KANSAS CORN STEM

Kansas Corn: Water, Water, Everywhere

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KANSAS CORN COMMISSION

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Kansas Corn: Water, Water, Everywhere
Grade Level: High School

Overview
Kansas has a diverse climate from the east to west ends of the state. In many parts of the state, corn farms are rain-fed, known as dryland or non-irrigated farms. These farmers normally receive enough rainfall to raise a crop. As you move toward the western part of the state, the climate is more arid and more farmers supplement their crops with irrigation, with the water sources coming mainly from underground aquifers. Farmers also can irrigate their crops from surface water sources, such as rivers and ponds. Many areas of the high plains region of western Kansas benefit from the Ogallala Aquifer, which supplies a water source for irrigation. Yet, the aquifer is a limited resource, and farmers are working hard to extend its life by finding ways to use less water to produce their crops.

When considering the irrigation needs of commercial crops, farmers must consider several variables. Is there groundwater or surface water available to irrigate the crops? Are the costs associated with irrigating justified economically? What is the best way to ensure that the water reaches the plant roots for the most benefit with the least amount of waste? Wind, evaporation, and runoff are all working against the farmer's goal of getting the water into the soil and, ultimately, into the roots of the plant itself. With multiple types of systems available to help meet the demands of water delivery, it is critical to understand some basics of irrigation. In this lesson, students will construct and evaluate some of the multitude of irrigation possibilities based on the amount of water that reaches deep enough in the soil to be taken up by the plant.

Kansas College and Career Ready Standards
Science
- **HS- ESS2-5.** Plan and conduct an investigation of the properties of water and its effects on Earths materials and surface processes.
- **HS-ESS3-1.** Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards and changes in climate have influenced human activity.
- **HS-ESS3-4.** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- **HS-LS2-7.** Design, evaluate and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- **HS-PS2-6.** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
- **HS- ETS1-1.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- **HS-ETS1-2.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- **HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-

offs that account for a range of constrains, including cost, safety, reliability and aesthetics as well as possible social, cultural and environmental impacts.

Language Arts

- **W.9-10.8.** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
- **W.9-10.7.** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- **SL.11-12.1.** Initiate and participate effectively in a range of collaborative discussion (one-on-one, in groups, and teacher-led) with diverse partners on grades 11-12 topics, texts and issues, building on others' ideas and expressing their own clearly and persuasively.

Math

- **HS: AL: Quantities.** N-Q Reason quantitatively and use units to solve problems. 1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. 2. Define appropriate quantities for the purpose of descriptive modeling. 3. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Learning Objectives

- Understand the importance of conservation of natural resources for the continued growth of crops.
- Understand the water cycle and the ways water moves in different forms.
- Understand how much water is needed for a corn plant to produce adequate yield.

Materials

- Kansas Corn: Water, Water Everywhere PowerPoint (available at www.kansascornstem.com)
- Student worksheet (pg. S1-4 or available at www.kansascornstem.com)
- Computer access
- Sprayer nozzles (garden irrigation nozzles work well)
- ¼-inch tubing to connect watering system
- Basin or tank to act as a water reservoir
- Pump-to-pump water through irrigation system
- Large containers for holding soil and plants with drain holes

- Moisture monitors
- Graduated cylinder
- Timer

Safety Considerations
As with any instance using water and electricity, make sure that you are not allowing electrical outlets to be splashed or become wet during the prototyping process.

Procedures for Instruction
Length of Time for Preparation: 20-30 minutes
Length of Time for Classroom Teaching: 2-multiple class periods, depending on instructional choices.

Background Information
Irrigation has been one of the most important agricultural advances of all time. The practice of irrigation of crops has been in place for more than 6,000 years with the first evidence being traced back to Mesopotamia. Early irrigation focused on moving water from one location to another generally through the construction of troughs or furrows that then used gravity to move the water from the source toward the crops. This early irrigation worked to provide much needed water to parched and marginal ground so that agricultural products were more reliable for the farmer and the cultures that surrounded farming areas. Later, pumps, such as simple windmill pumps, were utilized to help bring water from underground water reservoirs and low-lying water source to the surface. Simple gravity flow furrow irrigation has drawbacks, such as having to overwater parts of the field just to ensure those downhill would get enough, if any, water. In 1952, Frank Zybach, a farmer from Nebraska, developed center pivot irrigation. In center pivot irrigation, farmers could more reliably spread water over the entire field from a single line of pipe, supported by towers with wheels, moving it around a central pumping location in the middle of the field. These modern versions of pivots are still used today by farmers around the world.

In recent years, driven by the need to conserve precious freshwater resources, farmers and industry professionals are developing and experimenting with new types of irrigation water application devices, such as LESA (low elevation spray application) and MESA (medium elevation spray application). LESA utilizes the center pivot but allows for drop hoses that spray water 2-4 feet above the ground. MESA uses nozzles dropped 5-8 feet above the ground. LEPA (low energy precision application) utilizes bubbler nozzles that gently deliver water just 8-18 inches above the ground to combat wind-drift and reduce evaporation loss. Some LEPA systems use drag hose socks to apply water directly to the ground and into small basins or pits to prevent the water from moving from the application point and allow water to be absorbed. Another option of applying water to the ground surface is MDI (mobile drip irrigation), which applies water directly on the soil by utilizing center pivots that have microirrigation driplines that come in direct contact with the soil instead of being positioned above the crop. SDI (subsurface drip irrigation) is an irrigation system options that deploys underground microirrigation driplines running parallel and in close proximity to the crop rows themselves. Water is then pumped directly into the pipe system and allowed to diffuse into the soil, applying the water directly into the crop root zone. Since the water is applied below ground, evaporation losses and water runoff potentials are eliminated.

Regardless of the system, one basic fact is necessary to understand in irrigation. Mother nature can't always be depended on to deliver water at the right place, time and amount. In drier areas of the state, for good stable yields and increased production, well-designed efficient systems must be developed to maximize the output of acreage while decreasing inputs. This will also allow farmers to be good stewards of the natural resources that are available to them, making sure that the water resources we have now are not depleted but carefully utilized so that future farmers will have the same opportunities.

Classroom Discussion

Activity 1: The Water Cycle Review

Activating Prior Knowledge:

Materials needed: large poster paper or white boards, 3 colors of writing instruments.

- As individuals, have students draw the water cycle on a blank sheet of poster paper or large white board in one color. Allow 5-10 minutes depending on the prior knowledge of students.
    - Bring the class back together for a board meeting (all students and their work in a large circle facing the middle of the room so that all students can see all groups work).
    - Guiding questions: What are some features we all have? What are some features we don't have but should? Allow students to show their work and respond.
- In another color of writing utensil, have students try and label the forms water can take during the cycle (liquid, vapor (or gas), and solid).
    - Guiding questions: Does your cycle show all three forms? If not, what would you need to add to make sure all can be depicted?
- In a third color of writing utensil, have students describe how water moves from place to place in the water cycle.
    - Draw arrows to show water movement.
    - Label the arrows with the names of the processes causing the water to move (e.g., ... , etc.) evaporation from a lake, percolation from rain water soaking into the soil, etc.
    - Bring class back together for another board meeting.

- Compare diagrams: What processes do you have labeled on your cycle? Does everyone have the same processes? What, if any, processes are missing from our cycles? Allow students to respond and make changes to their diagrams as necessary.
- Now, focusing on the plants in our cycle, which processes are directly involved with water movement and plants? Would the plant survive if that process did not take place? How can we control that process to ensure the plant is getting enough water?
- Hopefully, this discussion will lead you to the ideas of rain, percolation, and water storage areas being essential inputs for plant production but also that evapotranspiration is a critical process that removes water from plants. As with other cycles, it is key to point out to students that a delicate balancing act has to occur for plants (and animals) to get the water they need for survival. If you are a farmer, you are partially at the behest of mother nature to provide to you that water. Yet in some cases, when ground or surface water is available, we can help it get exactly where we want it if necessary.

Procedure for Lab

Activity 2: How Much Water is Needed? Quick Discussion and Calculation.

This is a teacher-led discussion that can be completed at the chalkboard or Elmo. Students should be writing down the calculations, as they will be important data points for their design project later on.

Teacher: Let's calculate how much water is needed for an average yield of corn. Most corn needs 20-25 inches of water during the vegetative stage which is the emergence to maturity stages of the growing season. This will help to produce over 250 bushels of corn per acre of land. How much water is that? Let's try and convert this into a measurement we can understand, such as in terms of gallons of water.

Students: Have students complete the calculation below. Here is the conversion you will need: 1 in. of rain per acre is about 27,154 gallons How many gallons of water would be needed total?

27,154 gallons x 22 in. = 597,388 gallons of water

Teacher: That's a lot of water, right? What would that look like? The average high school competition pool in Kansas holds about 162,000 gallons of water. So, the amount of water we would need would fill up 3.68 or about 3 ¾ pools. Remember, this is per acre of land. What can we get from that much water?

Suppose that at harvest time, your data shows that you have an average of 200 bushels per acre of your corn. How many gallons of water were used to produce one bushel?

Students: Students can now calculate gallons per bushel. It may be helpful to write it on the board gallons per bushel.

597,388 gallons / 200 bushels = 2,986.94. So, let's say 2,987 gallons for one bushel of corn.
Source: https://articles.extension.org/pages/14080/corn-water-requirements

Activity 3: How Much Water Does Mother Nature Provide?

Provide a student sheet to each student.

- During this activity, students will select a particular geographic area to focus the rest of their research and design process on.
    - You can either assign each student or group a different location or allow them to choose their own. By assigning or allowing students to randomly select from a smaller number of choices, you can ensure that a variety of areas in the state are covered, allowing the class to show a better representation of the state as a whole.
    - Have students fill in the student sheet, collecting the data for yearly and monthly precipitation totals. You can toggle back and forth by using the parameter buttons provided in the upper right portion of the window.
    - Caution students to make sure they are computing their averages correctly, double checking numbers as necessary for plausibility.
    - As students create the graphs, there are multiple options. Graphs can be created either by hand on the graph paper provided or students could analyze their datasets and produce their graph through Excel or other data analysis software. Either will provide students with a visual representation of the data. This will allow them to see more clearly if there are any overall trends in the data collected.
- Data on precipitation can be found easily using Kansas climate data provided by Kansas State University at http://climate.k-state.edu/precip/county/. Again, this data can be focused on the same geographic regions selected by or assigned to the students.
    - Finally, have students consider other possible issues that could affect how water gets to plants. Guiding questions: What are some of the issues I might face getting water to my crops? How can I make sure the water gets to the crops themselves instead of ditches or other waterways? Brainstorm possible problems. How can the processes from the water cycle as discussed in the first activity be altered by normal climate changes? You can find more climate data at the link below which includes wind speed data, relative humidity data and various other climate and soil data points.
        - Use http://mesonet.k-state.edu/weather/historical/

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Activity 4: How Do I Get Water to My Crops?

Students will research irrigation practices past and present. This could be completed individually or as a group and can be as formal or informal as fits into your time and curriculum needs. Options could range from production of a flier, individual presentation, or a simple research and share, where each member of a group of students researches the pros and cons of each type of irrigation address on the Internet, then shares the information gathered with the group. Overall, the goal is to allow students to better understand the past and present irrigation practices and determine what benefits and drawbacks are seen in each process. Ultimately, students will be using this research to help them evaluate design options in the concluding design activity.

Past and Present: https://water.usgs.gov/edu/wuir.html Irrigation Water Use (Water School)

Short video: https://www.youtube.com/watch?v=24LJSJqpYuY (History Channel on Irrigation) * Please note that this video is from 2009 and technology has improved since then.

Activity 5: Designing My Best option! Design Group Approach.

Also found on student worksheet.

Problem: You need to get water to your crops, but you want to do it efficiently. Design an irrigation system that will allow you to make up the deficiency of water that you discovered must be covered for you to get a good crop.

Constraints: Use data collected previously to outline the limitations you have in your geographic area (wind, temperature, topography, cost, distance to pump, etc.).

- Present students with their task and guide them through the engineering and designing process to produce a prototype irrigation system.
- The area of constraints can allow you to limit the scope of this lab considerably. In some cases, based on the ability of your students and time constraints, you may want students to simply focus on making a semblance of an irrigation system. In that case, provide them with limited constraints, such as pump an x amount of water over a y given length of time in z type of soil. For others, a more in-depth study can be undertaken, looking at aspects such as wind speed, average humidity and temperatures, scheduling of irrigation, soil types, reservoir types, etc.
- Initially, students will struggle with coming up with possible systems, after all this is a big problem that people have been working on for thousands of years. Remind them that people with stone tools worked on this problem, too. If they can do this, so can we.

- You may choose to provide your students with a store of materials that they can choose from in order to create their system or allow students to create their own list of supplies. Primarily, you will need pumps (fish pumps work well on small scales), tubing, water reservoirs, and a water catchment system (larger bin or tub), unless you complete your tests outside.
- This will not be a one-class period project. Students need time to brainstorm, research, prototype, test, and repeat. Encourage students to keep notebooks or other forms of daily logs or records to support their data collection and analysis process.
- If students are working in groups, have students assign deadlines and prioritize their own work as a group in order to ensure progress is being made. Group documentation should be collected as well as individual documentation. Electronic file sharing systems such as Dropbox and GoogleDocs can be very helpful in this situation.
- Set up frequent round tables with your groups. Meeting with each group for a period of 10-15 minutes (as time allows) to check on group and individual progress. Guide students through the process by asking probing questions such as the following. How will you measure your success? What is your reasoning for that decision? Do you have data to support your decision as well? What is the priority for this class period or day?

An engineering and designing rubric is located on student sheet.

Teacher Resources
Please refer to the Kansas Corn website for helpful videos showing the use of Mesonet and Kansas Climate data sites.

Additional resources and video available at www.kansascornstem.com.

Assessments
Utilizing the rubric provided, students can be assessed on the overall design and successful demonstration of their final irrigation design. Again, remember that this lesson can be as large or small as is necessary for individual curriculum needs and should be adapted on a class-by-class basis.

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Science and Agriculture Careers
As with any field, research in the next big innovation can drive a huge portion of the business. In the case of irrigation, jobs in the areas of engineering, manufacturing, data collection and analysis, systems operation, and, of course, research and development are all critical to the development of the most efficient systems. As water resources are dwindling and government regulations are being more and more strenuous, it is becoming more important to ensure effective and efficient systems are being developed and deployed.

To learn more about agriculture careers, visit www.agexplorer.com. You can also find career profiles at www.kansascornstem.com.

Any educator electing to perform demonstrations is expected to follow *NSTA Minimum Safety Practices and Regulations for Demonstrations, Experiments, and Workshops*, which are available at http://static.nsta.org/pdfs/MinimumSafetyPracticesAndRegulations.pdf, as well as all school policies and rules and all state and federal laws, regulations, codes and professional standards. Educators are under a duty of care to make laboratories and demonstrations in and out of the classroom as safe as possible. If in doubt, do not perform the demonstrations.

How Much Water Do We Usually Get Per Year?

Visit: http://climate.k-state.edu/precip/county/

1. Select a county to complete your study: ____________________

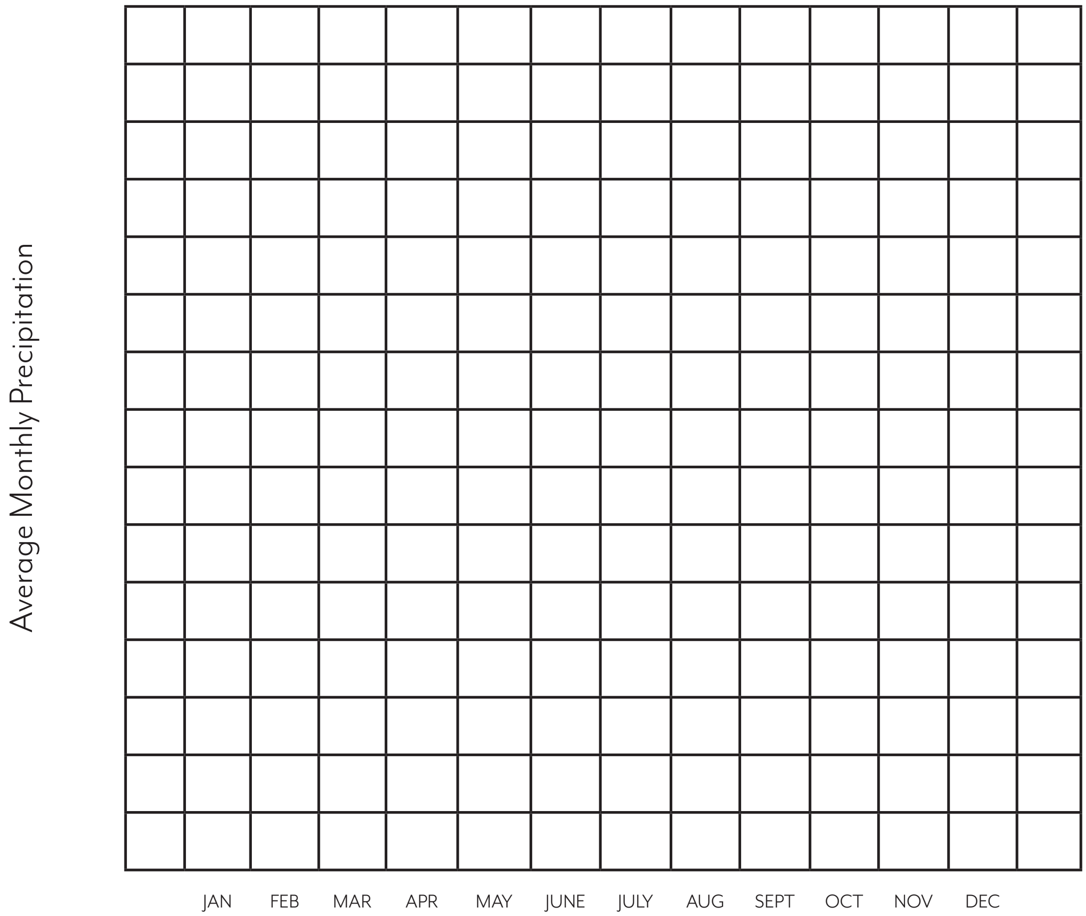
   How much rain did that county get in the last 5 years?

Year	In. of Rain.
2017	
2016	
2015	
2014	
2013	
Average: (total in. of rain / 5)	

2. When did the rain come? Precipitation that we receive as snow in December helps but doesn't have as much direct impact as rain during the growing season.

	2017	2016	2015	2014	2013	Monthly
Average						
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
Yearly Average						

3. Graph your data. Create a graph showing your average monthly precipitation over the year, January to December.



4. The planting season for corn is from May through September. Add up the total amount of average precipitation you would get in those months. It will take approximately 22 in. Do you have enough?

What other factors are at play? Brainstorm potential factors that can affect water in your area.
Hint: Think about what might affect water moving through the water cycle.

Type of Irrigation: https://water.usgs.gov/edu/wuir.html
Use the resources on the site above to help you determine the pros and cons of each type of irrigation.

Flood Irrigation		Drip Irrigation		Spray Irrigation	
Pro	Con	Pro	Con	Pro	Con

Problem: You need to get water to your crops but you want to do it efficiently. Design an irrigation system that will allow you to make up the deficiency of water you discovered that must be covered for you to get a good crop.

Constraints: Use data collected previously to outline the constraints you have in your geographic area (wind, temperature, topography, cost, distance to pump, etc.).

Rubric: The following rubric is to help guide you in your designing process. Remember, all good designs have been through multiple prototypes, ideas, and drafts. You have already done some research, so now go design.

	Advanced	**Proficient**	**Developing**	**Beginning**
Brainstorming	Generated multiple possible solutions that lay within all outlined constraints, based on scientific or engineering justifications stemmed from initial research or reverse engineering.	Multiple possible solutions without initial research, all possible solutions are within the initial constraints.	Multiple possible solutions within constrains that do not address all of the concerns outlined. Little scientific or engineering justification.	A single possible solution is presented. Options do not meet constraints. No sound scientific of engineering justification for options.
Evaluating possibilities	Determined to measure the success of possible solutions, fully documents processes followed to create and evaluate options.	Documentation of measurement of success that outlines discrete differences between possible solutions.	Measurement of success does not allow for differentiation between possible solutions but is documented.	Minimal testing is completed to discriminate between possible options.
Selecting preliminary designs	Analyzes preliminary data collected on possible solutions and chooses the best element or combination of elements based on data and/or research that objectively supports selection. Takes into consideration possible tradeoffs in options.	Analyzes data collected on possible solutions and chooses an element or combination of elements based on data and/or research that objectively supports selection. Potential tradeoffs not considered.	Data is not used systematically for initial decisions. Chooses design options that do not meet the initial constraints of project.	No data collected to support decisions made during the process. No logical for selection
Final prototype development	Final prototype actually does what it is designed to do. Has measureable success when demonstrated. Decision making processes are defended with data and reasoning. Prototype effectively communicates the form of the detailed final design, and exhibits quality/craftsmanship.	Prototype does what it is designed to do. Has demonstrated performance that could be optimized with additional experimentation. Decision making is based on data and is effectively demonstrated.	Meets most but not all constraints. Design provides limited performance. Design not fully documented or explained.	Prototype does not meet constraints. Basic function of design not completed. Final design not communicated.