

Problem-Based Mathematics: You Reap What You Sow

Crop Yield Analysis and Distribution



NOTES

Logistics: In this lesson, students will further analyze the three-field rotation system that was developed in the previous exercise. First, students will use information in a table to calculate the total crop yield of each field. Then, in a probability-based application, students will determine how random weather factors impacted crop yield and if any of their product was infested by pests. Finally, students will calculate the total profit from the crop yield and determine what percentage of the profit will be distributed amongst multiple commodities (i.e., family consumption, rent, sold for goods, etc.).

Materials:

per student:

1 – copy of the Student Pages

per group of two or three students:

1 – **Completed** Three-Field Rotation System Field Template

1 – Die

for the teacher (optional):

1 – Computer with Projector

Time: One to two 60-minute class period(s)

Objectives:

- Gain a historical perspective of the significance of agriculture and farming in the Medieval period. **RH.6-8.4, RH.6-8.7**
- Implement mathematical concepts (i.e., rates, probability, and number operations) representative of the effects of scientific variables in agriculture to determine overall crop yield. **MS-LS2-1, SEP2, SEP4, SEP5, SEP7, CCSS.MATH.CONTENT.5.NF.B.7.C, CCSS.MATH.CONTENT.7.SP.C.5, MP1, MP2, MP4**
- Mathematically calculate and represent the distribution of wealth amongst various quantities as a percent of the whole. **CCSS.MATH.CONTENT.6.RP.A.3.C, CCSS.MATH.CONTENT.7.RP.A.3**

Introduction: Students will use their completed Three-Field Rotation System Field Template (with arranged Crop Cards) to calculate their total crop yield and resulting profit. Prior to doing these calculations, students will revisit the idea that weather and pests are threatening variables that often deplete crop production. Students will also complete a series of

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mathematic skills that require the understanding of increasing and decreasing values by unit fractions, determining the percent of a total, and displaying data in a circle graph.

Activity:

Part I (30-60 minutes):

To begin, have students return to their original groups of two or three, and distribute the first student page, titled **Farming Factors Chart**.

Allow the students time to explore the chart, and discuss the information with a partner. Take several minutes to review the information with the students.

Explain to the students that they will be determining their crop yield and overall profit of their fields, but they must also take into consideration the various variables in farming, which they summarized in the *Farming Factors* lesson. To do this, students will complete a series of calculations. Review the **Farming Factors Chart** and procedures with the students to make sure they understand the tasks. As you review the chart, post the following questions to students:

Crop Yield: Students will first calculate the total crop yield per field for each year. Each crop is measured in bushels, and each bushel is valued at a specific amount. With this information, students will determine the total amount of crops that were initially produced (prior to weather and pests), and eventually calculate their total profit.



What do you think a bushel is?



How will you determine the overall profit for an entire year? What information will you use?



Pest Infestation: If any crops are planted *adjacent* to one another, either vertically or horizontally, have been infested. Students will reduce both infested crop yields by $\frac{1}{2}$. Students may need assistance with this calculation.

Math Vocabulary

- *Total*
- *Adjacent*
- *Consecutive*
- *Percent*
- *Circle Graph*

Calculators are optional!

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-  What does the word “adjacent” mean?
-  What would it look like if two crops were horizontally adjacent to one another?
-  What would it look like if two crops were vertically adjacent to one another?
-  What does the word “reduce” mean?
-  How do you reduce a number by $\frac{1}{2}$? Is there more than one way?

Weather: Students will determine how weather impacted each year’s crop supply by rolling a dice. Some outcomes will increase the crop yield by $\frac{1}{4}$, while others will decrease the production by $\frac{1}{4}$. “Lucky” students may have perfect weather and avoid a decrease in their crop yield. Students may need assistance with this calculation.

-  What is the likelihood that a weather factor will increase your crop yield?
-  What is the likelihood that a weather factor will decrease your crop yield?
-  What is the likelihood that you will roll “perfect weather”?
-  How do I increase a value by $\frac{1}{4}$? What is 36 increased by $\frac{1}{4}$?
-  How do I decrease a value by $\frac{1}{4}$? What is 36 decreased by $\frac{1}{4}$?

When students have a strong understanding of how to read and use the **Farming Factors Chart**, pass out the next two student pages titled, **Three-Field Rotation System Analysis**. Inform the students that they will record their mathematics in this table.



Students will use the **Farming Factors Chart** to fill in the **Three-Field Rotation System Analysis**.

Students should work together to complete these calculations, and may need to utilize a calculator. While students are

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working, you may wish to walk around the classroom to verify that they are correctly completing their work. *Note: Depending on student ability, you may wish to model the calculations for one year.*

An example of student work (for one year) may look like the following image. Notice, *n/a* indicates that pest infestation was not an issue. Also, a was rolled, so all crop yields increased by $\frac{1}{4}$.



Year	Field #	Crop Names	Crop Yield	Pest Infestation (include amount of increase or decrease)	Yield Adjusted for Pest Infestation	Weather Factors (include amount of increase or decrease)	Yield Adjusted for Weather	Crop Profit (per bushel)	Total Profit
1	1	Barley	36	n/a	36	+ 8	44	35	2,724
		Fennel	14	n/a	14	+ 4	16	26	
	2	Fava Bean	18	n/a	18	+ 5	23	16	
		Field Pea	16	n/a	16	+ 4	20	20	
3	FALLOW FIELD	X	X	X	X	X	X		

Debrief Part I:



When all small groups have completed their analysis, reconvene as a whole class and select individuals to discuss the following questions:

- ✓ **Were some crops more valuable than others? Why do you think this is?**
- ✓ **Did weather or pest infestations impact your crop yield more severally? Use data to support your conclusion.**
- ✓ **Describe why the three-crop rotation system is an efficient way to grow crops.**
- ✓ **If you were to do this exercise again, what would you do differently?**

Part 2 (30-60 minutes):

Next, students will analyze how medieval farmers distributed their overall profit from growing crops. To remind students of the various types of distributions that were made, refer students back to the book *Till Year's Good End*.

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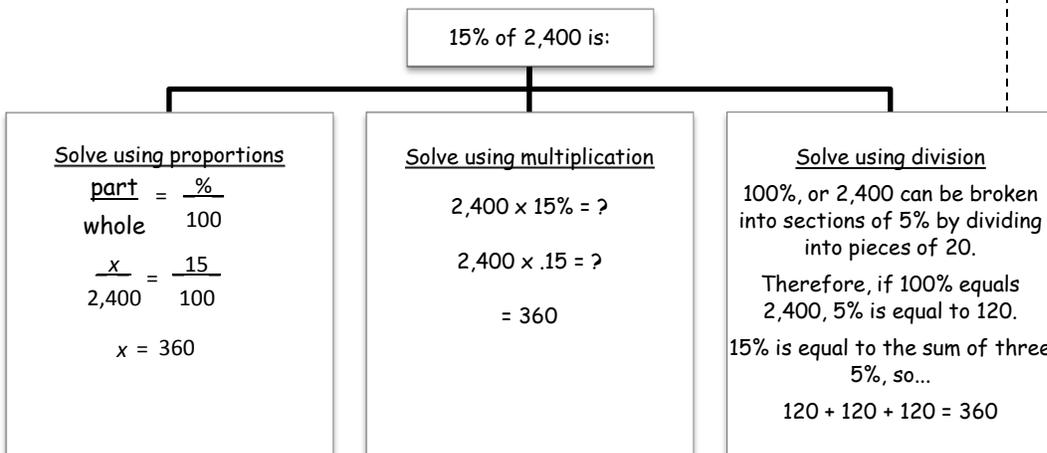
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Pass out the remaining two student pages titled, **Profit Distribution**. Inform the students they will choose ONE year from their field rotation to analyze. First, using calculations, students will determine how much of their **total** profit is used for family consumption, rent, replanting, machinery maintenance, and goods for selling.

To complete these calculations, students should be familiar with determining a percent of a number. The following questions will prompt student discussion regarding this concept:

- **What is a percent?**
- **What other ways can you represent a percent?**
- **If I know 50% of a number, how could I determine 25% of that same number? 10%? 5%?**
- **How can I determine the percent of a number?**
- **What is the sum of the percent values? Why would this be?**

There are a variety of ways to instructionally present this mathematical concept. The figure below shows several methods:



***NOTE:** Depending on student knowledge, you may wish to complete the first calculation as a whole class, and then allow time for the students to finish the task. There are multiple ways for students to arrive at a solution, so encourage students to investigate alternative ways to complete their work.*

Finally, students will represent this information in a circle graph. To prepare the students, pose the following questions in a whole class discussion:

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- **What percent value does the entire circle graph represent?**
- **Will each of your circle graphs represent the same amount in terms of profit? Why or why not?**
- **Which portion of your circle graph will be the largest?**
- **Which portion(s) of your circle graph will be the smallest?**
- **How should we begin splitting our circle into the appropriate percentages?**
- **How can I represent which section of the circle graph relates to each type of distribution?**

Allow an appropriate amount of time for students to complete their circle graphs. All graphs should have a title and key. You may wish to have students display their graphs around the room and complete a gallery walk. During this time, encourage students to explore that although each group was required to use the same percentage for each type of distribution, the profit value differed between groups. For example, although everyone was required to “give” 50% of their profit for land rent, that may have equated to \$120 for one group, but only \$87 for another group.

Debrief Part 2:



When all students have finished their investigation, reconvene as a whole class and select individuals to discuss the following questions:

- ✓ **Why did some people spend more of their profit on land rent (and other distributions) than others?**
- ✓ **How much more money do you spend on “sell for goods” than “replanting stock”?**
- ✓ **How much larger is the “land rent” section of your circle graph than the “machinery” section?**
- ✓ **Why is it important to include a key when you represent data in a circle graph?**



Farming Factors Chart

Crop Yield & Profit			Pest Infestation	Weather Factors
Crop	Yield per Field (in bushels)	Profit (per bushel)	<p>To determine if pests have infested your fields, analyze the location of your crops on the field template.</p> <p>If any two identical crops are <i>directly adjacent to one another</i>, either horizontally or vertically, they have been infested.</p> <div style="text-align: center; margin: 10px 0;"> </div> <p>Reduce both infested crop yields by ½. Round all values to the nearest whole number.</p> <p>Example: In Year 3, onions (30 bushels) and oats (40 bushels) were planted adjacent to one another.</p> <div style="margin-top: 10px;"> $\frac{\text{Infested Crop Yield}}{2} = \text{New Crop Yield}$ $\frac{30}{2} = 15 \text{ bushels of onions}$ $\frac{40}{2} = 20 \text{ bushels of oats}$ </div>	<p>To determine the weather implications that affected your crops, roll a dice.</p> <div style="margin-top: 10px;"> Frost - ¼ </div> <div style="margin-top: 10px;"> Sun Light + ¼ </div> <div style="margin-top: 10px;"> Perfect Weather! No Change </div> <div style="margin-top: 10px;"> Drought - ¼ </div> <div style="margin-top: 10px;"> Humidity + ¼ </div> <div style="margin-top: 10px;"> Flooding - ¼ </div> <p style="margin-top: 20px;">After each roll, apply the formula to each crop yield for that year.</p> <p style="margin-top: 10px;"><i>Round all values to the nearest whole number.</i></p>
Barley	36	35		
Beetroot	24	18		
Black Mustard	26	14		
Cabbage	20	25		
Fava Bean	22	16		
Fennel	12	26		
Field Pea	14	20		
Flax	38	38		
Lentil	32	18		
Lettuce	16	28		
Oats	40	32		
Onion	28	28		
Parsnip	30	22		
Radish	18	20		
Rye	34	30		
Wheat	42	40		



Three-Field Rotation System Analysis

Year	Field #	Crop Names	Crop Yield	Pest Infestation (include amount of increase or decrease)	Yield Adjusted for Pest Infestation	Weather Factors (include amount of increase or decrease)	Yield Adjusted for Weather	Crop Profit (per bushel)	Total Profit	
1	1									
	2									
2	3	FALLOW FIELD	X	X	X	X	X	X		
	2									
3	1									
	2	FALLOW FIELD	X	X	X	X	X		X	
3										



Three-Field Rotation System Analysis

Year	Field #	Crop Names	Crop Yield	Pest Infestation (include amount of increase or decrease)	Yield Adjusted for Pest Infestation	Weather Factors (include amount of increase or decrease)	Yield Adjusted for Weather	Crop Profit (per bushel)	Total Profit
4	1								
	2								
	3	FALLOW FIELD	X	X	X	X	X	X	
5	1	FALLOW FIELD	X	X	X	X	X	X	
	2								
	3								
6	1								
	2	FALLOW FIELD	X	X	X	X	X	X	
	3								



Profit Distribution

Crop Yield Analysis: As depicted in the book *Till Year's Good End*, crops that were grown by a farmer not only provided for their family, but were also used to collect seeds for replanting, pay rent for the land, and were often sold for goods.

Calculations:

- 1.) Choose **one** year from the *Three-Field Rotation System Analysis*: Year # _____
- 2.) Determine the **total profit** (in ducats) of that year: _____
- 3.) Complete the following calculations and determine how much of the total profit is used for each item:

Land Rent 50%	➔	Work:	➔	50% of _____ is:
Family Consumption 25%	➔	Work:	➔	25% of _____ is:
Sell For Goods 15%	➔	Work:	➔	15% of _____ is:
Replanting Stock 5%	➔	Work:	➔	5% of _____ is:
Machinery (Ox & Plow) 5%	➔	Work:	➔	5% of _____ is:



Profit Distributon

Using this data, construct a circle graph that illustrates the distribution of the total profit. Provide a key if necessary:

