GROWING AMERICA

Improving crop yield

Focus questions	How might we make accurate predictions to improve crop yield? What information helps us best prepare for and see an improved crop yield?
Learning target	Students will determine whether added nutrients improve yield.
Vocabulary	Nutrients, ammonia, potash, yield, central pivot irrigation

HS-LS2-2 Ecosystems: Interactions, Energy, and Dynamics

Performance expectation HS-LS2-2	**Classroom connection:** Students will use graphical comparisons of multiple sets of data to describe how nutrient application affects production.

Science and engineering practices

Using math and computational thinking **Constructing explanations and designing solutions** **Scientific knowledge is open to revision in light of new evidence**	**Classroom connection:** Students read graphs and apply new knowledge to predict outcomes. **Classroom connection:** Students construct an explanation to describe the effect of applied fertilizer and design a solution for fertilizer application the following year.

Disciplinary core ideas

LS2.A Interdependent relationships in ecosystems **LS2.C Ecosystem dynamics, functioning, and resilience**	**Classroom connection:** Students determine if the nutrients applied and other natural effects affect the crop yield. **Classroom connection:** Students describe how a farm field is different than a natural ecosystem in terms of dynamics, function, and resilience.

Cross-cutting concepts

Scale, Proportion, and Quantity	**Classroom connection:** Students will use a digital map of a field to help a farmer to determine where necessary nutrients should be applied.

Background

Farmers are managing ecosystems when they plant a field to grow a crop. Ecosystems consist of the living (biotic) and nonliving (abiotic) factors in the area. Soil, water, nutrients, organisms in the soil, and the seed that germinates and grows into a mature plant all work together with the weather conditions to produce the product that is harvested. The difference between an ecosystem that is left to nature to develop and the farm field is that the nutrients in the soil and the energy from the grown crop are removed from the field, so that there is a need to replenish the nutrients before the next planting season. Therefore, farmers must determine what nutrients need to be replaced, then apply synthetic or organic fertilizers to replace those nutrients.

Soil quality is impacted by several factors: the number of trips across the field (the more trips, the greater chance of soil compaction), the previous crop planted (some plants leave more nutrients than others or lessen the need for certain nutrients, i.e. legumes) and the climate of the area (temperature, rainfall, etc). The slope of the land and the location of the field play a role in wind or water erosion of the soil as well.

This activity was created using data from a farm that is located in Kansas with a pivot irrigation system to supply water to the crop when needed. The field is 80 acres in size (about 80 football fields). The digital maps of the field show different colors to represent differing amounts of nutrients applied and yield of areas in the field.

Using the digital maps of ammonia (nitrogen) application, potash (potassium) application, and yield, students will make observations and predictions that will help the farmer increase yield for the next harvest.

Prior knowledge

Students should have discussed plants, what they need to grow and produce seeds, weather conditions that help plants to grow (heat, sunlight, rain), and the components of soil (i.e. sand, silt, clay, organisms, air and minerals/nutrients). Students should understand that fertilizers commonly added to crops are nitrogen in various forms, phosphorus and potassium. They may need additional information about the function of the nutrients included in this activity: Ammonia (NH_3) and Potash, potassium compounds, most commonly potassium carbonate. Understanding how crops are planted, fertilized, and watered with a pivot irrigation system will help the students in visualizing what is happening on the farm ground.

Materials

- Printouts of the aerial information of the field:
  - Grain Harvest 2019: Corn
  - Grain Harvest 2020: Corn
  - Fertilizing Prescription (Dry) 2020: Potash (0-0-60)
  - Fertilizing Prescription (Dry) 2020: Ammonia (NH_3)
- Internet access may be desired for extensions or video support

Teacher preparation

This lesson is designed to be completed in one class period.

1. Make copies of each field map and student worksheet for each group.
2. Teachers may opt to show the whole class the two videos listed in the Extra Support below.
3. Divide the class into groups of 2, 3, or 4, depending on the size and needs of the class.
4. Pass out three field maps to each group. Pass out the “Grain Harvest 2020: Corn” image after students have answered question 8.
5. Consider discussing questions 10, 11 and 12 as a whole class discussion when all of the groups are finished.

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Procedure

1. Looking at "Grain Harvest 2019: Corn", what are some things your group notices about the circle? List at least three observations.

Possible answers: low crop yield in corners and several other areas of the field (B5, E9, F5, F6, H3, J2, J3, J5); looks like a ditch or stream from F1–F4, G5, G6 and H6; yield not consistent throughout

2. Make a guess as to what may have caused these conditions.

Possible answers: poor soil quality, too much water, dry conditions outside the circle

3. What are some areas within this crop circle that your group feels might need extra nutrients?

Possible answers: areas might include the washout places, the corners, the center, areas listed in #1

4. Looking at the image of the "Fertilizing Prescription (Dry) 2020: Ammonia (NH_3)" application to the field, why was it not applied evenly everywhere?

Possible answers: soil retained more nitrogen in certain areas, so application not needed

5. Using the "Grain Harvest 2019: Corn" and the "Fertilizing Prescription (Dry) 2020: Ammonia (NH_3)" images, what does your group think happened that required more ammonia to be applied where it was?

Possible answers: the water washed away a lot of nitrogen through erosion; edges of field lose more nutrients due to erosion; yield wasn't high in the areas where it is applied at highest rate, so more would be needed to increase yield

6. Looking at the image of the "Fertilizing Prescription (Dry) 2020: Potash (0-0-60)" application to the field, why was it not applied evenly everywhere?

Possible answers: soil retained more potassium in certain areas, so application not needed; yield was high in previous year so it would not need to be replaced

Student handout

7. With your group, list some reasons why potash might not be applied more towards the edges of the field.

Possible answers: the soil retains potassium better from erosion activities due to slope of the field; edges of the field are out of the area that receives water so are not productive without water from irrigation

8. With your group, predict what the "Grain Harvest 2020: Corn" image will look like.

Possible answers will vary

Take a few minutes to compare the application images and the harvest images.

9. Where on the "Grain Harvest 2020: Corn" image do you see the most change?

Possible answers: at J2, J3, J5, E9, H3, there is great improvement; J6 and K6 did not have data before, but show great improvement, even though the nutrients applied there were not the highest

10. What are some variables that will affect the "Grain Harvest 2020: Corn" image even after the farmer has applied the nutrients as needed?

Possible answers: rainfall, temperature during the growing season, amount of irrigation, plant population, weed pressure, disease, etc.

11. Looking at the image of "Grain Harvest 2020: Corn", list some practical suggestions for the farmer to try to increase crop yield.

Possible answers will vary

12. Farmers claim that the 4Rs of fertilizer are important for fertilizer application: *right rate, right time, right source* and *right place.* Explain why each term is important.

Possible answers: rate deals with the amount needed; place means it must be applied where the crop can take best advantage of it and may need to be incorporated into the soil; and the right time relates to the maturity of the crop during the growing season which makes a difference in how well the crop can use the nutrient. The right source of nutrients will also make a difference in how well it is taken up.

Differentiation

Other ways to connect with students with various needs:

- **Local community:** Field trip to a field; have a speaker (farmer, crop duster, co-op manager) in class; have students who have worked on farms tell of their experiences.
- **Students with special needs (language/reading/auditory/visual):** This is a small group activity (2, 3, 4 students), so assign groups according to individual needs.
- **Extra support:** The following videos may be helpful:
  - Highlighting the Roles of Fertilizers `youtu.be/mZ50ohq09b4`
  - Why Fertilizers Matter `youtu.be/5TzzP0y1T3g`
- **Extensions:** What differences might we predict if we are planting soybeans or wheat instead of corn? You may want to use the internet for resources.

Assessments

Rubric for assessment

Skill	Developing	Satisfactory	Exemplary
Student uses mathematical reasoning to read the graphical representations of yield data and fertilizer application and predict an outcome of fertilizer application.	Student could match color to the amount of yield that resulted and fertilizer applied, but did not make any connection between them.	Student read and matched color to the yield and fertilizer and made the connection that where more fertilizer was applied, it is expected to increase yield.	Student read and matched color to the yield and fertilizer and made the connection that where more fertilizer was applied, it is expected to increase yield, but observed exceptions.
Student constructs an explanation to describe the effect of applied fertilizer and design a solution for fertilizer application the following year.	Student's explanation describes the expected effect of applied fertilizer but does not include evidence or reasoning.	Student's explanation describes the expected effect of applied fertilizer, includes evidence or reasoning, but not both.	Student's explanation describes the expected effect of applied fertilizer and includes both evidence and reasoning.
Student describes how a farm field is different than a natural ecosystem in terms of dynamics, function, and resilience.	Student's explanation includes only one of three differences between a farm field and a natural ecosystem.	Student's explanation includes two of three differences between a farm field and a natural ecosystem.	Student's explanation includes at least three differences between a farm field and a natural ecosystem.

Rubric for self-assessment

Skill	Yes	No	Unsure
I am able to read and interpret soil test data.			
I used the data from nutrient applications to make a prediction about harvest 2020.			
I understand that adding nutrients (fertilizer) is not all that a farmer is concerned about when growing a crop.			
I constructed an explanation of the impact of added fertilizer in this case with evidence and reasoning			
I described the difference between a farm field and a natural ecosystem (re: dynamics, function and resilience).			