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Logistics: Grades 5-8. All activities require small groups of 2-3 students.

Lesson Summary: The proceeding activities are designed as an investigation of the mathematic and scientific principles involved in crop rotation systems. First, students will use their understanding of Earth and Life Science to brainstorm and evaluate the multiple variables which influence the growth and production of crops. Then, after reading a book, students will reflect on the historical implications of the crop rotation system, and discuss how this development increased crop production. Next, students will participate in a hands-on activity that simulates the three-field rotation system. In this activity, students will use their knowledge of integer operations, representative of corresponding nitrogen levels, to grow hypothetical crops. Finally, students will use data to calculate the overall crop production and yield of their fields while mathematically taking pest infestation and weather factors into account. Students will then analyze their overall profit, and determine how this amount is distributed amongst various commodities (i.e., family consumption, rent, replanting supply, etc.). The following information provides insight into the development and utilization of the three-field rotation system.

Technological Requirements: Teachers may wish to have a computer and projector readily available to aide in instruction.

Time: Three or four 60-minute class periods

Standards:

NGSS: **MS-LS2-1, MS-LS1-5**
Science and Engineering Practices: **SEP1, SEP2, SEP4, SEP5, SEP6, SEP7, SEP8**
Common Core Mathematics Standards: **5.NF.B.7.c, 6.RP.A.3.c., 6.NS.C.5, 7.RP.A.3, 7.NS.A.1.d, 7.SP.C.5**
Common Core Mathematics Practice Standards: **MP1, MP2, MP3, MP4, MP5, MP7, MP8**
Common Core English Language Arts (ELA) Literacy Standards: **RI.6.7, RI.7.2, RH.6-8.4, RH.6-8.7**

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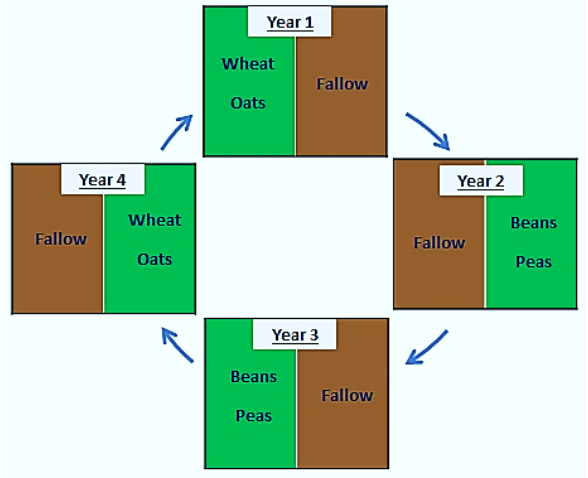
Introduction:

Farming and agriculture were a critical part of everyday life in the Medieval period. While multiple advancements in technology and engineering have developed over time, the initial agricultural principles that were used during this early time period contribute to the productivity of today's farms. During the Medieval period, peasants often relied on farming to provide for their families. Because they did not own their own land, peasants rented property from a local lord. Throughout the duration of each season, farmers typically repaid the lord in both service and crop yield. In addition to family consumption, crop production was also used as collateral for maintaining farming machinery, replanting stock, and as goods to trade and sell for additional income.

Prior to, and during, the earliest years of the Medieval period, farmers utilized a **two-field rotation system**. This design allowed farmers to use half of their land for crops, while the other half of the land remained empty, or **fallow**. The purpose of this design was to allow time for the soil to rest. Although medieval farmers may not have understood the science behind the rotation system, they observed that when crops had been planted year after year, the overall yield and quality of the crop had declined, and pest infestations soon claimed a larger portion of the crop. These observations led farmers to develop the two-field rotation system, which allowed for the replenishment of soil nutrients and controlled the threat of pest infestation.

The Yearly Cycle of a Two-Field Rotation System



However, although the two-field rotation system addressed issues such as soil nutrients and pest control, it was relatively ineffective in terms of labor vs. crop yield. For example, if a farmer was tending to a 60 acres plot of land, which had been divided into two fields, 30 acres would be used to plant crops, while the remaining 30 acres was left fallow. Traditionally, the farmer plowed the entire 60 acres at the beginning of the season, and had to plow the fallow field a second time before the end of the season.

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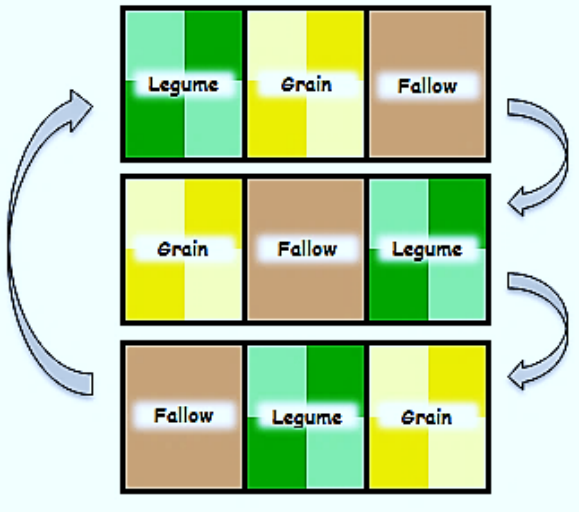
Therefore, although the farmer plowed a total of 90 acres, only 50% of the crops were reaped from the entire field. The mathematics of this idea is explained below:

Total Acres Plowed = Total Acres in the Field + Additional Fallow Acres
90 = 60 + (60 – 30)

Percent of Field Reaped = (Total Crop Acreage ÷ Total Field Acreage) x 100
50% = (30 ÷ 60) x 100

Over time, more efficient and economical farming systems were eventually developed. The two-field rotation system only allowed farmers to utilize 50% of their land, and the amount of labor that went into maintaining and harvesting the crop nearly outweighed the crop yield. Soon, a **three-field rotation system** was introduced, which allowed farmers to utilize approximately 67% of their land and produce a larger crop yield. Using the same 60 acre plot of land that was analyzed earlier (see two-field rotation system), the three-field rotation system was more effective in terms of labor vs. crop yield. The mathematics of this idea is explained below:

The Yearly Cycle of a Three-Field Rotation System



Total Acres Plowed = Total Aces in the Field + Additional Fallow Acres
80 = 60 + (60 – 40)

Percent of Field Reaped = (Total Crop Acreage ÷ Total Field Acreage) x 100
67% = (40 ÷ 60) x 100

Introduction

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The three-field rotation system allowed farmers to split their land into three fields, two of which were used to grow crops. The third field was left fallow, but often housed livestock which ultimately fertilized the soil. The first of the three fields was often planted during the spring months and contained legumes (beans and peas) that provided additional nitrogen to the soil. In the winter, cereal grains (wheat and rye) were often planted. The following year, the fields would rotate and a previously used field would become fallow. Although year-round farming is not possible in many areas of the world, Medieval Europe had very mild weather.

Today's farmers and agriculturists still use forms of crop rotation. They also have a better understanding of how soil nutrients, fertilizers, and pesticides contribute to crop production and sustainability.

Resources:

The following lessons and activities were developed with information from:

- http://www.flowofhistory.com/units/west/10/FC63
- http://www.infonet-biovision.org/default/ct/251/soilfertilitymanagement
- http://www.britannica.com/EBchecked/topic/611244/two-field-system
- http://www.princeton.edu/~achaney/tmve/wiki100k/docs/Crop_rotation.html
- http://studyjams.scholastic.com/studyjams/jams/science/ecosystems/nitrogen-cycle.htm
- http://www.classzone.com/books/ml_science_share/vis_sim/em05_pg20_nitrogen/em05_pg20_nitrogen.swf
- https://www.youtube.com/watch?v=QgcvFhMw4dk