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Objectives:

- Identify multiple row spacing models used by soybean farmers and determine how these planting arrangements impact crop yield.
- Explore how row spacing influences the amount of access that a plant has to the natural resources it needs to grow.
- Recommend a row spacing model that considers overall yield, economic efficiency, and potential environmental threats for a hypothetical farmer.

Background Information

Illinois is a leading **soybean** producing state. With loamy, nitrogen rich soil and a mild climate, Illinois serves as a perfect environment for these bushy, pod-bearing, warm weather legumes. Each year, at the beginning of the season, farmers develop a systematic approach to preparing their fields for planting. With the goal of optimizing yield, soybean farmers must determine how to maximize factors that lead to the growth of healthy, fruitful crops.

To achieve higher yields, these farmers prepare a management system that exercises best agronomic practices. One of these practices includes determining an appropriate **row spacing** model that uniformly distributes plants to maximize the crop's access to the natural resources and nutrients necessary for growth. Historically, soybeans have been planted in **30"** rows. However, recent research has indicated that narrower row spacing arrangements (i.e., **15"**, **10"** and **7.5"**) have resulted in higher yields.

Data has indicated that narrow row spacing of less than 30" provides soybean plants with the most access to sunlight, thus maximizing the opportunity for photosynthesis. As individual plants grow, their canopy becomes dense, and as a result, blocks sunlight from reaching the soil. Therefore, narrow row spacing also promotes soil moisture retention and decreased levels of weed growth. However, with a dense plant population, air circulation is often compromised and the risk of white mold growth and soybean cyst nematode infestation is increased. With the possibility of losing crops to disease, some farmers prefer wider row spacing models.

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Of course, economic factors such as equipment costs, workload expenses, harvesting efficiency and crop maintenance supplies (i.e. insecticides, fertilizer, herbicides, etc.) also influence a farmer's management plan. In the beginning of the season, farmers must determine the amount of seed needed to plant in their fields. Wider row spacing models accommodate less soybean plants per acre, so the cost of seed is potentially lower than that of narrow spaced fields. However, with more plants per acre, data indicates that 7.5"-15" fields produce 3-5 bushels of soybeans per acre more than 30" rows. So, although the initial cost of purchasing seed may be more expensive for narrow rows, the return on investment in terms of crop yield may outweigh that of wider spaced models.

Today, 72% of Illinois soybean farmers plant their seeds in rows less than 30". With the goal of minimizing input costs and increasing profitability, farmers must consider a variety of factors, including row spacing. In the following activity, students will explore and evaluate these factors to determine the "optimal" row spacing model.

Inquiry Overview

In this activity, students will investigate three soybean row spacing models that are traditionally utilized by Illinois farmers. Collecting information to present a recommendation to a hypothetical farmer, students will first explore one of three specific models to determine the field's potential yield and economic requirements. Students will then disburse into small groups where they will evaluate the remaining two row spacing options. In this setting, students will analyze the economic efficiency, potential environmental threats and the amount of access that crops have to natural resources as a result of each row spacing arrangement. Finally, students will select one row spacing model, or hybrid model, to recommend to the farmer. Student groups will prepare a brief presentation outlining the benefits and associated risks of implementing their array by citing and referencing the information and data that was collected throughout their investigation.

Activities

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Activity 1: Planting in Rows

Objectives:

- Identify multiple row spacing models used by soybean farmers and determine how these planting arrangements impact crop yield.
- Explore how row spacing influences the amount of access that a plant has to the natural resources it needs to grow.
- Recommend a row spacing model that considers overall yield, economic efficiency, and potential environmental threats for a hypothetical farmer.

Standards:

NGSS: SEP1, SEP2, SEP3, SEP4, SEP5, SEP7, SEP8
CCSS Mathematics: 7.NS.A.3, 7.EE.B.4, MP1, MP2, MP6
CCSS ELA/Literacy: RI.6.7, W.6-8.1, SL.6-8.1

***Estimated Time*:**

- **5 Minutes – Introductory Discussion**
- **15 Minutes – Field Card Analysis**
- **20 Minutes – Group Consensus and Recommendation**
- **20 Minutes – Presentation and Debrief**

Planting in Rows
Materials:
for each student:
- Student Pages

for each team of 3:
- Set of Field Cards

for the teacher:
- Computer with Internet Access

Advanced Planning:

Students will complete this activity by participating in two small groups. In the first arrangement, students will become an "expert "of a field, and then later form a second small group to share their information with other field "experts". Prior to beginning the activity, determine how you will distribute the Field Cards. It is recommended that an equal number of Field A, B and C cards are passed out to students, so that the second small group contains "experts" from each field.

Suggested Inquiry Approach:

To begin, arrange students in small groups of three (or another predetermined size). Pose the following questions to the class:

- **How might farmers arrange crops in their fields?**

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- **Why do you think farmers plant crops, such as corn and soybeans, in rows?**

Elicit responses from volunteers. If students are struggling to answer the question, ask them to reflect on the farm fields they may have seen in pictures, while driving along the highway, or in the media.

Next, ask students:

- **What factors impact the growth of a crop?**
- **What do you think farmers have to consider before planting seeds?**

Allow student teams a few minutes to discuss their answer as a group, and then ask for volunteers to share their thoughts. You may choose to record student responses on a whiteboard or chart paper to reference throughout this activity.

Part 1:

Distribute the student pages. Select one volunteer to read the background information aloud. Then, read the Farming Recommendation together. To propose a legitimate recommendation, students will have to analyze data, ask intentional questions, and seek additional information related to soybean farming practices.

At this time, provide each student group one Field Card. For the initial part of this activity, **each member in the group should receive the same field** (i.e., Field A, Field B, or Field C). Explain to the students that they will become the "expert" of this field and will later join team members of other groups to learn about the remaining two fields.

Working in this group, students will follow a series of procedures to investigate their specific field. First, they will make simple observations.

If students are struggling to gather observations from their card, you may choose to pose the following questions:

- **Explain the location of plants within the row. How are they spaced within the row and between rows?**
- **Describe the canopy closure. Do you think this is important?**
- **How many soybean plants have grown in the field sample illustrated on your card?**

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- **What additional information would you request in order to develop your recommendation?**

Students will now use the information on the card to determine the yield (in bushels per acre) of soybeans produced in their field. The following equation can be used to determine this value:

(plants per acre · pods per plant · seeds per pod) ÷ (seeds per pound) ÷ (pound per bushel)

Students will then explore the "economic efficiency" of their field by completing two calculations: **determining the cost of purchasing the soybean seeds** and **expected income gained by selling their bushels of soybeans** after harvest.

Finally, students will consider how their row spacing model influences crop yield by providing plants access to the natural resources needed to grow. These factors include efficient use of sunlight and soil moisture. Students will also consider if the arrangement promotes the growth of weeds, mold and other yield-depleting diseases. Allow students adequate time to discuss these elements, as they are important factors to consider when predicting crop yield.

After each group has come to a consensus and recorded their explanations, you may choose to briefly review their work.

Part 2:

Students will now form new groups of three (or another predetermined size) with "experts" from the remaining two fields. Provide students with clear directions on how to form these teams. Each group should have an "expert" from Fields A, B, and C.

In their new groups, students will take several minutes to compare their three fields. Encourage the students to spend adequate time gathering information from each field. This is an important step in the process of understanding the pros and cons of each row spacing model.

During this time, students may make the following observations:

- **Field A contains the largest number plants per acre. Field C contains the fewest number of plants per acre.**
- **Canopy closure is most dense in Field A, and least dense in Field C.**

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- **Field A produces the least number of pods per plant while Field C produces the largest.**
- **All fields seem to produce the same number of seeds per pod.**
- **Field A requires the farmer to purchase two bags of soybean seeds (with a large amount of "leftovers"), Field B only one bag, and Field C requires one bag (also with "leftovers").**
- **Field A produces the largest crop yield, and therefore, provides the farmer with the largest profit.**

With additional information, students will now reevaluate how row spacing provides plants access to natural resources and nutrients needed to grow. Students should complete this table by making comparisons across all fields.

Finally, student groups will use all of the information and data explored throughout the activity to develop their recommendation for the farmer. This document should contain the benefits and risks of using the recommended row spacing model, as well as an explanation of how it is "economically efficient".

When all groups have finished, allow time for each group to present their recommendation. Then, debrief the activity as a class.

Debrief Activity 1:

- ***How does plant spacing, both between rows and within rows, contribute to yield?***
- ***What are the pros and cons of planting in rows less than 30 inches? Rows 30 inches or greater?***
- ***What additional factors contribute to a farmer's decision of how to space their rows?***
- ***Would your recommendation change if the farmer had a 160 acre farm? Why or why not?***

EXTENSION

Students may choose to monitor the Soybean Planting Map. This website provides weekly crop estimates of the percent of soybeans planted in each state. Navigate to: http://www.agweb.com/soybean-planting-map/.

Background Information: Illinois is a leading **soybean** producing state. With loamy, nitrogen rich soil and a mild climate, Illinois serves as a perfect growing environment for these bushy, pod-bearing, warm weather legumes. Each year, farmers plant and harvest soybeans with the ultimate goal of optimizing yield while making responsible economic decisions. There are a variety of factors that contribute to the success of a crop, including the amount of space between individual rows. Providing each plant with an equal opportunity to obtain moisture, sunlight and nutrients makes **row spacing** an important consideration in a farmer's management system. Recently, scientists have collected data regarding a possible relationship between row spacing (**7.5"**, **15"** and **30"**) and its impact on soybean yields (in bushels per acre). Farmers use this data to develop a systematic approach in preparing their fields.

Farming Recommendation: A local farmer has become discouraged with the low soybean yield that his fields have produced over the last several years. His soybean plots have produced small, dry, shriveled plants and are often overpopulated with weeds and pests. The farmer has contacted your IMSA FUSION team inquiring about row spacing recommendations that may improve the growth and overall yield of his soybean fields. The recommendation must also be economically efficient. In order to make an appropriate recommendation, you will need to investigate several planting models to determine how row spacing may have an impact on crop yield.

To begin, your small group will receive one Field Card from your instructor. Each Field Card illustrates one of three row spacing models that you will investigate and potentially recommend to the farmer. You and your teammates will become the "expert" of this field and then join members of other groups to learn about the other two fields. In the second team, you will develop your recommendation for the farmer, and include data and information from your discussions.

Procedure:

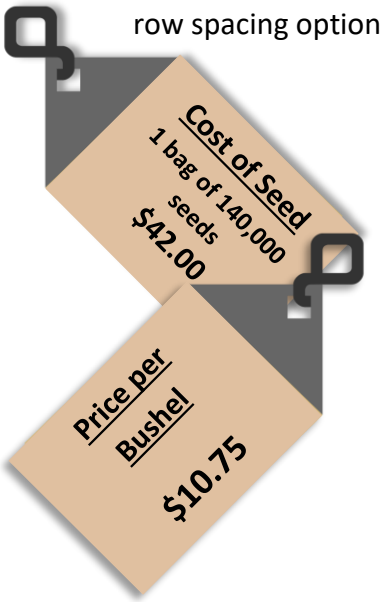
1. Obtain a Field Card from your instructor and record your team's designation and row spacing measurement: _____

2. Take several minutes to observe your card. Record any observations below:

3. The farmer's goal is to optimize his soybean yield by strategically spacing his seeds. Using the information provided on your card, write an equation that would determine the yield (bushels per acre) of soybeans produced in your field. Then, solve.

Yield (bu/acre): _____

4. Besides increasing yield, the farmer requested that your recommendation be "economically efficient". Use the additional information below to complete several calculations that would be useful for the farmer to consider when determining which row spacing option would be economically appropriate.



5. Row spacing influences crop yield because it often determines the amount of access that a plant has to the natural resources it needs to grow. Several examples are listed below. With your group, identify how the spacing of your field would impact the crop yield by providing access to these factors. Include an explanation of your reasoning.

Element	Impact on Crop Yield	Explanation
Efficient Use of Sunlight *Do crops get more or less access to sunlight?*		
Soil Moisture *Does the soil maintain or lose moisture?*		
Growth of Weeds *Does the arrangement of crops promote the growth of weeds?*		
Growth of Mold and Diseases *Does the arrangement of crops promote the growth of disease?*		

6. You will now form a new small group with two "experts" from additional fields. Listen to your instructor for directions.

7. In your new group, take several minutes to compare Field A, Field B, and Field C row spacing models. Observe the illustration of the canopy closure and take turns sharing the data and calculations you collected in your previous groups. Record important information below:

Field A	**Field B**	**Field C**

8. Next, reconsider how the spacing of a field impacts the crop yield by providing access to natural resources. You now have three models to consider. Does one row spacing arrangement provide more or less access to these elements? How will it impact crop yield? Record all information and include an explanation of your reasoning.

Element	**Impact on Crop Yield**		
	7.5" Row Spacing	**15" Row Spacing**	**30" Row Spacing**
Efficient Use of Sunlight *Do crops get more or less access to sunlight?*			
Soil Moisture *Does the soil maintain or lose moisture?*			
Growth of Weeds *Does the arrangement of crops promote the growth of weeds?*			
Growth of Mold and Diseases *Does the arrangement of crops promote the growth of disease?*			

9. Finally, as a group, use all of the information and data that you have explored to determine a row spacing recommendation for the farmer. In the space below, design your recommendation. A complete recommendation must include the benefits and risks of using the row spacing model, as well as an explanation of how it is "economically efficient".

10. Be prepared to present your recommendation to the class.