



Grade 3 to 5

FACILITATOR GUIDE
Soil Permeability &
Soybean Production Lab





Grade 3 to 5: Soil Permeability & Soybean Production

Length: 105 minutes

Objectives: Students will be able to:

1. Measure the permeability (rate which water flows) of three different soil types
2. Calculate averages using multiple pieces of data
3. Analyze data to rank the samples based on collected evidence about soil types
4. Apply the analysis to growing soybean plants

Standards Addressed:

South Dakota Science Standards:

3-LS4-3: Construct an argument with evidence how some organisms thrive, some struggle to survive, and some cannot survive in a particular habitat.

4-LS1-1: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

5-LS1-1: Support an argument that plants get the materials they need to grow chiefly from air and water.

Common Core – English Language Arts:

Literacy.RI.4.7: Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.

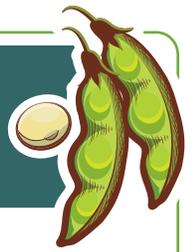
Literacy.W.4.1.b: Provide reasons that are supported by facts and details.

Literacy.SL.4.1.b: Follow agreed-upon rules for discussions and carry out assigned roles.

Common Core – Math:

4.NBT.A.3: Use place value understanding to round multi-digit whole numbers to any place.

4.MD.A.1: Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table.

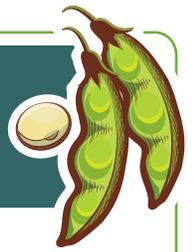


Material List

- Soil Scientist Log (1 for each student)
- Soil Samples — 5-gallon bucket at least half-full of each soil
 - Label the 3 samples as follows:
 - “Sample A” should contain a clay based sample
 - “Sample B” should contain a sand based sample
 - “Sample C” should contain a loam sample
- Permeability Test Materials (1 set for each group of 3 students)
 - 2 clear plastic cup
 - 1 clear plastic cup with holes in the bottom
 - 9 coffee filters
- Permeability Test Instructions (1 for each group of 3 students)
- Permanent Marker (3 per soil sample station, total of 9)
- Calculator (1 for each group of 3 students)
- Stopwatch (1 for each group of 3 students)
- Writing Utensil (1 for each student)
- Soybean Seeds — To send back to the classroom to make growth observations
- Access to water — Recommend a 5-gallon bucket at each soil sample station

Be sure to discuss with the teacher the logistics of the trip.

If desired, the teacher could likely supply some of the materials.



The chart below is a suggestion for what the farmer/grower would bring and what a teacher and student would bring.

Farmer/Grower	Classroom Teacher
<ul style="list-style-type: none"> • Three Soil Samples <ul style="list-style-type: none"> ○ Label the samples as follows: <ul style="list-style-type: none"> • Sample A = clay sample • Sample B = sand sample • Sample C = loam sample • Clear Plastic Cups – no holes <ul style="list-style-type: none"> ○ 2 for each group of 3 students • Clear Plastic Cups – holes <ul style="list-style-type: none"> ○ 1 for each group of 3 students ○ Drill ¼” holes in bottom of cups, 6 to 10 holes is ideal. Whatever number of holes works for the size of cup used, make all cups have that same number of holes. Drill multiple cups at once in a stack. • Coffee Filters <ul style="list-style-type: none"> ○ 9 for each group of 3 students • Permanent Markers <ul style="list-style-type: none"> ○ 3 per soil sample station, total of 9 • Soybean Seeds • Water 	<ul style="list-style-type: none"> • Copies of Soil Scientist Log <ul style="list-style-type: none"> ○ 1 for each student ○ Supply original copy to teacher early • Permeability Test Instructions <ul style="list-style-type: none"> ○ 1 for each group of 3 students ○ Supply original copy to teacher early <p style="background-color: #fff9c4; padding: 5px;">Ask Students to bring:</p> <ul style="list-style-type: none"> • Calculator <ul style="list-style-type: none"> ○ 1 for each group of 3 students • Stopwatch <ul style="list-style-type: none"> ○ 1 for each group of 3 students • Writing Utensil <ul style="list-style-type: none"> ○ 1 for each student <p style="background-color: #fff9c4; padding: 5px;">Suggestion: Folder or firm surface to use when writing data on paper out in the field.</p>



Introduction and Welcome (10 Minutes)

Facilitator opens the lesson by welcoming everyone to the site.

1. Facilitator has three containers (5-gallon buckets) each with a different soil in the container (one clay based, one sand based and one close to a loam).
2. Direct student's attention to the soils to discuss the following sequence of questions. The underlined words are terms that come up again in the lab.
 - a. Who can tell me what this is? (referring to soil)
 - i. Elicit responses: Among other points shared, be sure to note that each soil sample is different and there are a variety of soils. Point out that even in one field, multiple kinds of soil might exist.
 - ii. Make the connection that a Soil Scientist is someone who studies soil to gather evidence which is used to make decisions on how to use and manage the land.
 - b. Who can tell me what this is? (referring to a soybean plant or soybean seeds)
 - i. Elicit responses: Among other points shared, be sure to note that soybeans are one of South Dakota's top agricultural crops.
 - ii. Make the connection that the soybean plant produces soybean seeds. In the spring, farmers plant the seeds and about 60 days later, or about two months, the single seed will have reproduced to make on average 45 seeds. These soybean seeds are what is harvested in the fall and sold as a commodity which will then be used to a number of products, including: make animal feed and biodiesel.
 - c. What is the relationship between the soybean plant and the soil?
 - i. Elicit responses: Among other points shared, be sure to note that the plant's roots use the soil to hold the plant in place. The roots also take in nutrients the plant needs to survive, like water.
 - ii. Make the connection that between the particles of soil are small air spaces (let student hold a handful of soil to look at this).
 - iii. Note that we need this airspace for plants to properly grow.
 - d. Why do plants need this airspace in the soil?
 - i. Elicit responses: Among other points shared, be sure to note that air, water and other nutrients, moves through the pores in the soil. Use the example of a puddle after a hard rain disappearing after a period of time, because the water is able to move down into the airspaces in the soil.
 - ii. Make it clear that the movement of water through the pores in the soil is called permeability.
 - iii. Discuss how permeability will affect how well a soybean plant can grow.
3. Let students know that today we will explore how water and soil interact. We will do permeability tests similar to a Soil Scientists to identify characteristics about three soil samples. With the data we collect, we will discover which soil would be the best for soybean growth.



Activity 1 – Gathering permeability evidence (60 Minutes)

Instruction given in large group, then break students into groups of three to run tests

Activity 1 Facilitator tips

- Set up 3 areas with different types of soil
 - “Sample A” should contain a clay based sample
 - “Sample B” should contain a sand based sample
 - “Sample C” should contain a loam sample
- If using multiple times, laminate the Permeability Test Instructions to last longer.
- If some students are very quick doing the tests, encourage them to try the same test additional times to make sure their data is accurate.

1. Hand out “Soil Scientist Log” sheet and have students put name on the log sheet.
2. Give Instructions:
 - a. Explain to students for this activity they will be working through three soil samples: A, B and C, to gather evidence to help identify characteristics that would affect soybean growth. A soil scientist would complete similar tests to give recommendations to a farmer on how to best manage the field. The evidence collected in this activity will be used in the next activity to actually grow soybeans, so accuracy and double checking your data is very important.
 - b. Facilitator should verbally explain and physically model to students what needs to be done at each station. Do this by following the instructions on the Permeability Test Instructions card. Tell students that each station has a set of instructions that explain how to collect the required evidence.
 - c. Point out to students they will test permeability of each soil sample: A, B and C.
 - d. Emphasize that we are requiring three trials and will calculate averages at each station to increase accuracy of evidence.
 - e. Tell students the procedure is the same at each station, but they should see a difference in the evidence collected based on the different types of soil.
 - f. After completing the three trials at the station, calculate the average permeability time and write it in the chart.
 - g. Ask “What can I clarify?” and respond accordingly.
 - h. Let students know that you will announce “time to rotate” in about 15 minutes and students should stay at their station until the announcement is made. If they have extra time, run additional tests to check accuracy.
 - i. Break students into groups and sent them to a soil sample station to start.



Soil Permeability & Soybean Production Lab On-Farm Experience



Activity 1 – Gathering permeability evidence (60 Minutes) *Continued*

3. The facilitator will need to keep track of time and announce when the rotations should occur – 15 minutes should be enough time per soil sample.
4. When the final rotation is completed, bring students back together and discuss the evidence they collected from the tests. Groups will likely have different times which is ok as the analysis will be a comparison of each group's individual evidence.

Transition (1 Minute)

1. Tell students: Once a soil scientist completes the necessary test, like permeability, and gathers evidence, they analyze the evidence to identify the characteristics of each field. Let's take a few minutes to analyze our evidence and identify which soil types we think will be the best for producing soybeans.



Activity 2 – Analyzing permeability evidence (10 Minutes)

Instruction given in large group, then student's complete analysis individually and with group

Activity 2 Facilitator Tip:

- Have students do the analysis and ranking individually and then allow them to discuss and defend their rankings to a partner. This will help students further understand their analysis and how they are interpreting the evidence.
- A brief conversation about basic soil composition may be needed for them to understand the “A Soil Scientist Knows” statement.

1. Direct students to the bottom of the Soil Scientist Log page.
 - a. Ask for a volunteer to read “A Soil Scientist Knows”.
 - b. Discuss how this statement applies to ranking the best soil sample for growing soybeans based on the gathered evidence.
2. Direct students to analyze their evidence and rank the soil samples 1st, 2nd, and 3rd.
3. When the students have ranked their sites, have them write “Why” they ranked each soil sample the way they did, noting the relationship between water, soil and plant growth.
4. If time allows, have students discuss ranking with a partner.

Transition (1 Minute)

Tell students: Once a soil scientist has completed an analysis, they will recommend management practices to the farmer to best grow their soybean plants. Permeability is only one of many parameters a soil scientist looks at. However, the interaction of water and soil is one of the most important for plant growth.



Activity 3 – Soil permeability and yield (8 Minutes)

Instruction given in large group, then student's complete analysis individually and with group

Activity 3 Facilitator Tip:

- A brief conversation about what yield is and why it is important to a farmer will very likely be needed prior to completing this activity.
1. Direct students to “Soybean Yield” data chart on the back of the Soil Scientist Log.
 2. Direct students to write the permeability (slow, medium, fast) on the chart based off the data collected on the front of the page.
 3. Have students answer the questions under the Yield table “What is the relationship between soil permeability and soybean yield?”
 4. Discuss how soil permeability and other characteristics can effect plant growth, and ultimately soybean yield.



Activity 4 – Grow soybeans in the soil (5 Minutes)

Start in the field, then to be completed in the classroom

Activity 4 Facilitator Tip:

- Provide soil samples for a class project, or provide materials for each student to run their own test. Ask the teacher which would work best back in the class.
 - Best to provide non-inoculated seed. However, if the seeds contain proprietary genes, such as Roundup Ready® genes, refer to the following disclaimers:
 - *The use of the EPSPS gene, causing glyphosate resistance, in soybeans is proprietary and patented.*
 - *Obtaining and using the soybeans shall provide NO economic gain for any party involved.*
 - *NO soybeans shall be harvested from the plants used in the laboratory.*
 - *ALL soybean seedling must be destroyed at conclusion of the lab experience.*
1. Have the students hypothesize which soil they think will allow soybean seeds to germinate and begin vegetative growth the quickest based off their permeability data.
 2. Lead a discussion through the points on the Soil Scientist Log about writing a hypothesis.
 3. Direct each student to write their hypothesis on the back of the Soil Scientist Log under the “Soybean Growth Hypothesis”.
 4. Give the teacher samples of each soil and soybean seeds to continue their experience by growing seedlings in the classroom.



Review and Close (10 Minutes)

1. When all students have completed the Soil Scientist Log and discussion. Use this as a review activity and application of information into their lives. Suggested review questions/activities could include:
 - a. What kinds of evidence does a soil scientist use to give management advice to farmers about their field sites?
 - b. Why would a soil scientist run the same test multiple times?
 - c. How does soil type effect how soybean plants are able to grow?
 - d. What parts of the plant help the soybean survive, grow and reproduce? And how is this related to the soil?
 - e. Where do plants primarily get the materials they need to grow? And how is that related to soil?
 - f. What does this experience tell us about soil, is all soil the same?
2. Thank the students for coming and send off!

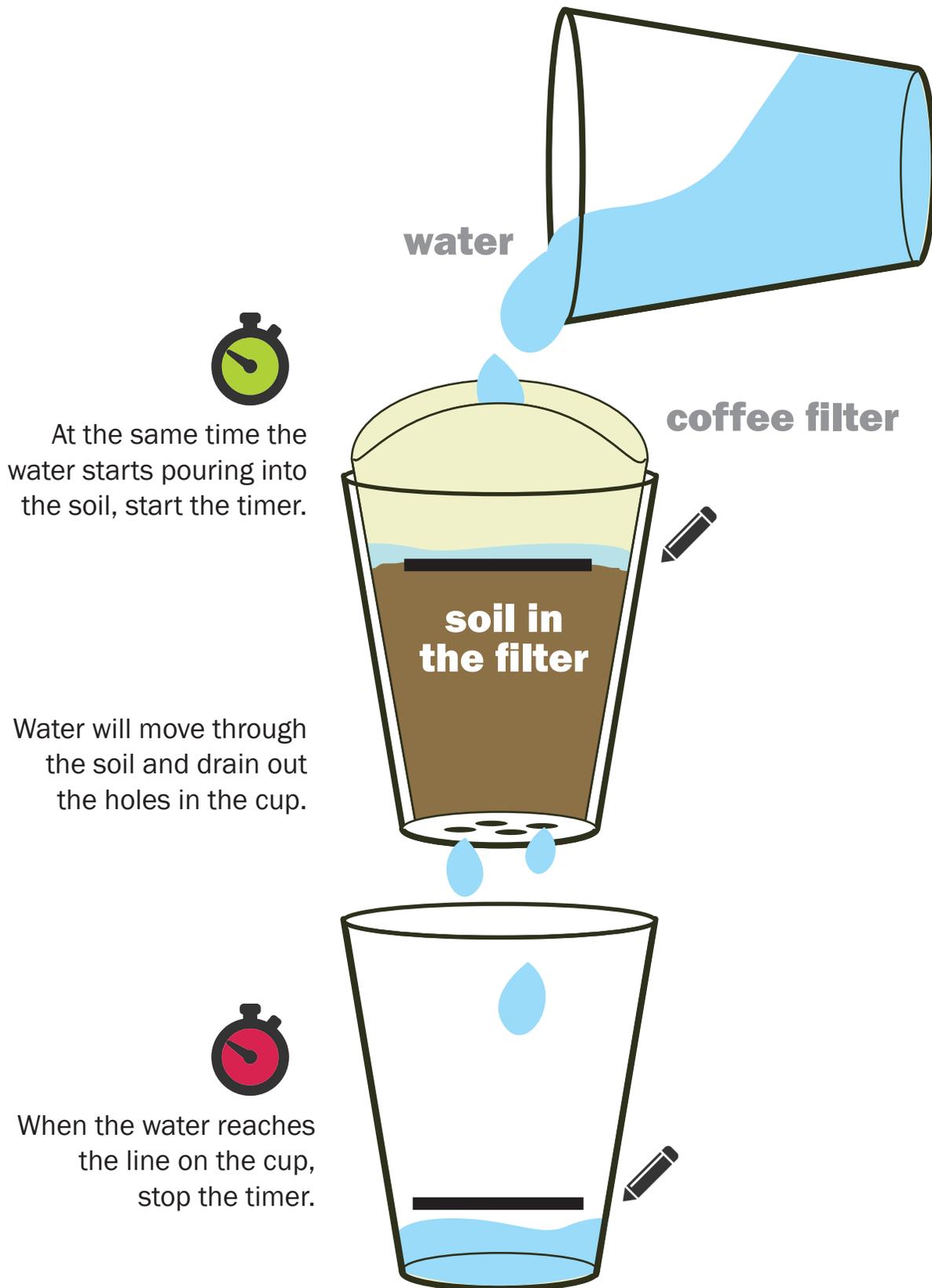


Materials:

1 clear plastic cup (with holes), 2 clear plastic cup (no holes), water, coffee filters, permanent marker

1. Draw a line around the cup with holes about 1 inch from the top.
2. Draw a line around one of the cups without holes about 1 inch from the bottom.
3. Place a coffee filter inside the cup with holes in it. This is your Permeability Test cup.
4. Fill the coffee filter up to the line with soil from the sample area.
5. Fill the cup that is not written on with water.
6. Working as a group complete the following:
 - a. Person 1: Pour water into the cup with coffee filter and soil.
 - b. Person 2: Hold cup with the line 1 in from the bottom under cup with soil to catch the water that moves through the soil.
 - c. Person 3: Start timer at same time Person 1 begins to pour water into the soil. Stop timer when water in cup Person 2 is holding reaches the line.

* Refer to image on back to help visualize each step
7. Record how many seconds it took for the water to move through the Soil Sample.
8. Remove coffee filter and soil, add new coffee filter and soil.
9. Dump water from cup that was catching water moving through soil.
10. Repeat steps 3 through 8 three times for each site.
11. Record all data in the data table.
12. Calculate averages.





Scientists Name _____

Permeability Data Tables

Sample A				
	Trial 1	Trial 2	Trial 3	Average
Time				

Sample B				
	Trial 1	Trial 2	Trial 3	Average
Time				

Sample C				
	Trial 1	Trial 2	Trial 3	Average
Time				

How to Calculate Average = $\frac{\text{Trial 1} + \text{Trial 2} + \text{Trial 3}}{3}$

A Soil Scientist Knows: A soil with medium permeability is desirable for plant growth. It will hold water and nutrients the plant needs and also will let water drain if there is too much. These soils are typically a good mix of sand, silt and clay. Fast permeability will drain water and nutrients away from the plant too quickly. These soils contain high amounts of sand. Slow permeability will hold too much water and could kill off the plant as the roots will not get any oxygen. These soils generally have high amounts of clay in them.

Which soil sample would be the most ideal for soybean growth?

Rank your soil samples based on the evidence collected above.

	Sample Letter	Why do you rank the soil samples the way you did?
1st		
2nd		
3rd		



Soil Scientist Log



Scientists Name _____

Soybean Yield

Soil Sample	Permeability (slow, medium, fast)	Soybean Yield
A		38 bushels per acre
B		32 bushels per acre
C		46 bushels per acre

What is the relationship between soil permeability and soybean yield?

Soybean Growth Hypothesis

A hypothesis is written with three parts: if, then, and because.

If (I do this) , then (this) will happen because (information I know).

1. If (I do this) – refers to the independent (controlled) variables
 - In this lab, we should be talking about planting soybeans in different types of soil.
2. Then (this) will happen – refers to the dependent variable that you will measure and collect data on.
 - In this lab, we should be talking about seed germination, emergence and/or vegetative growth.
3. Because (information I know) – is justification for your educated guess.
 - Use the permeability and yield data to support your hypothesis.

Write your hypothesis:
