that the reason for these results were because 2002 had the least amount of rainfall compared to the other two years.

Wallace and Batchelor (1997) Found that around the world there are abundant amounts of fresh water that have yet to be discovered. However, there are also regions around the world such as Africa and Asia that may not always have access to freshwater year-round. In places like this it is important to do all that you can to keep the crops well fed with a limited amount of water.

The purpose of this research was to show a range of different techniques that could lead to increased crop production by improving agricultural water use efficiency. One technique that

was mentioned was that increasing the total amount of water that is available to the plants. Another technique is increasing the efficiency with which that water is used to produce biomass.

To increase the amount of water available to rain fed plants, one option would be to decrease runoff by applying mechanical changes to the surface soil. Another option to reduce runoff would be to add more vegetation cover. Another way to increase water storage in soil is to reduce evaporation in the soil. Surface tillage with sweep tillage or disk helps to reduce soil evaporation. In one of the studies that they worked on, they found that there was a significant difference in soil evaporation compared to soil under a tree canopy and soil without a tree canopy.

Payero (2006) conducted a study where the objective was to find the amount of yield response of corn to deficit irrigation, as well as to determine which of several seasonal water variables correlated best to corn yield in the semiarid climate that it was in.

This study was examined in North Platte, Nebraska. Water variables included, irrigation, total water, rain and irrigation, evaporation, crop evapotranspiration, crop transpiration, and the ratios of crop evapotranspiration and crop transpiration to evapotranspiration and transpiration when water is not limited.

In 2003, seasonal irrigation depths per treatment ranged from approximately 245mm to 395 mm. These seasonal irrigation depths supplied between 34.7% and 55.7% of seasonal crop water requirements for evapotranspiration when water was present. In 2004, seasonal irrigation depths ranged from 34 to 161 mm, representing between 4.7% and 21.2% of seasonal crop requirements.

The linear relationship between grain yield and some of the water variables changed significantly from year to year, while others were very consistent. These results indicate that

trying to increase crop water productivity by imposing deficit irrigation for corn might not be a beneficial strategy under the conditions of this study. However, it is recognized that there could be other good justifications for deficit irrigating corn in this environment, other than increasing crop water productivity.

Nijbroek (2003) put together a study that was conducted in 1998 in southwest Georgia. The objective of this study was to find the potential value of spatially variable irrigation management using a crop simulation model.

The soybeans for this study were planted on June 10th and rows were spaced about 45cm. Three different irrigation options are available in this research. These options include a non-irrigated or rainfed option, a user provided irrigation schedule, and an automatic irrigation option. The non-irrigated option simulates crop growth using only rainfall data, whereas the automatic irrigation option applies irrigation as a function of threshold parameters that can be defined by the user of the crop model. Soil water content was measured weekly for 10 weeks by gravimetric sampling in each management zone during this field study. The first measurement was made 5 days prior to planting and sampling was finished whenever the crop stand was mature and had ceased extracting significant soil water quantities. The difference in the gross margins of the irrigation options were small. However, this was partially due to the very small area of the study site, almost two hectares. As well as the high amount of rainfall in southwest Georgia did not create high amounts of water stress for the crops that were studied.

Zhang (2014) conducted research that was done on the topic of salt build up using mulched drip irrigation. Mulched drip irrigation has several advantages such as increasing water use efficiency by delivering water precisely to root zone and eliminating most useless soil evaporation by mulching; improving soil thermal conditions for crop germination and seedling

growing during early spring when the frozen injury occurs frequently; and decreasing labor input by applying fertilizer and pesticide automatically with water. The mulched drip irrigation has now become popular in other arid and semi-arid areas of China.

Generally, the main soil types in the study area are loamy sand and sandy loam. It was conducted with cotton. Soil samples were collected two times a week in cotton growth period using an auger

In this study they found that salts are likely to build up on the surface of cultivated soil under current MDI practice, long-term salt accumulation should be another important concern for MDI management in arid and semi-arid areas.

Xue (2003) Investigated the effect of available soil water on root and shoot growth, and root water uptake in winter wheat. Irrigation treatments involved planned soil water deficit and irrigation application relative to plant development stage. Irrigation from jointing to anthesis increased shoot growth, evapotranspiration, grain yield, harvest index and water use efficiency. Irrigation had no effect on water use efficiency for biomass. For the deficit-irrigation treatments, shoot dry weight was related to frequency and timing of irrigation application.

Crops that received irrigation at jointing and booting had higher shoot dry weight than those received irrigation at anthesis and middle grain filling. Available soil water levels did not affect rooting depth because of a relatively deep root system in rainfed crops. However, available soil water was shown to significantly affect the rooting pattern. Soil drying from floral initiation to booting promoted root growth, but decreased root growth from booting to late grain filling. Root water uptake rate decreased as available soil water decreased.

The literature suggests that irrigation is an important factor for increasing crop yields in arid climates. Here the impact of irrigation on Nebraska corn yields will be examined using a multiple regression weather model.

CHAPTER 3
RESEARCH QUESTION

Farming technologies have evolved drastically over time. There have been numerous technological advances whether it be the equipment that is being used to do the planting, spraying, or harvesting, or whether it be what is being planted such as GMO's or numerous other tactics that are used today. Throughout history, and still today, farmers are always trying to be efficient as possible with any type of crop that they are growing. However, there are some things that the farmers are not able to control. Probably one of the biggest things that they cannot control would be weather. Weather can drastically impact how much a plant will produce. The research for this project will look at two main factors that will have an impact on crop production. These two things are temperature and precipitation. It is known that both things have an impact on the production of any type of plant. With corn being one of the toughest crops, meaning that it can grow in many different weather conditions and has a wider range of temperature as well as precipitation that it can still successfully grow in. This research will show how precipitation and temperature affect non-irrigated corn yields as well as irrigated corn yields. This could be important for farmers to see because it could give them insight on if investing in some sort of irrigation system would be beneficial for their farm.

CHAPTER 4

DATA

The data for my research was based off multiple different data sets. The first set of data was made up of corn data for irrigated as well as non-irrigated data for the State of Nebraska. This data was collected over the entire state of Nebraska. This data was found using the United States Department of Agriculture (USDA) website. The USDA is a federal executive department that is responsible in developing and executing federal laws that are related to farming, forestry, rural economic development, and food. This department was founded on May 15, 1862. The USDA collects all sorts of different data sets that have to do with agriculture. These data sets come from surveys as well as censuses. The corn data that was used for this research was measured in corn, grain, bushels per acre. The years that were analyzed for this research and having both irrigated and non-irrigated data were from 1968 to 2018 (51 years).

The next set of data that was used for this research was weather data. The weather data that was used included average temperature as well as average precipitation for the growing season for the state of Nebraska. This data came from the National Oceanic and Atmospheric Administration (NOAA). The NOAA is an American scientific agency that focuses on the conditions of the oceans, major waterways, and the atmosphere. The data that was found from this source and used for this research was for precipitation as well as temperature. For both precipitation and temperature, the months that it was analyzed were from May through September. The reason that only these five months were chosen to be analyzed were because they are considered to be the growing months for corn crops. After finding this data, I simply recorded the average temperature as well as the total amount of precipitation for the entire state of Nebraska.

The final thing that was looked at whenever conducting the research for this project was trend. The trend category for this data represents the advances in farming equipment and technologies over time. The reason that this was important is because it show how the average amount of corn produced each year continually increases.

To get the results for this research, there were two regression analysis that were ran. For these two regression tests, the first was for how temperature and precipitation affected non-irrigated corn yields in Nebraska from the year 1968 through 2018. The second regression analysis was for how temperature and precipitation affected irrigated corn yields in Nebraska for the same years as the first test. Another thing that was analyzed through these tests was the trend. The trend showed how technology has improved over time for both irrigated and non-irrigated corn yields in their respective tests.

The dependent variable for the first test was non-irrigated corn yields and the dependent variable for the second test was irrigated corn yields. This data was from the USDA website. For the two main independent variables, precipitation and temperature were used. This data was from the NOAA website. Another independent variable that was used in both regression tests was the trend.

CHAPTER 5

RESULTS

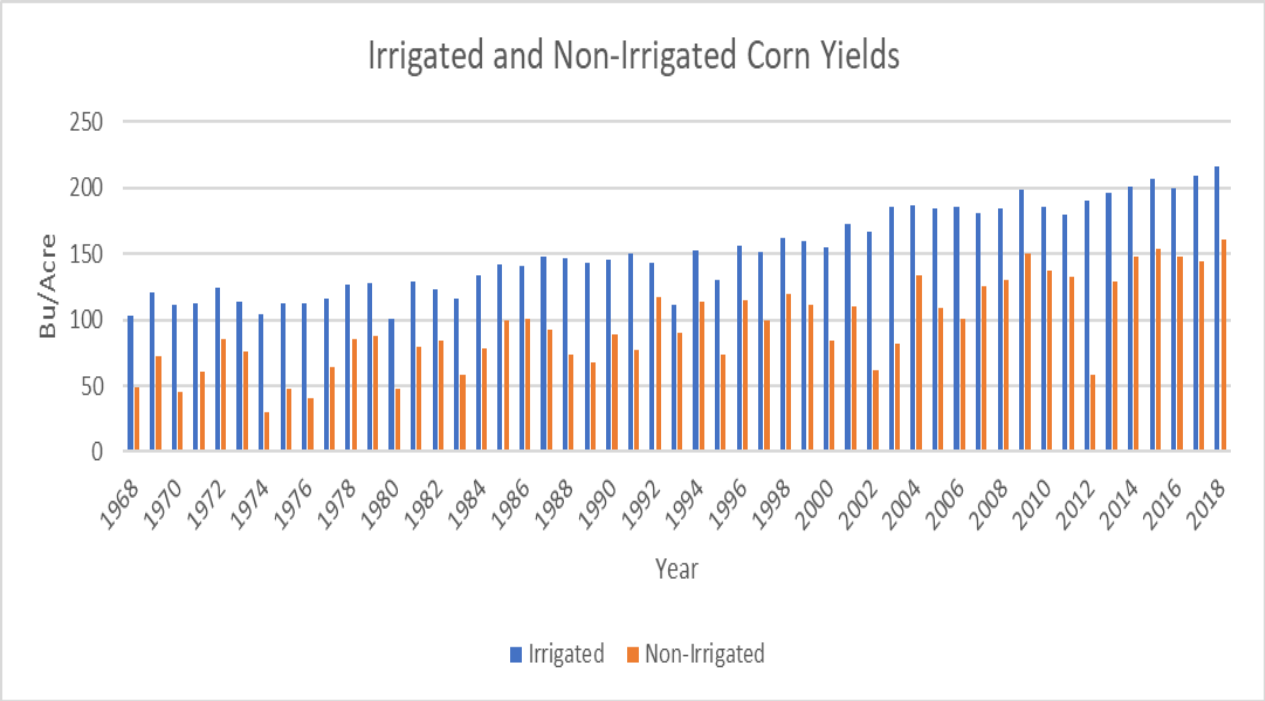
After completing this research, the results showed a lot of different things. Some variables had good significance and other variable did not show good significance. Whenever choosing what to measure for this research, it was decided to go with corn, grain measured in bushels per acre. Since irrigated and non-irrigated corn were being compared, the research was set up so that both variables were dependent variables in their appropriate tests. The independent variables that were used in this research were average temperature, total precipitation, and trend.

For the non-irrigated data, the R-squared value was 0.67 meaning that 67 percent of the variance of non-irrigated corn yield is explained by the variance of average, temperature, and total precipitation. The coefficient for average temperature was -2.04. this means that for every degree that temperature increases, non-irrigated corn yield well decrease by 2.04 bushels per acre. The coefficient for precipitation was 1.82. This means that for every inch that precipitation increases, non-irrigated corn yield will increase by 1.82 bushels per acre. The coefficient for trend for non-irrigated data was 1.87. This means that for each additional year, non-irrigated corn will produce 1.87 additional bushels of corn grain per acre.

For the irrigated data from this research, the R-squared value was 0.90. This means that 90% of the variance of Irrigated corn yield data for the state of Nebraska is explained. The coefficients for average temperature and total precipitation were 0.45 and 0.47. This translates to for every degree that average temperature increases for the five months that were tested, bushels per acre will increase by 0.45. Whenever precipitation increases by one total inch, Irrigated corn yield will decrease by 0.47 bushels per acre. Also, the trend showed that for every additional year, irrigated corn will yield 2.09 additional bushels per acre.

Whenever precipitation was examined, it showed that for irrigated crops, the amount of precipitation was shown to be insignificant. This means that the amount of precipitation had no effects on the irrigated corn. However, for the non-irrigated corn, the amount of precipitation was significant on how much corn was produced at the end of the growing season.

Table 1 - Nebraska Irrigated and Non-Irrigated Corn Yield 1968-2018



Dependent Variable: NON_IRRIGATED
Method: Least Squares
Date: 04/21/21 Time: 12:08
Sample: 1968 2018
Included observations: 51

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	112.2058	46.71404	2.401971	0.0203
@TREND	1.867426	0.199170	9.376023	0.0000
AVG__TEMP_	-2.040025	1.166290	-1.749157	0.0868
PRECIPITATION	1.816861	1.362069	1.333898	0.1887

R-squared	0.670025	Mean dependent var	94.61373
Adjusted R-squared	0.648963	S.D. dependent var	33.30303
S.E. of regression	19.73149	Akaike info criterion	8.877494
Sum squared resid	18298.60	Schwarz criterion	9.029010
Log likelihood	-222.3761	Hannan-Quinn criter.	8.935393
F-statistic	31.81175	Durbin-Watson stat	1.866718
Prob(F-statistic)	0.000000		

Figure 1 - Non-Irrigated Regression Model

Dependent Variable: IRRIGATED
Method: Least Squares
Date: 04/21/21 Time: 12:06
Sample: 1968 2018
Included observations: 51

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	85.97192	25.39181	3.385813	0.0014
@TREND	2.092684	0.108261	19.33004	0.0000
AVG TEMP	0.452324	0.633947	0.713505	0.4791
PRECIPITATION	-0.469362	0.740364	-0.633961	0.5292

R-squared	0.901219	Mean dependent var	151.9608
Adjusted R-squared	0.894914	S.D. dependent var	33.08516
S.E. of regression	10.72522	Akaike info criterion	7.658258
Sum squared resid	5406.426	Schwarz criterion	7.809773
Log likelihood	-191.2856	Hannan-Quinn criter.	7.716156
F-statistic	142.9332	Durbin-Watson stat	1.523126
Prob(F-statistic)	0.000000		

Figure 2- Irrigated Regression Model

CHAPTER 6

CONCLUSION

The data from the National Oceanic and Atmospheric Administration (NOAA) as well as the United Stated Department of Agriculture (USDA) was very beneficial to use with this testing. The data that was found from these two websites gave great information to show how the crops were affected by precipitation amounts and temperature throughout the growing seasons especially for the non-irrigated corn.

When comparing irrigated and non-irrigated corn yields, there were certain things that had to be considered. Some things that must be considered are location, weather, drought, and soil type. When putting together this research the main purpose was to see if there was a significant difference when comparing irrigated corn and non-irrigated corn. Over the fifty-one years that were analyzed, the two main variables that were used gave great insight to this comparison. The amount of precipitation seemed to be the difference maker between a successful or unsuccessful corn yield as this showed a significant difference between the two. In non-irrigated corn for every inch that precipitation increased, the corn yield increased by 1.82 bushels per acre. In irrigated corn, whenever precipitation decreases by one total inch, Irrigated corn yield will increase by 0.47 bushels per acre.

This problem of inconsistent precipitation throughout the growing years showed to have a greater effect on non-irrigated corn compared to having little to no effect on the irrigated corn yields. With the irrigation system in place Nebraska irrigated corn yielded greater amounts year after year compared to that of non-irrigated Nebraska corn.

Like most of the article reviews that I had, this study shows that some sort of irrigation system will be beneficial to creating greater yields. It also showed that the irrigated corn yields

were more consistent in creating higher yields year in and year out. This is easy to see when looking at the Nebraska irrigated and non-irrigated Corn Yield 1968-2018
table that displays the number of bushels per acre over all fifty-one years.

Overall, irrigation systems do make a difference in corn yielded compared to non-irrigated. This means that they would be a wise choice for farmers to invest in if they wanted a more consistent yield year in and year out especially if they live in areas that are prone to little rain fall or drought. However, the costs for these irrigation systems must first be considered before investing.

REFERENCES

"United States Department of Agriculture." USDA. Accessed November 5, 2021. https://www.nass.usda.gov/Quick_Stats/.

Chen, J. (2021, October 11). *What does the U.S. Department of Agriculture (USDA) do?* Investopedia. Retrieved November 5, 2021, from https://www.investopedia.com/terms/u/usda.asp.

About our agency. About our agency | National Oceanic and Atmospheric Administration. (2021, October 27). Retrieved November 5, 2021, from https://www.noaa.gov/about-our-agency.

Ayars, ., et al. "Subsurface Drip Irrigation for Corn Production: a Review of 10 Years of Research in Kansas." *Irrigation Science*, Springer-Verlag, 1 Jan. 1999, link.springer.com/article/10.1007/s00271-003-0085-3.

Vories, E.D., et al. "Subsurface Drip Irrigation of Corn in the United States Mid-South." *Agricultural Water Management*, Elsevier, 21 Jan. 2009, www.sciencedirect.com/science/article/pii/S0378377408003181.

Wallace, J. S., and C. H. Batchelor. "Managing Water Resources for Crop Production." *Philosophical Transactions of the Royal Society B: Biological Sciences*, U.S. National Library of Medicine, 29 July 1997, www.ncbi.nlm.nih.gov/pmc/articles/PMC1691982/.

Payero, José O., et al. "Yield Response of Corn to Deficit Irrigation in a Semiarid Climate." *Agricultural Water Management*, Elsevier, 9 Mar. 2006, www.sciencedirect.com/science/article/pii/S0378377406000278?casa_token=AjxmLcE8TqQAAAAA%3AvnujTNJl9n84HNNnzXn7XDjRF2vjiUp6Q3-AgKkR6hg_-mgZR2ZE92RSX5aPa9Mt_KbkFIGAfJg4.

Nijbroek, Ravic, et al. "Optimizing Irrigation Management for a Spatially Variable Soybean Field." *Agricultural Systems*, Elsevier, 8 Mar. 2003, www.sciencedirect.com/science/article/pii/S0308521X02001270.

Zhang, Zhi, et al. "Soil Salt Distribution under Mulched Drip Irrigation in an Arid Area of Northwestern China." *Journal of Arid Environments*, Academic Press, 22 Feb. 2014, www.sciencedirect.com/science/article/abs/pii/S0140196314000238.

Xue, Q., et al. "Root Growth and Water Uptake in Winter Wheat UNDER Deficit Irrigation." *Plant and Soil*, Kluwer Academic Publishers, 26 June 2003, link.springer.com/article/10.1023/A:1026230527597.

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