

Problem-Based Mathematics: You Reap What You Sow

Three-Field Rotation System



NOTES

Logistics: In this lesson, students will engineer their own three-field rotation system using a variety of hypothetical nitrogen supplying and nitrogen feeding crops. This lesson builds upon the science concepts that were explored in the previous activity, and incorporates mathematical skills, such as integers and number operations, in a real-world context.

Materials:

per student:

- 1 – copy of the Student Pages

per group of two or three students:

- 1 – Three-Field Rotation System Field Template
- 1 – Copy of Crop Cards (the students will cut these)
- 1 – Die
- 1 – Pair of Scissors

for the teacher (optional):

- 1 – Computer with Projector

Time: One 60-minute class period

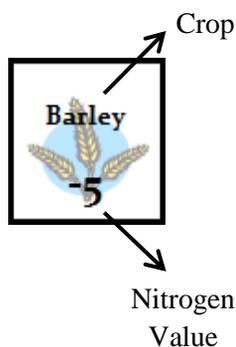
Objectives:

- Strategically manipulate positive and negative numbers, symbolic of nitrogen levels, to devise a three-field rotation system in a real-world context. **CCSS.MATH.CONTENT.6.NS.C.5, CCSS.MATH.CONTENT.7.NS.A.1.D, SEP2, SEP5, MP2, MP3, MP4, MP7**
- Engineer a model representative of a three-field rotation system, and evaluate how this model impacts the influence of previously identified farming variables in relation to crop production. **MS-LS1-5, SEP1, SEP2, SEP5, SEP6**

Introduction: Allow time for the students to review the role that soil nutrients have in farming. While there are multiple nutrients that contribute to the growth of plants, nitrogen is one of the most significant. In this activity, students will complete a hands-on simulation of field rotation by strategically arranging crops in an effort to avoid depleting soil nutrients. Each crop contains a specific nitrogen feeding or nitrogen supplying value, and must be methodically arranged from year to year in order to avoid nitrogen depletion.

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Activity:

First, arrange students in groups of 2 or 3. Pass out the first two student pages, titled **Observations and Guidelines**, and one set of Crop Cards to each group. Ask for one volunteer to read the problem statement aloud.

Students will now take several minutes to analyze the Crop Cards and record their findings. The Crop Cards consist of 16 types of crops that were traditionally farmed during the Medieval period. Each card consists of the crop's name and nitrogen value. Several crops are **nitrogen feeding** (a negative nitrogen value) while others are **nitrogen supplying** (a positive nitrogen value). Allow time for students to record their observations. Then, review the following questions as a whole class:

-  **What do you notice about the Crop Cards?**
-  **Which crops would be considered nitrogen feeding crops? Give several examples.**
-  **Which crops would be considered nitrogen supplying crops? Give several examples.**

Next, have the students cut out their Crop Cards. While they are cutting, pass out the **Three-Field Rotation System Field Template** and the next student page, titled **Crop Cycle Table**. It may also be helpful for the students to group their cards by crop name.

Before allowing the students to continue, it is recommended that you review the guidelines with the students. You may choose to have them individually read the information, and then explain the guidelines to their partner.

First, choose one student to read the **GOALS** of the activity aloud:

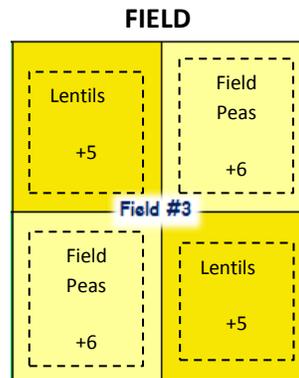
-  Each **type** of crop must be grown within the 6 year period. **Not all Crop Cards will be used.**
-  At all times, the nitrogen levels for each field must be at, or above, 0.

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Then, select one student to read the **GUIDELINES** of the activity aloud:

-  One **FIELD** is made of four squares.
-  Nitrogen suppliers can only be planted with suppliers. Nitrogen feeders can only be planted with feeders.
-  Only **two types** of crops can be planted in each field (a total of four crop cards). Cards should be arranged in the 2x2 square.
-  The nitrogen levels in each field carry over from year to year, and a fallow field always increases a field's nitrogen level by 8.
-  If all of the nitrogen has been depleted, crops cannot be planted. Therefore, the **nitrogen level in each field cannot fall below 0**.



Next, students will begin to arrange their Crop Cards in a systematic order. To begin, have students read the **GETTING STARTED** portion of the activity aloud. It is very important that the students understand how to set up *Year 1* on their template. You may choose to model the initial steps of this activity

- 1.) Because *Year 1, Field 1* will house **nitrogen feeding** crop, you must first determine the level of nitrogen that is initially in the soil.
- 2.) Roll a die and multiply the number by 4. **This is the starting nitrogen level**. Enter this amount in your **Crop Cycle Table** for *Year 1, Field 1*.
- 3.) Based on your starting nitrogen level, select two **nitrogen feeding** crops and place them in *Year 1, Field 1*. List the crops that you planted, and the total ending nitrogen level.
- 4.) Look at your **Crop Cycle Table**, and note that the beginning nitrogen level in *Year 1, Field 2* is 0.
- 5.) Select two **nitrogen supplying** crops and place them in *Year 1, Field 2*. In your **Crop Cycle Table**, in *Year 1, Field 2*, list the crops you planted, and the total ending nitrogen level.

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- 6.) Continue to select and arrange your crops based on the ending nitrogen level from the previous year, as this is the amount where your new year begins. Each type of crop must be grown, and the nitrogen level cannot fall below 0.

When all students are aware of the directions and objectives, allow approximately 30 minutes for the students to arrange their crops on the field template and calculate their nitrogen levels. All work should be completed in the **Crop Cycle Table**. You may wish for students to have access to calculators.



Next, as students complete their field templates and meet the requirements of the activity (each type of crop was grown and the nitrogen levels at the end of each year were at 0 or higher), pass out the final student page, titled **Three-Field System Analysis**. Allow time for each group to reflect on how they arranged their crops and the logistics of the rotation system.

OPTIONAL: You may also choose to have students tape down their Crop Cards, and then display each group's activity on the wall. Students could then do a gallery walk and view the multiple ways in which crops may be arranged.

Debrief:



Convene all groups into a class discussion setting. Pose the following questions to students:

- ✓ **Were some crops more difficult to “grow” than others? Explain.**
- ✓ **Were you able to “grow” each type of crop on your first try? Explain.**
- ✓ **What was your strategy to ensure that each type of crop was grown?**
- ✓ **Describe the rotation system that developed as you arranged your crops.**
- ✓ **Describe the relationship between the three-field rotation system and soil nutrition.**
- ✓ **How do you think the three-field rotation system helps to manage pest infestations?**



Observations and Guidelines

Objective: Design a three-field rotation system in which each type of crop is grown, and soil nutrients are maintained.

Observations:

1.) What do you notice about the Crop Cards?

A large, empty rounded rectangular box with a black border, intended for the student's response to question 1.

2.) Which crops would be considered nitrogen feeding crops? List several examples.

A large, empty rounded rectangular box with a black border, intended for the student's response to question 2.

3.) Which crops would be considered nitrogen supplying crops? List several examples.

A large, empty rounded rectangular box with a black border, intended for the student's response to question 3.



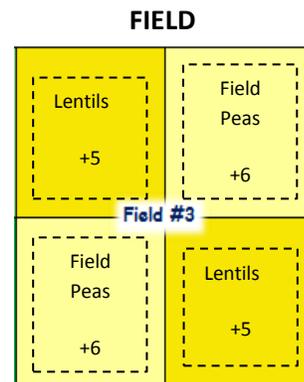
Observations and Guidelines

Goals:

- Each **type** of crop must be grown within the 6 year period. **Not all Crop Cards will be used.**
- At all times, the nitrogen levels for each field must be at, or above, 0.

Guidelines:

- A **FIELD** is made of four squares.
- Nitrogen suppliers can only be planted with suppliers. Nitrogen feeders can only be planted with feeders.
- Only **two types** of crops can be planted in each field (a total of four crop cards). Cards should be arranged in the 2x2 square.
- The nitrogen levels in each field carry over from year to year, and a fallow field always increases a field's nitrogen level by 8.
- If all of the nitrogen has been depleted, crops cannot be planted. Therefore, the **nitrogen level in each field cannot fall below 0.**



Get Started:

- 1.) Because *Year 1, Field 1* will house **nitrogen feeding** crop, you must first determine the level of nitrogen that is initially in the soil.
- 2.) Roll a die and multiply the number by 4. **This is the starting nitrogen level.** Enter this amount in your **Crop Cycle Table** for *Year 1, Field 1*.
- 3.) Based on your starting nitrogen level, select two **nitrogen feeding** crops and place them in *Year 1, Field 1*. List the crops that you planted, and the total ending nitrogen level.
- 4.) Look at your **Crop Cycle Table**, and note that the beginning nitrogen level in *Year 1, Field 2* is 0.
- 5.) Select two **nitrogen supplying** crops and place them in *Year 1, Field 2*. In your **Crop Cycle Table**, in *Year 1, Field 2*, list the crops you planted, and the total ending nitrogen level.
- 6.) Continue to select and arrange your crops based on the ending nitrogen level from the previous year, as this is the amount where your new year begins. Each type of crop must be grown, and the nitrogen level cannot fall below 0.



Crop Cycle Table

Year	Field	Starting Nitrogen Level	Crop(s)	Ending Nitrogen Level
1	1			
	2	0		
	3	0	Fallow Field	8
2	1			
	2			
	3	8		
3	1			
	2			
	3			
4	1			
	2			
	3			
5	1			
	2			
	3			
6	1			
	2			
	3			



Three-Field Rotation System Analysis

With your partner, complete the following reflection exercises:

- 1.) Describe the rotation system that developed as you arranged your crops.

A large, empty rounded rectangular box with a black border, intended for the student to describe the rotation system they developed.

- 2.) Create an illustration of a three-field rotation system. Label each type of field.

A large, empty rounded rectangular box with a black border, intended for the student to create an illustration of a three-field rotation system and label the fields.