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INCREASING FOOD PRODUCTION WITH PRECISION AGRICULTURE

PRESENTED in PARTNERSHIP with NORTHROP GRUMMAN Foundation

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Adapted from: National Agriculture in the Classroom - Increasing Food Production with Precision Agriculture. Molly Brandt and Erin Igram. Accessed 2017. https://www.agclassroom.org/teacher/matrix/lessonplan_print.cfm?lpid=513

THIS LESSON WAS DEVELOPED IN COLLABORATION WITH THE FOLLOWING EARTHECHO EXPEDITION FELLOWS:

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INCREASING FOOD PRODUCTION WITH PRECISION AGRICULTURE

INTRODUCTION

Participating in this hands-on lesson, students will lead each other through the integration and application of a real-life situation using what they have learned in this lesson. Students will have an understanding of how precision agriculture uses geographic information systems (GIS) to help farmers and manufacturers use a sustainable growing method to reduce their carbon footprint by making informed, efficient, and responsible decisions about how and when they plant, grow, irrigate, harvest, and transport crops. Engaged in creating their own mini irrigation system based on the information presented in the accompanying PowerPoint and worksheet, students will integrate their knowledge and skills empowering them as leaders of their own learning.

SUMMARY

1. Subject(s): Science, Technology, Engineering, and Math
2. Topic or Unit of Study: Water, Conservation, Plants, Engineering, Agriculture
3. Grade/Level: 6-8
4. Objective: As a result of these activities, students will be able to:
   a) Understand that water is a key element for life on Earth and that human population growth is a major contributor to water scarcity.
   b) Explore and understand how an irrigation system works.
   c) Analyze how irrigation and agriculture may have both long and short-term impacts for humans and the natural environment.
   d) Explain how new technologies in agriculture can help increase food production while reducing water use.
   e) Calculate water use efficiency.
   f) Design and build a variable rate irrigation system.
5. Time Allotment: 5 Periods of 55 minutes

TEACHER BACKGROUND

BACKGROUND INFORMATION:

Can you imagine foods in the future being provided from locally grown, fresh, organic, sustainable farms without harmful chemicals, pesticides, or synthetic nutrients?! Well, thanks to the Growing Green movement, which supports the need for considerably less water, t in America this reality is happening NOW.

How is this possible? One answer is **Precision Agriculture** used in harmony with aquaponic farms such as *Future Foods Farms* in Brea, California. Future Foods Farms is created, owned, and supported by Chef Adam Navidi. **Precision Agriculture** is an engineering concept being implemented as a major component of the quest to not only end the real-world problems of food insecurity, but to aid in the critical conservation of water.

Engineering and forward-thinking concepts such as *Future Foods Farms* are the answer to the efficiency and survival of our planet. Our young people are the hearts and minds of the environmental movement, and therefore they are the driving force behind these and other great engineering concepts. The future is NOW!

Engineering concepts such as **Precision Agriculture** are changing the way we grow food by applying technology to improve food production. Highly modernized equipment allows farmers to put in less labor, yet achieve larger yields. **Precision Agriculture** is an innovative farming management concept based on observing, measuring, and responding to inter, and intra-field variability in crops. Variable rate irrigation (VRI) is a type of **Precision Agriculture** that involves applying water at a variable rate along the center pivot, rather than in one uniform rate along the *entire* length of the system. How is that possible?

Well, by using a GPS system farmers can create maps to find the field's boundaries. They then use Field Computers with the ability to control fertilizer, herbicide, and pesticide application through an automated delivery system. Farmers can check yields and moisture levels and then use Rate Controllers to figure the amount of irrigation and fertilizer warranted in a field. WOW!

Thanks to EarthEcho, in this lesson students are given the opportunity to work on their very own **Precision Agriculture** design with support of the attached PowerPoint and student worksheet. Young people are the hearts and minds of the environmental movement, let's see what great engineering looks like in their hands.

VOCABULARY:

Global Positioning System (GPS): a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth

acre: a unit of area equal to 43,560 square feet (about the size of a football field)

bushel: a measure of capacity usually for dry goods equal to 64 pints

finite resources: resources that do not renew themselves at a sufficient rate (nonrenewable)

irrigation: the artificial application of water to the land or soil

pivot: equipment used to irrigate fields (large sprinkler)

section: one square mile of land (640 acres)

variable rate irrigation: applies exactly the right amount of water to each foot/meter of the field

water use efficiency (WUE): the ratio of water used in plant metabolism to water lost by the plant through transpiration

yield: measure of grains or seeds generated from a unit of land (agricultural output)

Engage

1. Ask students if they know the current population of the world. *(approximately 7 billion)*
2. Ask, "Is our population increasing or decreasing?" *(increasing)* Ask students, "What necessities will we need more of in order to accommodate 2 billion additional people on the earth?" *(food, water, energy, goods, and medical technologies, etc.)*
3. Ask students to begin thinking about the overall impact of population growth as they watch the video, Agriculture is Under Pressure.
4. Following the video, ask the class what the overall message is or what stuck out to them. Lead the discussion to conclude that farmers need to produce more food using the same resources.
5. Explain that we will need to find solutions to feed a growing population. With limited resources (arable land, water, plant nutrients, etc.), we must do more with less without degrading our natural world.
6. Introduce the word *efficiency*. Discuss the definition and give real-life examples of efficiency that students will relate to. Point out that farmers will need to be more and more efficient to keep up with the demand for food.
7. Ask students what types of resources farmers need in order to produce our food. As you discuss the following resources, point out that they are limited. We can't obtain more. Therefore, we need to be more efficient in our use of them. *(open space to grow crops or raise livestock, water, arable land)*
8. Point out that farmers have become more efficient in previous years through the use of technology. Ask students, "What are some examples of technology that farmers are using today?" *(Students may discuss GPS, maps, cell phones, automated irrigation systems, computers, large machinery (tractors) with automated features, etc.)*
9. **Introduce the concept** of *precision agriculture*. Explain that precision agriculture utilizes various technological instruments to make agriculture more precise and efficient. As an example show the video clip Kinze Autonomy Project: Harvesting System. As the video clip plays ask students what they notice is different about the tractor *(there isn't a driver.)* Explain that this tractor is operated using robot and GPS technology. This allows a single worker to harvest an entire field.
10. Show the first 3 minutes of the video clip, Precision VRI to explain and illustrate the unique components in each field that impact the water needs.

Explore

Calculating WUE and Building a VRI System

1. Give each student one copy of the student handout.
2. Complete "Part 1" of the handout. This section can be completed as a class, in groups, or individually. Slides 5-20 walk through the worksheet step-by-step.

3. Move on to "Part 2" of the handout. Guide students through the instructions for the variable rate irrigation activity in the student handout. Using slides 22-30, explain to students that they will build a device to vary water flow (just like in variable rate irrigation). Their goal is to build a system to divide 16 oz. of water into three cups with 2 oz., 6 oz., and 8 oz. of water in each.
4. Form students into groups of three. Distribute a 16 oz. water bottle, 3 cups, scissors, and a choice of straws or other materials to each group.
5. Give students 10 minutes to construct a device to simultaneously divide the water into 3 different amounts. Allow students to test their design and share it with the class.
6. After their designs have been tested, instruct students to complete part 3 of their handout.

STUDENT MATERIALS

Materials List

- Increasing Production with Precision Agriculture student handout, 1 per student
- Increasing Production with Precision Agriculture PowerPoint
- Mini Irrigation System Design Assessment Rubric
- Self-Evaluation of Team Design Challenge

For each lab group:

- Water bottle (16 oz)
- 1 Styrofoam cup
- 3 plastic cups
- Variety of straws (jumbo, regular, coffee).
- Calculators

Explain

1. Following the activity, summarize why farmers would want to use variable rate irrigation.
   - Increase crop yields. Too much or too little water decreases plant health and crop yield.
   - Conserve water.
   - Provide exact and precise watering for each soil type and slope within a field. *(Soil type can vary within a field. Clay soil holds high amounts of water which allows the roots to soak in the water for a longer time. In sandy soils, water can quickly run through the soil without penetrating the roots)*.
2. Use slide 4 of the *Increasing Production with Precision Agriculture* PowerPoint to give clarification on how soil type affects water-holding capacity.
3. Use slide 5 to show a picture of a field being watered uniformly. Ask students if they can see a section of the field that needs more water.
4. Use slides 6-9 to summarize key points.
5. Based on the previous activities, ask students to explain why precision agriculture is the answer to increasing yields without increasing resources. Could this technology be applied to any other situations?

Example of a VRI System

Evaluate Rubric

MINI IRRIGATION SYSTEM DESIGN ASSESSMENT RUBRIC

Utilize the Student Handouts and Assessments to evaluate your student's understanding of precision agriculture.

				Points
Identifying the problem(s) and brainstorming solutions	30 Showed a clear understanding of the problem(s) to solve. Independently brainstormed solutions.	20 Needed some teacher direction to define the problem(s) and brainstorm possible solutions.	10 Needed lots of teacher direction to define the problem(s). Little if any independent brainstorming.	
Working as a team member	25 Worked well together. All team members participated and stayed on task. All gave thoughtful insight about precision agriculture.	15 Some team members were occasionally off task. Only some explained precision agriculture.	10 Most team members were often off task and not cooperating or participating fully. Majority of the members have not gained much understanding of precision agriculture.	
Using the design process	25 Team brainstormed main design ideas and tested and improved the design. Final design complete or nearly complete irrigation system, and shows creative problem solving. The model simultaneously divided water into 3 different amounts.	15 Some team members were occasionally off task. Final design showed only some elements of an irrigation system. The model simultaneously divided water into just 2 different amounts.	10 Team brainstormed few design ideas and did little testing or redesigning. Final design lacks clear design idea(s) and failed to simultaneously divide the water into 3 different amounts.	
Processing the science and engineering	20 Team gave a strong presentation of its solution to the challenge and showed clear understanding of the science concepts and design process, with precision and efficiency as main goals in their design. Team gave a thoughtful response to Elaborate.	10 Team gave a basic presentation of its solution to the challenge and showed basic understanding of precision and efficiency as goals in the creation of an irrigation system. Team gave some response to Elaborate.	5 Team gave a weak presentation of its solution to the challenge and showed little understanding of a precise and efficient irrigation system. Team gave a short or even no response to Elaborate.	
			total	

Name:____________________ Date:____________________ Period:____________________

INTRODUCTION: follow along with the slides to answer the questions

1. What is the purpose/goal of variable rate irrigation (VRI)?

2. What technologies make VRI possible?
   a.
   b.
   c.
   d.

3. Vocabulary
   a. __________________ The artificial application of water to land or soil
   b. __________________ Equipment used to irrigate fields
   c. __________________ A unit of area equal to 43,560 square feet (one football field)
   d. __________________ One square mile of land (640 acres)
   e. __________________ A measure of capacity, usually for dry goods, equal to 64 pints
   f. __________________ Measure of grains or seeds generated from a unit of land (agricultural output)

PART 1: How does water use efficiency vary within the field?

Yield data was collected during harvest. Sensors in the harvest equipment monitored the amount of corn harvested in each location of the field and recorded the data in a yield map. An average of the yield in each section was calculated to measure water use efficiency (WUE) in each section.

Example:

Overall field yield:

Irrigated yield: 150 bushels/acre

Dry land yield: 168 bushels/acre

Irrigation: 10 inches

WUE = Irrigated Yield - Dry land Yield

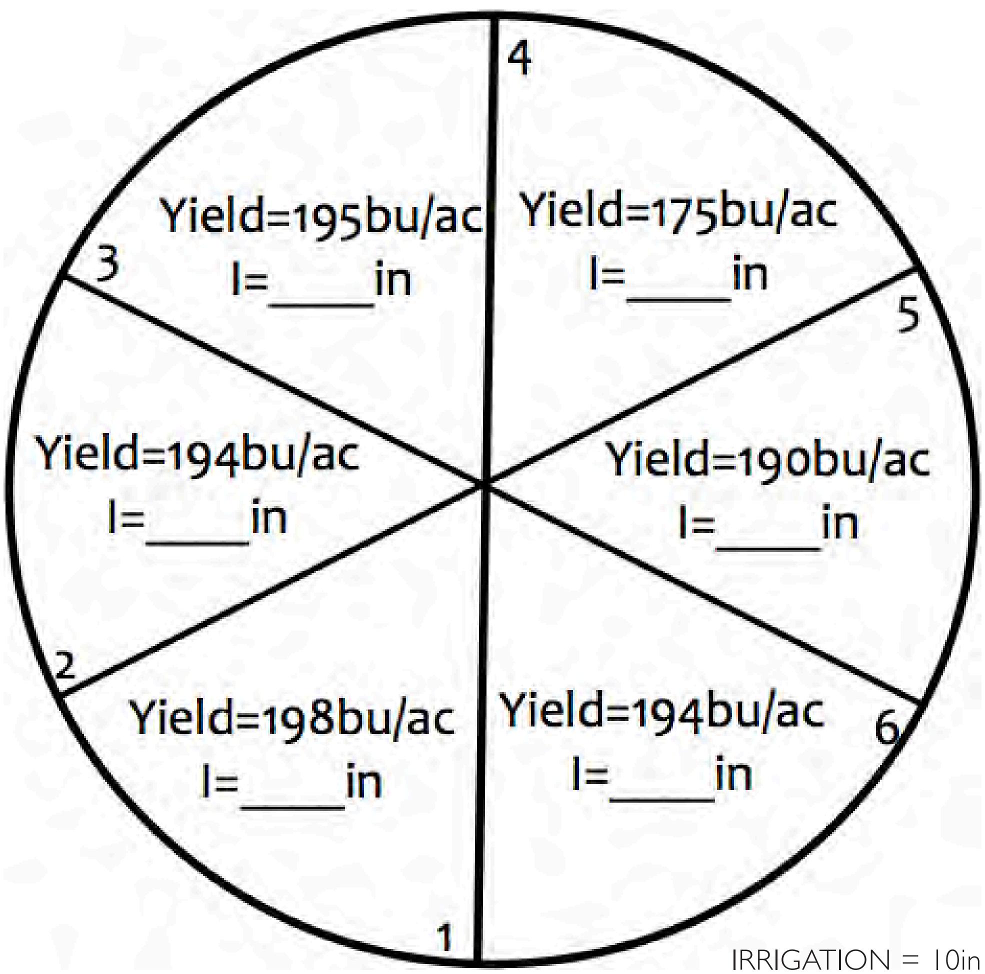
Irrigation

WUE = 190 bushels/acre - 168 bushels/acre

10 in

WUE = 2.20 bushels/acre inch

Set 1



IRRIGATION = 10in

Zone 1 Calculations:

Zone 4 Calculations:

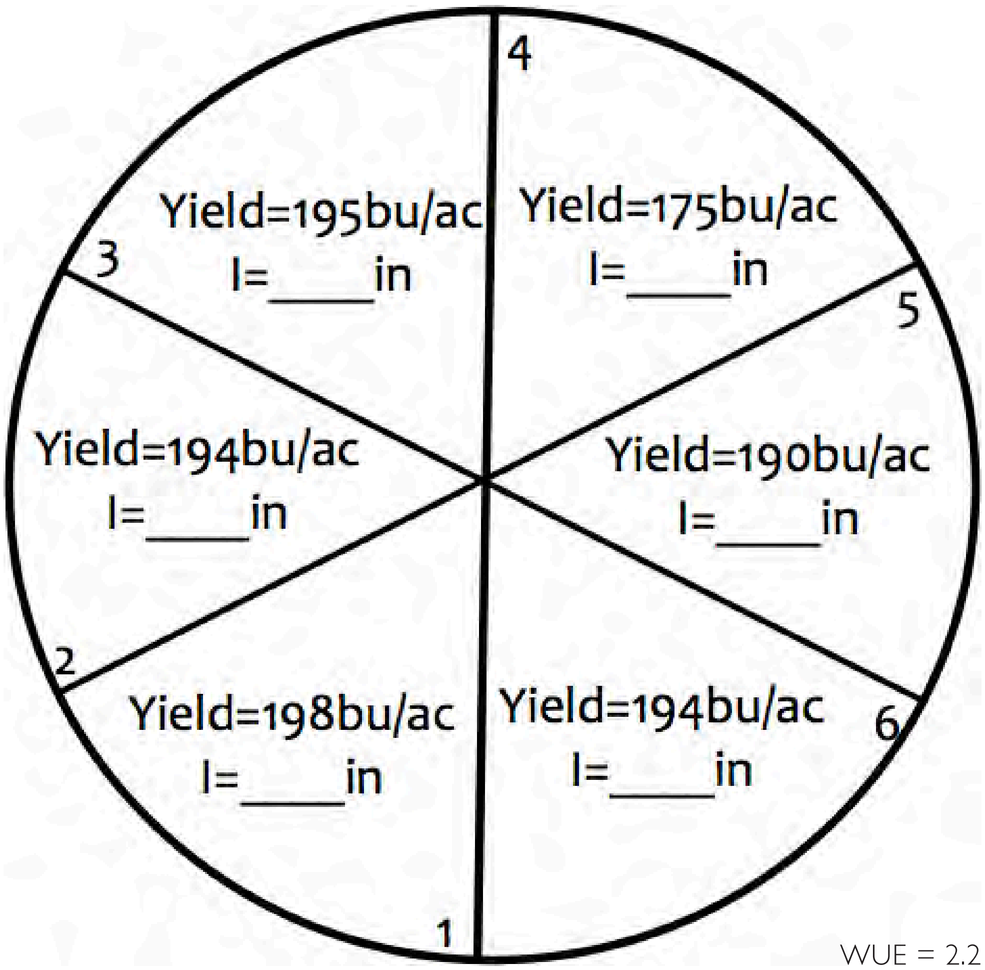
Zone 2 Calculations:

Zone 5 Calculations:

Zone 3 Calculations:

Zone 6 Calculations:

Set 2



WUE = 2.2

Zone 1 Calculations:

Zone 2 Calculations:

Zone 3 Calculations:

Zone 4 Calculations:

Zone 5 Calculations:

Zone 6 Calculations:

PART 2: How can we construct a device that will vary the rate of flow?

Problem and Objective:

We will

In order to

Brainstorm: What will your try first?

Materials:

Testing: What did you change in your plan in order to succeed?

PART 3: Reflection

Was your design successful? How?

What could have been done to improve your design?

Why do you think that varying water amounts is useful?

SELF-EVALUATION OF TEAM DESIGN CHALLENGE

Name: ______________________ Team: __________ Date: _______

Briefly describe your contribution to your team:

If you were doing this project again, what would you do differently to improve your work?

How could your team work together more effectively on the next challenge?

Other Comments:

Your grade for yourself: ____/4

RESOURCES

1. EarthEcho - Episode 3 earthecho.org/expeditions
2. EarthEcho - Chef Adam - STEM Career Closeup earthecho.org/expeditions
3. Future Foods Farm: http://futurefoodsfarms.com/Future_Foods_Farms/Welcome.html

CITATIONS

- Adapted from: National Agriculture in the Classroom - Increasing Food Production with Precision Agriculture. Molly Brandt and Erin Ingram. Accessed 2017. https://www.agclassroom.org/teacher/matrix/lessonplan_print.cfm?lpid=513
- Scientific American: Precision Farming Increases Crop Yields. Geoffrey Ling and Blake Bextine. June 26, 2017. Accessed 2017. https://www.scientificamerican.com/article/precision-farming/

EDUCATIONAL STANDARDS

NGSS STANDARDS

Performance Expectations:

MS-EST1-1. - Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

SEP – Constructing explanations and designing solutions

DCI - ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of test results leads to greater refinement and ultimately a better solution.

Performance Expectations

MS-ESS3-3. - Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

SEP – Constructing explanations and designing solutions

DCI – ESS3.C: Human Impacts on Earth Systems

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.

- Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

CCC – Cause and Effect

- Relationships can be classified as causal or correlational, and correlational does not necessarily imply causation

Science and Engineering Practice

Constructing Explanations and Designing Solutions - Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

Common Core State Standards - Math

- 6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-ESS3-3), (MS-ESS3-4)
- 7.RP.A.2 Recognize and represent proportional relationships between quantities. (MS-ESS3-3), (MS-ESS3-4)
- 6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS3-2), (MS-ESS3-3), (MS-ESS3-4)