Seed to STEM

# Kansas Corn:
## Starts with Soil -
## An Investigation of Soil and Its Properties

This lab is made possible with the support and content contributions of the Kansas Corn Commission.

Kansas Corn Commission

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# Kansas Corn: Starts with Soil
## Grade Level: Middle School

### Overview
In this unit, students will learn about the essential nutrients for the growth of corn plants. Students will also learn how farmers use soil sampling to monitor the health of their fields by analyzing the nutrients it contains. Knowing the soil health in different parts of their fields, farmers can strategically plan what parts of the field needs what types and amounts of fertilizer. Students will learn and practice the proper procedures for collecting a soil sample. They will then examine their soil samples by determining the different soil components, testing for soil pH, and examining how air space allows soil to hold and transmit water. Students will be considering why corn can be in grown in all 50 states, but also what makes Kansas soils so ideally suited to growing corn.

### Kansas College and Career Ready Standards
*Agriculture*
- **4.** Graph & discuss the change in world population over the last 100 years and its impact on land, medicine, food production and supply, and agriculture technology. **(M,E,LA)**
- **5.** Describe the size, number, and what is grown on farms in Kansas and your home county. **(M,E)**
- **6.** Describe the importance of American agriculture in world food production. **(M,E,LA)**

*Careers in Agriculture*
- **2.** Research agriculture career opportunities. **(LK MS 28) (CD)**
- **3.** Identify an example of a career in each sector. **(LK MS 67) (CD)**
- **4.** Identify important skills for all careers. **(LK MS 30)**
- **5.** Identify career interests and preferences. **(LK MS 29) (CD)**

*Plant Systems*
- **1.** Define agronomy. **(LA,E)**

*Natural Resource Systems*
- **4.** Define soil. **(S,E, LA)**

*Environmental Systems*
- **1.** List causes of erosion to soil. **(LA,E)**
- **2.** List important soil and water conservation practices. **(M, LA,E)**

*Teamwork*
- **1.** Participate in team activities, and complete team tasks.
- **2.** Clarify statements, receive and give information, propose alternative plans, and come up with a workable solution.

*Introduction to Agriscience - 18001*
- **025.** Plant Systems
    - **8.** List the requirements for plant growth. **(S)**

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*Introduction to Agriscience - 18001 (continued)*

- **28.** Natural Resource Systems
  - **8.** List the four components of soil. **(S)**
  - **9.** Identify the different soil classes. **(S)**
  - **10.** Compare sand, silt, and clay particles in a soil sample. **(S)**
- **31.** Agricultural Issues
  - **3.** Research a current agriculture issue. **(LA)**
  - **4.** Discuss nutritional needs of humans and the food groups they need. **(S)**
  - **5.** Cite important relationships between land characteristics and water quality.

*Workplace Skills*

- **32.** Listening Skills
  - Follows oral instructions:
    - Listen for and identify key words.
    - Listen for words that identify a procedure.
    - Listen for steps or actions to be performed.
    - Listen for clues regarding the order or sequence in which a task is performed.
- Distinguish fact, opinion, and inference in oral communication.
- Analyze a speaker's point of view.
- Draw conclusions or make generalizations from another's oral communication.

*Language Arts Grade 7:*

- **RI.7.11** Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on Grade 7 reading and content, choosing flexibly from a range of strategies.
- **RI.7.11.a** Use context as a clue to the meaning of a word or phrase.
- **W.7.1** Write arguments to support claims with clear reasons and relevant evidence.
- **SL.7.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.
- **SL.7.2** Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text, or issue under study.
- **SL.7.3** Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and the relevance and sufficiency of the evidence.

*Language Arts Grade 8:*

- **RI.8.11** Determine or clarify the meaning of unknown and multiple-meaning words or phrases based on Grade 8 reading and content, choosing flexibly from a range of strategies. **RI.8.11.a** Use context as a clue to the meaning of a word or phrase.

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*Language Arts Grade 8 (continued)*

- **W.8.1** Write arguments to support claims with clear reasons and relevant evidence. a. Introduce claim(s), acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.
- **SL.8.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on Grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
- **SL.8.2** Analyze the purpose of information presented in diverse media and formats (e.g., visually, quantitatively, orally) and evaluate the motives (e.g., social, commercial, political) behind its presentation.
- **SL.8.3** Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and relevance and sufficiency of the evidence and identifying when irrelevant evidence is introduced.

*Math Grade 7:*

- **7.RP.2.** Recognize and represent proportional relationships between quantities.
    - **7.RP.2a.** Determine whether two quantities are in a proportional relationship.
- **7.SP.5.** Express the probability of a chance event as a number between 0 and 1 that represents the likelihood of the event occurring. (Larger numbers indicate greater likelihood. A probability near 0 indicates an unlikely event, a probability around 1 2 indicates an event that is neither unlikely nor likely, and a probability near 1 indicates a likely event.) **(7.SP.5)**

*Math Grade 8:*

- **8.EE.3.** Read and write numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g. use millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology. **(8.EE.4)**

### Learning Objectives

- Define an essential element.
- Compare and contrast the essential nutrient requirements of plants and humans.
- Explain why plants cannot use elemental nitrogen found in the atmosphere.
- Identify the sources for each essential nutrient needed by plants.
- List aspects of soil composition.
- Understand that soils are living and dynamic.
- Recognize that soils vary in composition and pH.
- Measure the pH of a soil sample using three different methods – pH probe, pH testing kit, and pH paper.
- Explain how pH affects the availability of nutrient uptake by plants.
- Recognize that plants take up water and nutrients from the soil.

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*Learning Objectives (continued)*

- Recognize that growing crops can deplete agricultural soils of nutrients.
- Understand soils provide support for plants' root systems.
- Understand soils hold water and make it accessible to plants.

### Materials

*Materials for Worksheets:*

- Colored pencils
- The Periodic Table Handout (pg. S1, or available online at www.kscorn.com)
- Chemical Symbols of the Elements Worksheet (pg. S2, or available online at www.kscorn.com)
- Sources of Essential Nutrients Handout (pg. S3, or available online at www.kscorn.com)
- Starts with Soil PowerPoint (available online at www.kscorn.com)

*Materials for Soil Sampling:*

- Soil Sampling Guide (pg. S4-S5, or available online at www.kscorn.com)
- Soil Texture Feel Test Sheet (pg. S6-S7, or available online at www.kscorn.com)
- Per group of students:
    - Soil core probe or shovel
    - Bucket (1-5 gal)
    - Empty clear water bottles (1 per student)
    - Tape measure to monitor distances between samples
    - Clipboard with grid to document sample locations
    - Hand trowel or shovel (optional)
    - Optional: Flags or stakes for making a grid in the field

*Materials for Class Demonstration – Separation of Soil Types:*

- 3 clear plastic bottles or glass canning jars (12 oz each)
- Potting soil, local soil, and sand (10 oz each)
- Water
- 1 bottle of dish soap or Calgon Water Softener (helps particles separate)
- Clear rulers (for measuring separated soil particle layers)

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*Materials for Activity Station 1 – Dry Soil:*

- 2 hand lenses
- Pencils
- 1 tsp each of potting soil and local soil
- Dry Soil Investigation Worksheet (3 pages: pg. S8 (1 per student) and pg. S9-10 (1 per group); pg. S8-S10, or available online at www.kscorn.com)

*Materials for Activity Station 2 – Soil and Air Space:*

- 3 clear test tubes or graduated cylinders (50 ml)
- Potting soil, local soil, and sand (1 oz or 30 ml each)
- Water (4 oz or 120 ml)
- 1 ruler
- Soil and Air Space Investigation Worksheet (1 per student; pg. S11, or available online at www.kscorn.com)

*Materials for Activity Station 3 – Soil and Water:*

- 3 clear or translucent graduated cylinders (100 ml)
- Potting soil, local soil, and sand (4 oz or 120 ml each)
- Water (4 oz or 120 ml )
- Soil and Water Investigation Worksheet (1 per student; pg. S12, or available online at www.kscorn.com)

*Materials for Activity Station 4 – Soil pH:*

- Sand
- Soil
- “pH Down” from kit, or white vinegar (or 0.5 M solution of hydrochloric acid)
- “pH Up” from kit, or drain cleaner ( or 0.5 M solution of sodium hydroxide)
- pH testing kit based on barium sulfate
- pH test strips (1-12 range) and litmus paper for quick acid/ base indicators or pH probes
- Distilled water
- Soil pH Investigation Worksheet (1 per student; pg. S13-S15, or available online at www.kscorn.com)

*Materials for The Big Apple: Demonstration for Land Use*

- Apple
- Paring knife
- Small cutting board

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### Safety Considerations
Proper personal protective equipment should be used at all times during laboratory activities. For these labs it is recommended that students be equipped with safety glasses or goggles, have latex or neoprene gloves made available to them, and lab coats or aprons are recommended to protect clothing.

### Procedures for Instruction
Length of Time for preparation: 60 minutes
Length of Time for Classroom Teaching: 60 minutes

*Preparation Procedure*

**Classroom Demonstration – Separation of Soil Types:** Prepare soil separation bottles/jars at least one day before making observations. Bottles can be prepared ahead of time by students. Clear plastic, 12-oz bottles work well. Fill each bottle about 2/3 full of soil. Place potting soil, local soil, and sand in separate bottles. Add water to near the top of each bottle. Place caps on the bottles, and shake the contents well. Place the bottles in a location where they will not be disturbed. Adding a squirt of clear dish detergent, or Calgon Water Softener, can aid in separation of soil particles.

**Classroom Setup for Activity Stations:**
Divide the class into groups for the four activities.  For larger classes the room can be set up into eight groups, having two of each of the activity stations.

These four activities can be done as rotations in which students travel to each of the four activities and do the procedure listed with their soil sample. or you can complete each of these activities separately, as an entire class.

- **Activity Station 1 - Dry Soil Investigation:** Make available potting soil and the local soil collected earlier, (about 1 tsp for each group of 4 students). Have hand lenses available and Dry Soil Investigation Worksheet (pg. S8 (1 per student) and pg. S9-10 (1 per group); pg. S8-10, or available online at www.kscorn.com)

- **Activity Station 2 - Soil and air space:** Provide three clear test tubes that can hold 50 ml.  If these are not available, you can use graduated cylinders. Make available at least 1 oz (30 ml) each of potting soil, local soil, and sand.  Have a ruler and a container that holds at least 120 ml of water and Soil and Air Space Investigation Worksheet (1 copy per student; pg. S11, or available online at www.kscorn.com)

- **Activity Station 3 - Soil and Water:** Provide three 100-ml graduated cylinders, at least 120 ml each of potting soil, local soil, and sand. Provide a container that holds at least 120 ml of water and Soil and Water Investigation Worksheet (1 copy per student; pg. S12, or available online at www.kscorn.com)

- **Activity Station 4 - Soil pH:**
  - Prepare the three soil samples. Split the soil into three containers. When finished, samples should be close to a pH of 5.0, 6.5, & 8.0. This will require a little trial and error. Mix a little bit of soil with sand to make a soil mixture with little buffering capacity. The sandy texture of the soil will reduce the soil's resistance to changing pH when you add acid or base-forming materials.
  - The pH DOWN solution should be used to REDUCE the pH of the soil sample for your pH of 5.0 and pH of 6.5 samples (depending on the starting pH of your soil). Vinegar or 0.5 M solution of hydrochloric acid may be used to lower the pH of the soil sample.
  - The pH UP solution, drain cleaner, or a 0.5 M solution of sodium hydroxide may be used to RAISE the pH of the soil sample to obtain your 8.0 pH sample
  - Add pH UP or pH DOWN in small quantities, stirring the soil to make sure they are incorporated before measuring the soil pH again to measure your progress. Apply pH DOWN to the 1st container of soil, mixing and measuring frequently until you get it to reach 6.5. Repeat for container 2 until pH of 5.0 is reached. If you add too much pH down or vinegar, simply add pH up or a base to bring it back up to where you want it.
  - In the third container add the pH UP solution or drain cleaner until it reaches a pH of 8.0. If you add too much pH up or drain cleaner, simply add pH down or an acid to bring it back up to where you want it.
  - **Note: The soil pH should be known by you, but not by your students. Label the containers, Sample 1 – Adam's Soil, Sample 2 – Brent' Soil, and Sample 3 - Charles's Soil.**

Set up the different types of pH monitoring methods: pH paper, pH meter or probe and pH test kit (usually come with directions for home lawn or garden care). Print Soil pH Investigation Worksheet (1 per student; pg. S13-15, or available online at www.kscorn.com).

### Background Information

During the past 50 years, the population of Earth has more than doubled, yet the amount of land devoted to farming has stayed about the same. During the same time, the world has witnessed impressive gains in agricultural productivity. Farmers in North America produce 300% to 400% more food from the same amount of land. Still, it is estimated that the Earth will hold over 9 billion people by 2050. How will we feed all these additional people in a sustainable manner?

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Farmers are able to increase their crop yields by breeding better plant varieties, adopting better water management practices, and using commercial fertilizers more wisely.

Today, at least one-third of the world's food supply is produced using commercial fertilizers to replace soil nutrients removed by crop harvesting. Fertilizer management practices play a large role in increasing crop production. This is done by ensuring the appropriate type of nutrient is used at the right time, applied in the proper amount, and placed where the plant can most easily use it. These practices also minimize nutrient losses to the environment.

Soil is essential to our survival, as well as for nearly every organism on Earth. Soils are slowly produced by the weathering of rocks. Constant exposure to wind and rain cause the rocky crust of the rock to slowly break down into smaller particles. As rainwater seeps into cracks, temperature extremes cause the water to freeze – the rock expands, contracts, and fractures. It can take centuries to produce fertile topsoil.

These weathering actions are helped along by organisms that live on and in the soil. Soils are composed of inorganic material from rock and organic material derived from living and dead organisms. Both are important to support plant growth.

As inorganic material is broken down by weathering, particles of various size are produced. "Soil texture" refers to the relative proportions of different-sized particles found in the soil. Scientists classify soil particles into three categories – clay, silt, and sand.

The smallest particles, are called "clay". Clay is important in holding nutrients. Clay helps hold nutrients until they are displaced by another element. For example, nutrients can be absorbed by a plant root, eaten by a soil microbe, or chemically stored in the soil for later use by plants. The next largest particles are called "silt". "Sand" refers to the largest particles. Soils vary in their proportions of clay, silt, and sand.

The ability of a soil to accept and retain water is largely determined by the relative amounts of clay, silt, and sand present. "Porosity" refers to spaces in the soil that can hold either air or water. "Permeability" is defined as the rate at which water can travel through soil. Soils with desirable properties for farming are called "loams". Loamy soils typically contain about 50% air space, which allows root systems to "breathe." This is why corn is grown throughout the Midwest where loam is the prevalent soil type.

The solid part of soils is about 90% minerals and 10% organic material. Although the organic fraction of most soils is small in volume compared to the mineral fraction, it plays an important role in supporting plant growth. The organic material is composed of living organisms, plant roots, and plant and animal residue. A single gram of healthy topsoil may contain 100 nematodes (small roundworms), 1 million fungi, and 1 billion bacteria. The soil is a "bank" for nutrients that are absorbed, "withdrawn" by plants, and these nutrients must be replenished, "deposited" for continued plant growth. Kansas soils are especially well suited to the growth of corn, which grows best in the loamy soils that are prevalent throughout the Midwest. Students will be investigating the properties of soils and how it influences the availability of soil nutrients for plant growth. Students will also dig deeper into why our soils are so well suited to growing many different crops, but especially corn.

### Classroom Discussion

Length of Time for Classroom Teaching: 20-40 minutes

Use Starts with Soil PowerPoint available on www.kscorn.com to guide classroom discussion.

1. Guiding question to post as "bell work" or written largely on your board:
   - "What do you need to live?" -- Have students brainstorm what they need to live by prioritizing the things they need the most. If students are struggling with this task, have them rank things based on how long they could live without it, often times it is fun to relate this to survival shows or being stranded on a deserted island.

2. Once students have identified what they truly need to survive, post the periodic table of the elements (Slide 3) and have students try to locate these things that they need most (air, water, food) on the periodic table of the elements.

3. Use Slides 4 and 5 to discuss the elements found in food that they eat, as well as "common knowledge." For example, "milk is high in calcium" and "bananas are high in potassium."

4. Guide students to write a hypothesis regarding which nutrients are essential for plants and for animals, and where or how they get them (Slide 6)
   - An example might be: "Plants and animals have similar nutrient needs, including oxygen and hydrogen from air and water, as well as carbon and nitrogen from the air or from "food." Additional micronutrients can be obtained from the food, plants, or from the soil."

5. Have students test their hypothesis by displaying the essential nutrients for plants and having students color those in green (Slide 7), then essential animal (human) nutrients in blue (Slide 9).

6. Have students examine their table and discuss with their neighbor whether or not the amount of overlap between essential nutrients of plants and animals is surprising to them.

7. Have students write a definition for an "essential nutrient". Next, discuss as a class how to tell if a nutrient is truly essential, and what a plant might look like if it is not receiving that nutrient in the proper amount (Slide 12).

8. Independent activity: Pass out the Sources of Essential Nutrients Worksheet (pg. S3, or available online at www.kscorn.com). Refer to Slide 13, "Choose the Source Activity" students should determine whether they think the essential nutrient comes from the air, water, or soil.

*Class Demonstration: Separation of Soil Types*

**Note:** Be careful when moving the three bottles with the soils settled in water. Excessive movement will cause the soil layers to mix together. Try to keep the bottles undisturbed so later classes can view them.

1. Remind students that in the previous lesson they investigated essential plant nutrients that are found in soils. Ask, "Aside from essential elements, what else do you find in soils?" Guide the discussion toward soil consists of nonliving inorganic material, such as clay, silt, and sand, as well as living and nonliving organic material, such as dead plant material, bacteria, insects, and worms.

2. Show the class the bottles of potting soil, local soil, and sand, which were previously mixed with water and allowed to settle. Ask students to gather around the bottles and make observations about the different soils. Students will observe that the different soils separate differently. The potting soil will show a thick layer of dark material on the bottom, a thick layer of cloudy water, and a thinner layer of organic material on the top. Local soils may differ, but a typical soil will show layering similar to potting soil, though there may be less organic material floating on the surface. Most of the sand will form a very thick layer on the bottom of the container. There will be a thick layer of clear water and a very thin layer of material on the surface.

3. Ask, "Can you identify the organic material in each container?" If necessary, explain that the organic material is less dense than the inorganic material; therefore, it floats on the surface of the water.

4. Explain to students that the cloudiness in the water comes from inorganic particles called "clay", which are so small that they can remain suspended in the water. Point out that most of the nutrients in the soil are found in the organic material and the clay.

5. Ask students the following questions:
    - Do all soils support the growth of plants equally well?
    - Which soil do you think would be best for growing corn?

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Discuss how soils differ in their amounts of organic material and clay, and they will vary in their ability to support plant growth. Briefly discuss best management practices for collecting soil samples, or discuss this outside in the field as you give students directions for collecting soil samples.

### Procedure for Lab

*Collecting Soil Samples*

Length of Time for Collecting Soil Samples: 20 -25 minutes

1. Gather supplies of collecting soil samples. Reference the Soil Sampling Guide (pg. S4-S5, or available online at www.kscorn.com). See Teacher Tips

2. Discuss with students the importance of a "representative sample" by comparing taking samples of the soil to basing demographic data on a random drawing of students from your class. For example, if one student was selected, one would assume that all student were white males wearing t-shirts, jeans, and tennis shoes. Likewise, with soil samples, if you only take one core sample from one area, you might make assumptions about the whole field, which is not a good representation of what the soil is actually like. For this reason, students will need to plot out random soil samples from different quadrants of a field that appear to be a good representation of the field as a whole. This is easiest to measure using a grid system, which you could mark out in advance with stakes or flags to save time, or allow students to create and develop a "system" as an additional supplemental activity.

3. Once students have identified a sample site, demonstrate for students how to use the soil core probe to take a sample of the soil down to a depth of 8-10 inches. Explain that this depth is significant because this is typical root depth and will give you the best idea of nutrients available to the plant. If a probe is not available, shovels can work, but make sure that they are cleaned to prevent contamination of the sample.

4. Students will need to take 10-15 representative cores from a variety of sites throughout the field to be sampled. You may choose to reduce the number of cores collected for the sake of time. **Note: Color coded flags, or numbered wooden stakes can be helpful to identify different sites at which they need to take a soil core sample.**

5. The cores should then be mixed together in the bucket to create a randomized, representative soil sample that students will bring in to use for further analysis in their soil laboratory activities. Typically, one pint of this mixed soil is mailed in to be analyzed through soil testing agencies.

6. Remind students that it is essential to properly label where their soil came from so that when they receive results they know which of the field the results are referring to.

7. **Avoid a messy classroom, by having students stay outside while identifying soil texture with the "feel method". Bring bottles of water and the Soil Texture by Feel Method Guides (pg. S6-S7, or available online at kscorn.com) outside. Using their representative soil sample, students should try to identify the soil texture using the "feel method."** Have students verify that data was recorded, as well as clean equipment before returning to the classroom

Explain that they are now going to investigate some other properties of soils that affect plant growth. Divide the class into groups of four to five students and direct them to their work areas. Students will rotate between four activities to explore the properties of soil and investigate how they may affect the growth of corn.

**Note:** Instruct students to follow the directions on their handouts, record their observations, and answer any questions. Give students approximately 15 minutes to complete their investigations.

*Activity Station 1 – Dry Soil Investigation.*

**Step 1**. Place 1 tsp of potting soil in the center circle of one copy of the graphic organizer and 1 tsp of local soil in the center circle of the other copy of the graphic organizer.

**Step 2.** Use a hand lens and a pencil to sort the soil components into the categories listed on pg. 2 and 3 of the Dry Soil Investigation Worksheet (pg. S8-S10, or available online at kscorn.com).

**Step 3.** Once both soil samples have been separated into their components, compare the results for the two types of soils.

Discussion Questions

1. In what ways are the two soil types similar? How are they different?
2. Can you tell by visual inspection how well a soil will support plant growth? Why or why not?

*Activity Station 2 – Soil and Air Space:*

**Step 1.** Label three 50-ml test tubes "potting soil", "local soil", and "sand".

**Step 2.** Place 20 ml of the appropriate soil into each test tube.

**Step 3.** Use a ruler to measure the height of the soil in the test tube. Make a mark near the top of the test tube at a position twice the height of the soil.

**Step 4.** Slowly add 20 ml of water to the tube containing the potting soil. Record your observations in the table on the Soils and Air Investigation Worksheet (pg. S11, or available online at kscorn.com). Repeat, adding 20 ml of water to the tubes containing local soil and sand.

Discussion Questions

1. Why did the final water level differ among the three types of soil?
2. Why is it important for plant growth that soils contain air space?

### *Activity Station 3 – Soil and Water:*

**Step 1.** Label three 100-ml graduated cylinders "potting soil", "local soil", and "sand".

**Step 2.** Place 80 ml of the appropriate soil into each graduated cylinder.

**Step 3.** Slowly add 20 ml of water to the graduated cylinder containing the potting soil. Record your observations in the table on the Soil and Water Worksheet (pg. S12, or available online at kscorn.com). Note how long it takes water to move through the soil. Repeat, adding 20 ml of water to the cylinders containing local soil and sand.

Discussion Questions

1. "Infiltration" refers to the ability of soil to accept water. Which of the soils you tested accepted the most water?
2. "Percolation" refers to the ability of soil to transmit water throughout its depth. Which of the soils you tested allowed for the fastest water movement? Which allowed water to reach the greatest depth?

### *Activity Station 4 – Soil pH:*

**Step 1.** Tell students that they will be testing soil samples that were sent in from three farms.
Demonstrate to the students how to use each of the three pH testing methods.

- Use a pH testing kit based on barium sulfate in powdered form, where a small sample of soil is mixed with distilled water, which then changes color according to the acidity or alkalinity.
- Use pH paper. A small sample of soil is mixed with distilled water, into which a strip of pH paper is inserted. Show students how to compare results to the pH paper color chart.
- Use an electronic pH probe, in which a rod is inserted into moistened soil and measures the concentration of hydrogen ions.

**Step 2.** Instruct students to complete the information on their Soil pH Investigation Worksheet (pg. 13-15, or available online at www.kscorn.com). When finished, discuss class results and have groups share their recommendations for each farmer based on the soil pH test.

Discussion Questions:

1. Why it would be important for farmers to know the pH of their soil?
2. How did the type of soil influence the pH of the soil?
3. In general, which soil type and which pH range would you expect corn to grow best in?

### Teacher Tips

From Collecting Soil Samples: Laminate a class set of Soil Sampling Guide Sheets (pg. S4-S5, or available online at kscorn.com), or put them in a page protector and use clear tape to seal the top to avoid contamination from soil and aid in quick “wipe down” clean up!

Visit www.kscorn.com for additional teacher tips. Nutrients for Life middle school curriculum is a resource that can be used that also contains additional activities and supplemental materials. https://www.nutrientsforlife.org

### Reflections and Conclusion

*Class Discussions After Completing the Activity Stations:*

After the groups complete their investigations, reconvene the class and ask each group to take turns reporting their results. Review and summarize the following key concepts for each activity station:

*Activity Station 1 – Dry Soil Investigation:*

- Soils differ in their composition.
- Soils contain organic and inorganic particles of varying size.
- Soils contain microorganisms that cannot be seen but are critical to plant growth.
- Visual inspection cannot fully evaluate the nutrient content of soils.

*Activity Station 2 – Soil and Air Space:*

As water was slowly added to the soil samples, students should have noted that both the potting soil and the local soil produced air bubbles that rose to the surface. Fewer air bubbles would be seen when water was added to sand. After the water was allowed to percolate into the potting soil, students should have observed that the final water level was approximately halfway between the surface of the soil and the line drawn on the test tube. This means that the potting soil contained about 50% air space. The local soil would also contain a significant amount of air space, though it may be less than the potting soil. The sand would display only a small amount of

air space, depending on the grain size.
Make sure to bring out the following points:

- Soils differ in the amounts of air space that they contain.
- Average soils that support crops consist of nearly 50% air space.
- The air space in soil can be occupied by either air or water.
- Soils need both air space and water to support a plant's root system.
- Plant roots absorb nutrients from the soil water.

### *Activity Station 3 – Soil and Water:*

As water was slowly added to the potting soil, students should have noted that water was immediately taken up by the soil and that some water reached the bottom of the graduated cylinder in less than one minute. The results with local soil would vary, depending on its composition. Most soils would accept the water less quickly than the potting soil, and the rate at which the water percolates through the soil would be somewhat slower. The sand will accept the water almost as quickly as potting soil. Make sure that students recognize that differences in soil texture mean that soils differ in their ability to accept water (infiltration) and transmit it (percolation).

### *Activity Station 4 – Soil pH:*

After conducting these activities, review and summarize the following key concepts:

- Agronomy is the science of soil management and crop production.
- Agronomists as well as Soil Scientists use their knowledge of chemistry and pH to help farmers achieve maximum plant growth. This in turn helps provide a more plentiful food supply.
- Nutrients can be added, or amended, in the soil. Nutrient availability is greatly influenced by the pH of soils.

Ask students to list properties of soils that are important to support plant growth. Record responses. Students should mention the following:

- The soil is firm enough to support the plant's root system.
- The soil contains the essential plant nutrients.
- The soil contains adequate amounts of organic material and clay.
- The soil contains about 50% air space.
- The soil allows water to infiltrate and percolate through it.

### The Big Apple: Demonstration for Land Use

1. Explain to the class that this activity is concerned with how we as a society use land. The amount of land on Earth stays the same, so as the world's population gets larger, it becomes even more important that we make wise decisions about how it is used.

# Kansas Corn: Starts with Soil
## Grade Level: Middle School

2. Explain that land is used for many different reasons. Ask, "What are some of the most important uses for land?" Record students' responses.

   Students' responses may include the following:

   - Farming
   - Homes
   - Industries or places where we work
   - Pastures or land for livestock
   - Parks, sports, and recreation
   - Wildlife habitat

Note: If one of these uses is not mentioned by a student, ask guiding questions to bring it out. A student may point out that some land, such as a desert, has no use. Of course, any land that is not being used by humans can be considered a habitat for wildlife, and it provides a variety of other economic services for people. For example, wetlands help remove nutrient pollution from rivers, lakes, and estuaries.

3. Call attention to the apple and the knife. Explain that the apple represents Earth. Ask, "How much of the total Earth's surface do you think is devoted to farming?" Students' responses will vary.
4. Use the knife to cut the apple into 4 equal parts. Set 3 parts aside and hold up 1 part. Explain that the surface of the world is about 70 percent water, so this 1 piece represents that part of the surface that is land. Remind students of the many different uses for this relatively small amount of land.
5. Use the knife to cut the quarter piece of apple in half 3 more times, each time discarding 1/2. Finally, hold up 1 of the smallest pieces and explain that it represents 1/32 of the surface of Earth or 1/8 the land where we live. This is the amount of land available for farming. Point out that the skin on this small piece of apple represents the tiny layer of topsoil that we depend on to grow food.
6. Explain that because we put land to so many different uses, the amount devoted to farming has hardly changed during the past 50 years. Scientists are worried about how we will feed the world's growing population in the next 50 years. With so little land available for farming, it is important that we take care of the soil that gives us so much so we can continue to produce healthy crops for the future.

### Science and Agriculture Careers

Ask students if they know what an agronomist does. Introduce them to this career field by explaining that agronomists help farmers prepare and maintain their soil to achieve the maximum plant growth. They are experts in the science and technology of producing and using plants for food, fuel, fiber, and land reclamation. They work in areas of plant genetics, plant physiology, meteorology, and soil science. Explain that agronomists help farmers achieve the maximum production from their land. They know the specific needs of plants, and they find methods for making soil as productive and fertile as possible.

# Kansas Corn: Starts with Soil
## Grade Level: Middle School

**To learn more about agriculture careers visit agexplorer.com. You can also find career profiles at kscorn.com.**

### Sources

- Nutrients for Life Foundation's Nourishing the Planet in the 21st Century – https://www.nutrientsforlife.org
- Soil Texture by Feel Method Guides – http://www.ndhealth.gov/wq/sw/z1_nps/pdf_files/soil_texture_feel_test.pdfNational Ag in the Classroom: Know your pH lab: https://www.agclassroom.org/teacher/matrix/lessonplan.cfm?lpid=317
- This lesson was funded in 2011 by the California Department of Food and Agriculture's (CDFA) Fertilizer Research and Education Program (FREP). Chemistry, Fertilizer, and the Environment was designed to reinforce chemistry and environmental science concepts while educating students about the relationships between food, plant nutrients, farmers and the environment.
  Executive Director: Judy Culbertson
  Illustrator: Erik Davison
  Layout and Design: Nina Danner
  Author(s): Mandi Bottoms and Shaney Emerson
- Journey 2050: Nutrients Video from Presentation – https://www.youtube.com/watch?v=d4XT5UxRfYs
- Nitrogen Cycle Video from Presentation – https://www.youtube.com/watch?v=xfwZV6rtnvw
- Soil Texture by Feel on Youtube – https://www.youtube.com/watch?v=IOyaBxj767s
- Soil Samping Guide, provided by Spectrum Analytic Inc. – https://www.spectrumanalytic.com/services/analysis/soilguide.pdf

Any educator electing to perform demonstrations is expected to follow *NSTA Minimum Safety Practices and Regulations for Demonstrations, Experiments, and Workshops*, which are available at http://static.nsta.org/pdfs/MinimumSafetyPracticesAndRegulations.pdf, as well as all school policies and rules and all state and federal laws, regulations, codes and professional standards. Educators are under a duty of care to make laboratories and demonstrations in and out of the classroom as safe as possible. If in doubt, do not perform the demonstrations.

# Kansas Corn: Starts with Soil
## Grade Level: Middle School

**Soil PH Investigation Worksheet-KEY**

*Introduction*

Congratulations! As a new agronomy graduate you were fortunate enough to land a job working in the The K-State Research and Extension Soil Testing Laboratory at Kansas State University. In order to better understand accuracy of methods of measuring pH that homeowners, gardeners and farmers have commercially available to them, you are going to be monitoring and analyzing the accuracy of several pH measuring techniques. There are a lot of other important tests to run, but it is important to get an accurate pH reading, as the pH of the soil will influence the availability of other nutrients in the soil for plant growth. Once you have determined the pH of the soil samples, you will need to write a recommendation to the farmers who submitted the samples regarding how they should amend their soil to maximize their corn production.

*Procedure*

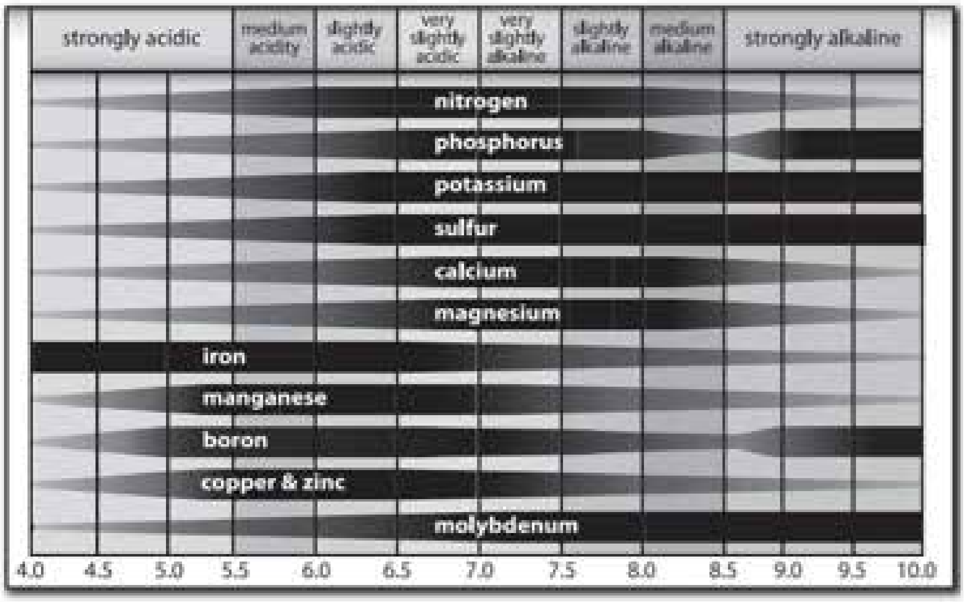
1. Work together with your group. There are three soil samples in the lab. Soilsample one is from Adam's farm, soil sample two is from Brent's farm, and soil sample three is from Charles' farm. Mark each of your three cups with the appropriate name or number and place one spoonful of soil from each farmer's field in the respective cup.
2. Make a soil slurry by measuring out approximately twice the amount of distilled water as the amount of soil you have in your cup. Your goal is to have a soil slurry that is approximately two parts water to one part soil. Mix up the slurry with your spoon or stirring stick.
3. Select a method for testing your soil pH and follow the directions for using that test. For the most accurate results, use all three methods and take an average. Record your results on the chart.
4. Clean up your lab area.
5. Compare your test results to the nutrient availability chart on the back of this handout. Use classroom resources or the Internet to research information and fill out the report for each farmer.

*Test Results*

| Farmer | Soil pH using pH probe | Soil pH using pH test strips | Soil pH using soil pH test | Average pH |
|---|---|---|---|---|
| Adam | Answers vary ~5.0 | Answers vary ~5.0 | Answers vary ~5.0 | ~5.0 |
| Brent | Answers vary ~6.5 | Answers vary ~6.5 | Answers vary ~6.5 | ~6.5 |
| Charles | Answers vary ~8.0 | Answers vary ~8.0 | Answers vary ~8.0 | ~8.0 |

# Kansas Corn: Starts with Soil
## Grade Level: Middle School

1. Based on a comparison to the nutrient availability chart:




a. What nutrients might be limited in Adam's field?

- Average pH in field: *5.0*
  Nutrients limited by pH: *Nitrogen, Phosphorous, Potassium, Sulfur, Calcium, Magnesium*

b. What nutrients might be limited in Brent's field?

- Average pH in field: *6.5*
  Nutrients limited by pH: *None, but possibly slightly Molybdenum*

c. What nutrients might be limited in Charles' field?

- Average pH in field: *8.0*
- Nutrients limited by pH: *Iron, Manganese, Boron, Copper and Zinc, potentially Phosphorous (though usually not until 8.5 or higher)*

2. If needed, what method for amending soil pH would you advise for each farmer?
When answering this question, consider the following factors (Internet research recommended):

- Cost of altering pH through addition of lime or elemental sulfur vs. cost of adding various nutrient amendments
- Cost of transportation and application of the amendment
- Options for growing crops best suited for existing soil pH
- Length of time needed for a measurable change in soil pH to occur
- Soil texture
- Form of the amendment: liquid, powder, or granular

# Kansas Corn: Starts with Soil
## Grade Level: Middle School

Name ______________________________ Date __________

*Soil Sample 1: Adam's Farm*

**Background information sent in with the soil sample:**

Adam is farming 40 acres of sweet corn in a river valley with sandy soils. He sent in his soil sample following harvest in hopes of having plenty of time to amend the soil if it is needed. He reported marginal yields from this field last year and suspects his plants were deficient in certain nutrients. Adam's access to equipment is limited, but he does use an ATV to monitor and manage his ground.

**Average pH:** *5.0*

**Recommendation:** *Adam can apply lime to his field to slowly bring up the pH of his 40 acres of sandy soil, because the soil is sandy loam it should change more readily. Application rates should be between 5,000-10,000 lbs. per acre depending on the pH variability in his field. He should follow up with additional samples to see if there are particular problem areas with a lower pH that may require more lime than other parts of the field to more accurately determine the rate at which to apply lime. Additional resource about lime and its effects on crops: https://www.agronomy.k-state.edu/documents/nutrient-management/nmrg-ppt-soil-ph,-liming-and-salt-affected-soils.pdf*

*Soil Sample 2: Brent's Farm*

**Background information sent in with the soil sample:**

Brent has been using precision farming techniques for the last 5 years on this particular 80 acres of the 500 acres that he rents or owns. He manages soil health closely and this soil test is part of an annual program he uses to make sure he is maximizing yields on his farm ground. This field just came out of irrigated soybean production and is due to be planted to field corn in the spring. Brent has unlimited access to a variety of equipment.

**Average pH:** *6.5*

**Recommendation:** *Brent seems to have good management techniques for his crops. A pH of 6.5 is considered acceptable for most nutrient availability so Brent should continue to monitor his fields using soil samples, tissue samples and periodically scouting to make sure crops don't show any signs of distress or disease, but at this time his pH does not require any adjustment.*

# Kansas Corn: Starts with Soil
## Grade Level: Middle School

*Soil Sample 3: Charles' Farm*

**Background information sent in with the soil sample:**

Charles raises commercial hogs and row crops on his 400 acre farm. This particular soil sample comes from the "Home 40" where his hog barns are located and are on the corner of the busy intersection of his driveway and his secondary road. This sample was taken during production of irrigated field corn that he uses as feed for his hogs. He believes that his corn has been showing signs of micromineral deficiency.

**Average pH:** *8.0*

**Recommendation:** *Charles has the best solution to his problem right at his fingertips. He needs to apply his hog waste to his high pH fields to increase the nitrogen level in the soil and bring the pH down closer to 7. Charles should work with an expert to determine methods and rates for applying the fertilizer to his crops while still making sure to meet environmental regulations. Sometimes this can be done through specialized irrigation systems, but he may even be able to broadcast solid waste using a manure spreader if he is not set up to apply liquid waste to his fields through his current irrigation system. The microminerals in the manure should also help alleviate the deficiencies he is seeing in his crops, but Charles should use soil sampling after applying manure to check micronutrient levels of his soils. Next year Charles should also make sure to avoid early irrigation which could cause soils to seal over and exacerbate the micromineral deficiency.*

For more tips on managing high pH soils, check out this resource from Pioneer:
https://www.pioneer.com/home/site/us/agronomy/library/corn-high-ph-soils/

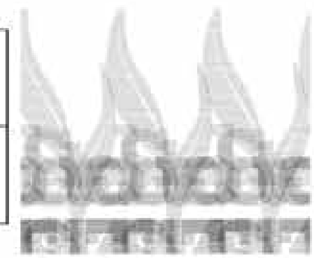
*Activity Station 4 – Soil pH:*

# Do plants and animals need the same things?

## Write a hypothesis regarding which NUTRIENTS are essential for plants and for animals, and WHERE OR HOW THEY GET THEM

| 1 | 2 | | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| hydrogen 1 H 1.0079 | | | | | | | | | | | | | | | | | | helium 2 He 4.0026 |
| lithium 3 Li 6.941 | beryllium 4 Be 9.0122 | | | | | | | | | | | | boron 5 B 10.811 | carbon 6 C 12.011 | nitrogen 7 N 14.007 | oxygen 8 O 15.999 | fluorine 9 F 18.998 | neon 10 Ne 20.180 |
| sodium 11 Na 22.990 | magnesium 12 Mg 24.305 | | | | | | | | | | | | aluminium 13 Al 26.982 | silicon 14 Si 28.086 | phosphorus 15 P 30.974 | sulfur 16 S 32.065 | chlorine 17 Cl 35.453 | argon 18 Ar 39.948 |
| potassium 19 K 39.098 | calcium 20 Ca 40.078 | | scandium 21 Sc 44.956 | titanium 22 Ti 47.867 | vanadium 23 V 50.942 | chromium 24 Cr 51.996 | manganese 25 Mn 54.938 | iron 26 Fe 55.845 | cobalt 27 Co 58.933 | nickel 28 Ni 58.693 | copper 29 Cu 63.546 | zinc 30 Zn 65.39 | gallium 31 Ga 69.723 | germanium 32 Ge 72.61 | arsenic 33 As 74.922 | selenium 34 Se 78.96 | bromine 35 Br 79.904 | krypton 36 Kr 83.80 |
| rubidium 37 Rb 85.468 | strontium 38 Sr 87.62 | | yttrium 39 Y 88.906 | zirconium 40 Zr 91.224 | niobium 41 Nb 92.906 | molybdenum 42 Mo 95.94 | technetium 43 Tc [98] | ruthenium 44 Ru 101.07 | rhodium 45 Rh 102.91 | palladium 46 Pd 106.42 | silver 47 Ag 107.87 | cadmium 48 Cd 112.41 | indium 49 In 114.82 | tin 50 Sn 118.71 | antimony 51 Sb 121.76 | tellurium 52 Te 127.60 | iodine 53 I 126.90 | xenon 54 Xe 131.29 |
| caesium 55 Cs 132.91 | barium 56 Ba 137.33 | 57-70 * | lutetium 71 Lu 174.97 | hafnium 72 Hf 178.49 | tantalum 73 Ta 180.95 | tungsten 74 W 183.84 | rhenium 75 Re 186.21 | osmium 76 Os 190.23 | iridium 77 Ir 192.22 | platinum 78 Pt 195.08 | gold 79 Au 196.97 | mercury 80 Hg 200.59 | thallium 81 Tl 204.38 | lead 82 Pb 207.2 | bismuth 83 Bi 208.98 | polonium 84 Po [209] | astatine 85 At [210] | radon 86 Rn [222] |
| francium 87 Fr [223] | radium 88 Ra [226] | 89-102 * * | lawrencium 103 Lr [262] | rutherfordium 104 Rf [261] | dubnium 105 Db [262] | seaborgium 106 Sg [266] | bohrium 107 Bh [264] | hassium 108 Hs [269] | meitnerium 109 Mt [268] | ununnilium 110 Uun [271] | unununium 111 Uuu [272] | ununbium 112 Uub [277] | | ununquadium 114 Uuq [289] | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Lanthanide series | lanthanum 57 La 138.91 | cerium 58 Ce 140.12 | praseodymium 59 Pr 140.91 | neodymium 60 Nd 144.24 | promethium 61 Pm [145] | samarium 62 Sm 150.36 | europium 63 Eu 151.96 | gadolinium 64 Gd 157.25 | terbium 65 Tb 158.93 | dysprosium 66 Dy 162.50 | holmium 67 Ho 164.93 | erbium 68 Er 167.26 | thulium 69 Tm 168.93 | ytterbium 70 Yb 173.04 |
| * *Actinide series | actinium 89 Ac [227] | thorium 90 Th 232.04 | protactinium 91 Pa 231.04 | uranium 92 U 238.03 | neptunium 93 Np [237] | plutonium 94 Pu [244] | americium 95 Am [243] | curium 96 Cm [247] | berkelium 97 Bk [247] | californium 98 Cf [251] | einsteinium 99 Es [252] | fermium 100 Fm [257] | mendelevium 101 Md [258] | nobelium 102 No [259] |



Seed to STEM

Name ________________________ Date ____________

## Chemical Symbols of the Elements

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Actinium | Ac | Europium | Eu | Molybdenum | Mo | Scandium | Sc |
| Aluminum | Al | Fluorine | F | Neodymium | Nd | Selenium | Se |
| Antimony | Sb | Francium | Fr | Neon | Ne | Silicon | Si |
| Argon | Ar | Gadolinium | Gd | Nickel | Ni | Silver | Ag |
| Arsenic | As | Gallium | Ga | Niobium | Nb | Sodium | Na |
| Astatine | At | Germanium | Ge | Nitrogen | N | Strontium | Sr |
| Barium | Ba | Gold | Au | Osmium | Os | Sulfur | S |
| Beryllium | Be | Hafnium | Hf | Oxygen | O | Tantalum | Ta |
| Bismuth | Bi | Helium | He | Palladium | Pd | Tellurium | Te |
| Boron | B | Hydrogen | H | Phosphorus | P | Terbium | Tb |
| Bromine | Br | Indium | In | Platinum | Pt | Thorium | Th |
| Cadmium | C | Iodine | I | Polonium | Po | Thallium | Tl |
| Calcium | Ca | Iridium | Ir | Potassium | K | Tin | Sn |
| Carbon | C | Iron | Fe | Promethium | Pm | Titanium | Ti |
| Cerium | Ce | Krypton | Kr | Protactinium | Pa | Tungsten | W |
| Cesium | Cs | lanthanum | La | Radium | Ra | Uranium | U |
| Chlorine | Cl | Lead | Pb | Radon | Rn | Vanadium | V |
| Chromium | Cr | Lithium | Li | Rhenium | Re | Xenon | Xe |
| Cobalt | Co | Lutetium | Lu | Rhodium | Rh | Ytterbium | Yb |
| Copper | Cu | Magnesium | Mg | Rubidium | Rb | Yttrium | Y |
| Dysprosium | Dy | Manganese | Mn | Ruthenium | Ru | Zinc | Zn |
| Erbium | Er | Mercury | Hg | Samarium | Sm | Zirconium | Zr |

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Name ______________________________ Date ____________

## Sources of Essential Nutrients

| *Essential Nutrient* | *Air* | *Water* | *Soil* |
|---|---|---|---|
| Boron (B) | | | |
| Calcium (Ca) | | | |
| Carbon (C) | | | |
| Chlorine (Cl) | | | |
| Copper (Cu) | | | |
| Hydrogen (H) | | | |
| Iron (Fe) | | | |
| Magnesium (Mg) | | | |
| Manganese (Mn) | | | |
| Molybdenum (Mo) | | | |
| Nickel (Ni) | | | |
| Nitrogen (N) | | | |
| Oxygen (O) | | | |
| Phosphorus (P) | | | |
| Potassium (K) | | | |
| Sulfur (S) | | | |

Spectrum Analytic Inc

# Soil Sampling Guide

Maximizing productivity is a fact of life in agriculture. The demand for high yields, top quality and environmental stewardship will always be a driving factor. Unfortunately good yields and top quality don't happen automatically. However, there are tools available to guide you toward these goals in a reliable manner. Soil analysis is the first building block in a sound fertility program. *Soil reports should always be used with other information as a guide in arriving at fertilizer and lime recommendations which will help the grower attain their crop yield and quality goals.*

## How to Take Soil Samples

**Important:** Accurate soil analysis with meaningful interpretation requires properly taken samples. Follow all directions carefully and correctly. Sampling technique presents the greatest chance for errors in results. Laboratory analytic work will not improve the accuracy of a sample that does not represent the area.

### 1. Select the Proper Equipment

Collect samples using chrome plated or stainless steel sampling tubes or augers. A clean spade or shovel can also be used. Avoid galvanized, bronze or brass tools. Use clean, plastic buckets. Do not use galvanized or rubber buckets, as they will contaminate the samples. (Figure 1)

### 2. When to Take Samples

Sampling can take place during any period of the year. However, it is best to sample a field at about the same time of year. Wait a minimum of thirty days to sample after applications of fertilizer, lime, or sulfur.

### 3. Sample Area

Samples must be representative of the area you are treating. Most often, sampling by soil color is an acceptable method for dividing large fields into "like" areas. County ASCS aerial photographs can be used as a guide. Areas that differ in slope, drainage, past treatment, etc. should be sampled separately (fig. 2). Sampling across dissimilar soil types is not recommended. And finally, the sample area should be large enough for special lime or fertilizer treatments.

Always remember to remove any surface debris prior to sampling.

**Do Not Sample:**

- Dead or back furrows.
- Fence rows, old or new.
- Old roadbeds, or near limestone gravel roads.
- Terrace channels.
- Wind breaks or snow fence lines.
- Turn-rows.
- Spill areas.
- Fertilizer bands including Anhydrous N.
- Unusual or abnormal spots.

### 4. Sample Depth

Refer to Table 1 on page 2 for the correct sampling depth. Sampling depth must remain consistent because many soils are stratified and variation in depth will introduce errors into the analytic results.

To test for soil stratification, sample through the soil profile, separately, 0" to 2", 2" to 4", 4" to 6", and 6" to 8". Remember to take the recommended number of cores per sample. The greater the difference in the analytic data between samples, the greater the degree of stratification.

### 5. Number of Cores and Acres per Sample

Various studies have shown that proper sampling requires at least 10 core per sample, and sometimes 15 or more cores, depending on the nature of the soil and the size of the area being sampled. A smaller number can introduce variability into the results from different sampling years. There is no rule for the number of acres to include in a single sample. This must depend on the local situation. However, the University of Illinois has long recommended that a single sample should represent no more than 5 acres. Very small sampling areas, such as residential landscape plants and some small gardens may use fewer cores per sample.

## 6. Preparing Samples for Shipment

**Thoroughly mix** the randomly taken core samples in a plastic bucket and remove a separate, well-mixed composite sample (½ to 1 pint) from the mixture. Place it into the lab's sample bag, filling it to the "line." New plastic sandwich bags can be substituted. Make sure to double bag these types of bags. All samples taken for Nitrogen analyses should be immediately air-dried, shipped early in the week, or shipped frozen.

Once the sample is in the bag, fold the top down to exclude air and roll it down to close and fold the tabs.

Write your sample ID designation (include grid sub sample identification where applicable) and your customer's name on the bag where requested.

## 7. Completing the Information Form

On the Information Form record the same sample, and sub-sample IDs, and the customer name with the address. In the indicated area include your business name and address. Complete all the remaining information as required.

## 8. Mailing the Sample

Spectrum provides the shipping containers (at a nominal fee) but other boxes may be used. A strong envelope may be used when shipping only a few samples.

Figure 1

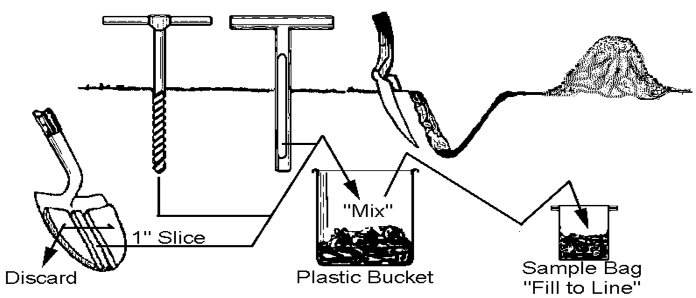



Figure 2

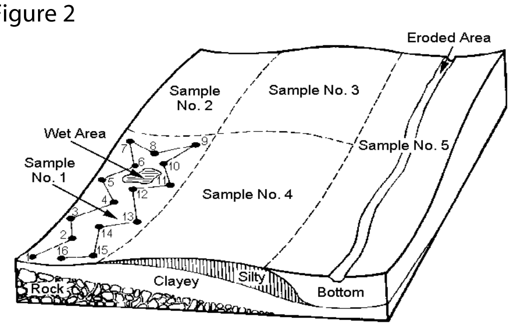



Figure 3: Trees

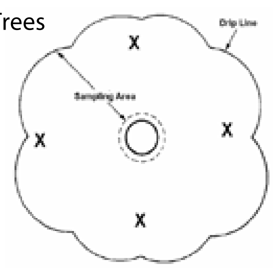



Figure 4: Sampling Fields with Banded Fertilizer

$$S = 8 \times \frac{\text{band spacing (inches)}}{12}$$

Where **S** = number of cores to take outside the band for each core taken in the band.

## Table 1: Depth to Sample

| Type of Sample | Sample Depth | Misc. Notes |
|---|---|---|
| Conventional Tillage | 7″ | Sampling depth must remain constant. |
| Strip/Band Fertilization (known) | 7″ | See Figure 4 for instructions. |
| Strip/Band Fertilization (unknown) | 7″ | Take 20+ random samples 90° to band rows. |
| Reduced Tillage or No-Till | 2″ and 7″ | 2″ sample is for surface pH determinations. |
| Orchards and other trees | 7″ | Take samples inside the "drip line" (Figure 3) |
| Lawn/Turf | 4″ | Remove the sod piece from each core sample. |
| Pasture | 4″ | Remove the sod piece from each core sample. |
| Special Problem Solving | 7″ and 36″ | Take 7″ sample and 36″ sample from the "same hole" |
| Pre Sidedress Nitrogen Test | 12″ | Take samples when corn is 10″ to 12 ″ tall. |
| Soil Nitrogen Tests | 12″ to 36″ | Drier climate soils require the taking of deeper samples. |
| Soybean Cyst Nematode Samples | 7″ | Sample near planted row, in fringe of damaged areas. |

# Determining Soil Texture by the "Feel Method"

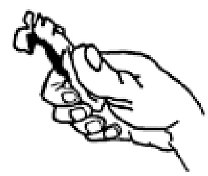
**Texture Classification**

| | |
|---|---|
| C | = Coarse |
| MC | = Moderately Coarse |
| M | = Medium |
| F | = Fine |

Start

Place approximately one tablespoon of soil in palm. Add water a drop at a time and knead the soil to break down all aggregates. Soil is at the proper consistency when plastic and mobile, like moist putty.

Does soil remain in a ball when squeezed?
- NO → Is the soil to dry?
  - YES → Place approximately one tablespoon of soil in palm...
  - NO → Is the soil too wet?
    - YES → Add dry soil to soak up water. → Place approximately one tablespoon of soil in palm...
    - NO 0 -10% ** → SAND C*
- YES → Place ball of soil between thumb and forefinger, gently pushing the soil with the thumb, working it upward into a ribbon. Form a ribbon of uniform thickness and width. Allow the ribbon to emerge and extend over the forefinger, breaking from its own weight.



Does the soil form a ribbon?
- NO 0 -15% ** → LOAMY SAND C *
- YES → Does the soil make a weak ribbon less than 1" long before breaking?
  - NO → Does the soil make a medium ribbon 1" to 2" long before breaking?
    - NO → Does the soil make a strong ribbon 2" or longer before breaking?

**Weak ribbon** — YES → Excessively wet a small pinch of soil in palm of hand and rub with forefinger.
- Does the soil feel very gritty? YES 0-20% → Sandy Loam MC
- NO → Does the soil feel very smooth? YES 0-27% → Silt or Silt/ Loam M
- NO → Neither grittiness nor smoothness predominates. YES 7-27% → Loam M

**Medium ribbon** — YES → Excessively wet a small pinch of soil in palm of hand and rub with forefinger.
- Does the soil feel very gritty? YES 20-35% → Sandy Clay Loam MC
- NO → Does the soil feel very smooth? YES 27-40% → Silty Clay Loam F
- NO → Neither grittiness nor smoothness predominates YES 27-40% → Clay Loam F

**Strong ribbon** — YES → Excessively wet a small pinch of soil in palm of hand and rub with forefinger.
- Does the soil feel very gritty? YES 35-55% → Sandy Clay MC
- NO → Does the soil feel very smooth? YES 40-60% → Silty Clay F
- NO → Neither grittiness nor smoothness predominates YES 40-100% → Clay F

* Sand Particle size should be estimated (very fine, fine, medium, coarse) for these textures. Individual grains of very fine sand are not visible without magnification and there is a gritty feeling to a very small sample ground between the teeth. Some fine sand particles may be just visible. Medium sand particles are easily visible. Examples of sand size descriptions where one size is predominant are; very fine sand, fine sandy loam, loamy coarse sand.

** Cay percentage range.

**Modified from: Thien, Steven J., Kansas state University, 1979 Jour. Agronomy education.**


POOR RIBBON
LESS THAN 1 INCH
1 2 3 4 5


MEDIUM RIBBON
1 TO 2 INCHES LONG
1 2 3 4 5


GOOD RIBBON
MORE THAN 2 INCHES LONG
1 2 3 4

Name ______________________________ Date ____________

# Dry Soil Investigation

*Procedure*

**Step 1 –** Place 1 tsp of potting soil in the center circle of the "Potting Soil Separation Sheet" and one tsp of local soil in the center circle of the "Local Soil Separation Sheet."

**Step 2** – Use a hand lens and pencil, to sort the soil components into four different categories: "Small Particles," "Large Particles," "Plant Material," and "Animal Material."

**Step 3** - Once both soil samples have been separated into their components, compare the results for the two types of soils.

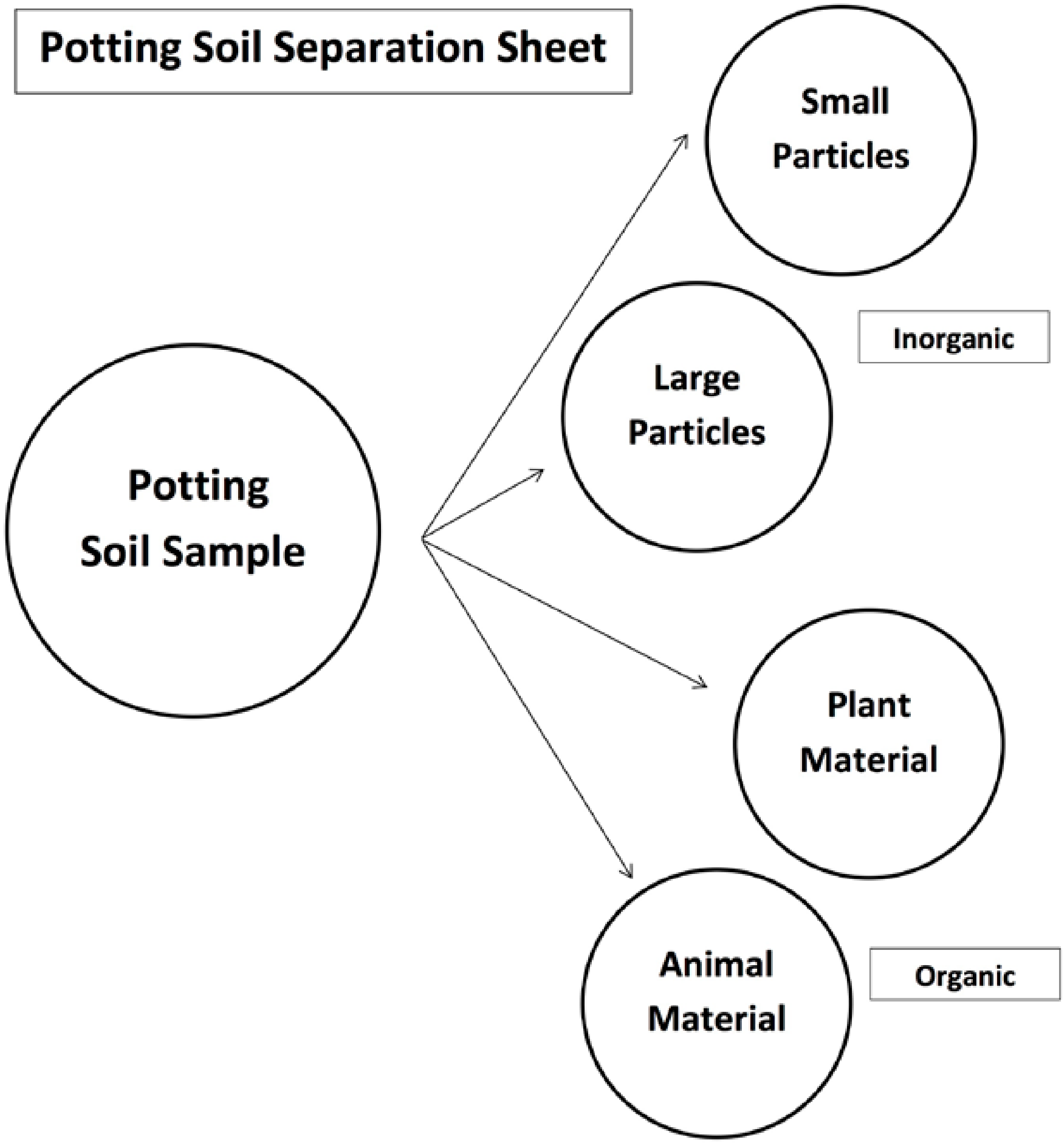
*Discussion Questions*

1. In what ways are the two soil types similar?

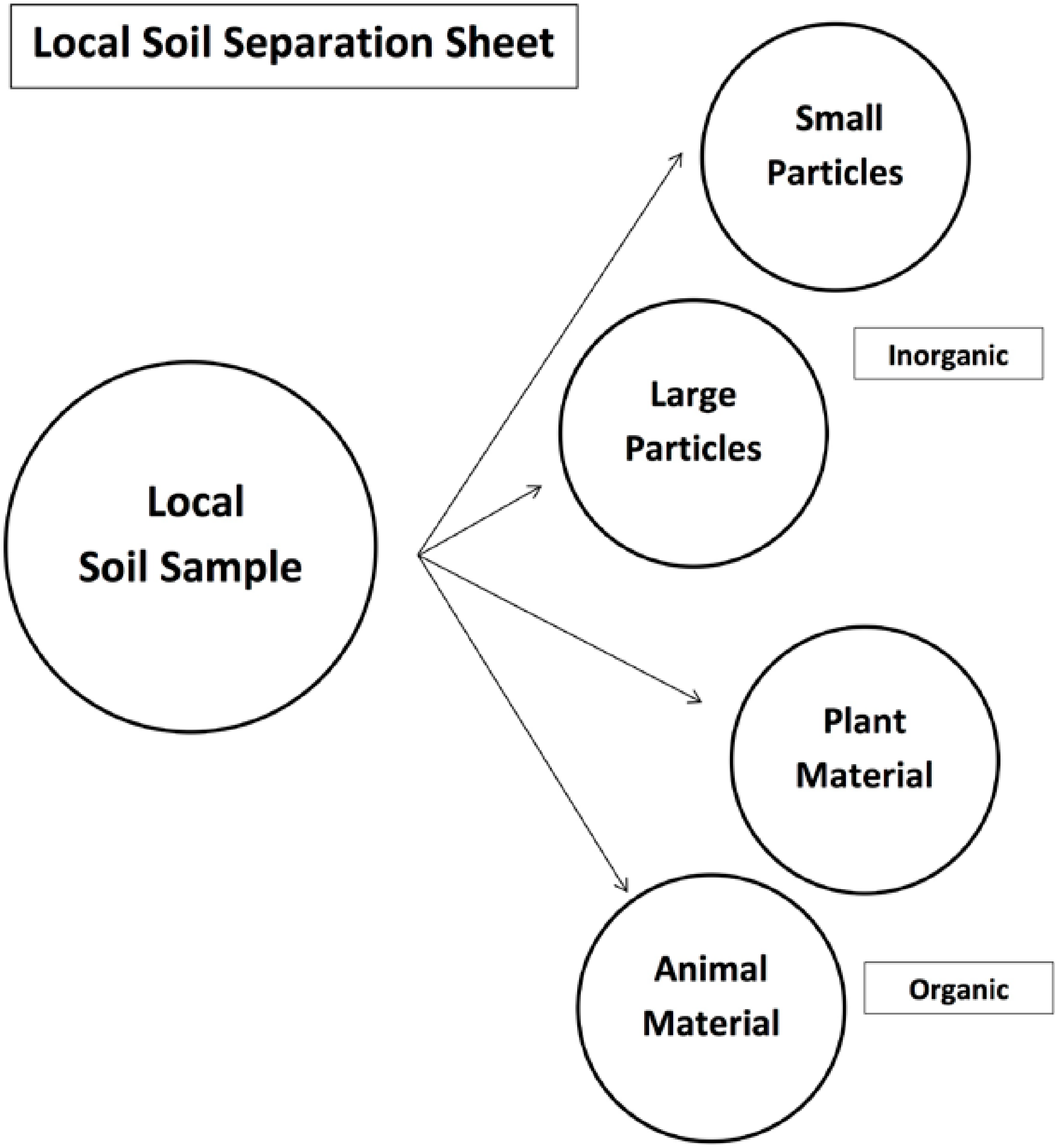
2. In what ways are the two soil types different?

3. Can you tell by looking at these soil samples if either would support plant growth? How were you able to make that conclusion?

# Potting Soil Separation Sheet



# Local Soil Separation Sheet



Name ______________________________ Date ____________

## Soil and Air Space Investigaion

*Procedure*

**Step 1** – Label three 50 ml test tubes "Potting Soil", "Local Soil", and "Sand".

**Step 2** – Place 20 ml of the appropriate soil into each test tube.

**Step 3** – Use a ruler to measure the height of the soil in the test tubes. Make a mark near the top of the test tube at a position twice the height of the soil.

**Step 4** – Slowly add 20 ml of water to the test containing the potting soil. Record your observations in the table below. Repeat, adding 20 ml of water to the test tubes containing local soil and sand.

| *Soil Type* | *Observations* |
|---|---|
| Potting Soil | |
| Local Soil | |
| Sand | |

*Discussion Questions*

1. Why did the final water level differ among the three types of soil?

2. Why is this important for plant grow?

Name ______________________________ Date ____________

## Soil and Water Worksheet

*Procedure*

**Step 1** – Label three 100 ml test tubes “Potting Soil”, “Local Soil”, and “Sand”.

**Step 2** – Place 80 ml of the appropriate soil into each graduated cylinder.

**Step 3** – Use a ruler to measure the height of the soil in the test tubes. Make a mark near the top of the test tube at a position twice the height of the soil.

**Step 4** – Slowly add 20 ml of water to the graduated cylinder containing the potting soil. Record your observations in the following table. Record how long it takes water to move through the soil. Repeat, adding 20 ml of water to the cylinders containing local soil and sand.

| *Soil Type* | *Time* | *Observations* |
|---|---|---|
| Potting Soil | | |
| Local Soil | | |
| Sand | | |

*Discussion Questions*

1. “Infiltration” refers to the ability to accept water. Which of the soils tested accepted the most water?

2. “Percolation” refers to the ability of soil to transmit water throughout its depth. Which of the soils tested allowed for the fasted water movement? Which allowed water to reach the greatest depth?

Name ________________________________ Date ______________

# Soil PH Investigation Worksheet

*Introduction*

Congratulations! As a new agronomy graduate you were fortunate enough to land a job working in the The K-State Research and Extension Soil Testing Laboratory at Kansas State University. In order to better understand accuracy of methods of measuring pH that homeowners, gardeners and farmers have commercially available to them, you are going to be monitoring and analyzing the accuracy of several pH measuring techniques. There are a lot of other important tests to run, but it is important to get an accurate pH reading, as the pH of the soil will influence the availability of other nutrients in the soil for plant growth. Once you have determined the pH of the soil samples, you will need to write a recommendation to the farmers who submitted the samples regarding how they should amend their soil to maximize their corn production.

*Procedure*

1. Work together with your group. There are three soil samples in the lab. Soil sample one is from Adam's farm, soil sample two is from Brent's farm, and soil sample three is from Charles' farm. Mark each of your three cups with the appropriate name or number and place one spoonful of soil from each farmer's field in the respective cup.

2. Make a soil slurry by measuring out approximately twice the amount of distilled water as the amount of soil you have in your cup. Your goal is to have a soil slurry that is approximately two parts water to one part soil. Mix up the slurry with your spoon or stirring stick.

3. Select a method for testing your soil pH and follow the directions for using that test. For the most accurate results, use all three methods and take an average. Record your results on the chart.

4. Clean up your lab area.

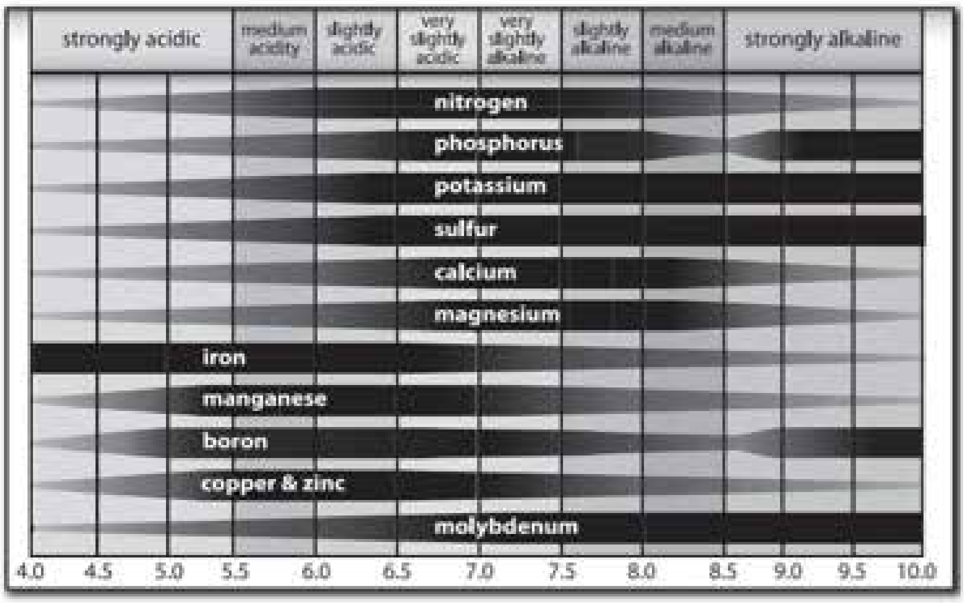
5. Compare your test results to the nutrient availability chart on the back of this handout. Use classroom resources or the Internet to research information and fill out the report for each farmer.

*Test Results*

| Farmer | Soil pH using pH probe | Soil pH using pH test strips | Soil pH using soil pH test | Average pH |
|---|---|---|---|---|
| Adam | | | | |
| Brent | | | | |
| Charles | | | | |

Name ______________________________ Date ____________

1. Based on a comparison to the nutrient availability chart:




a. What nutrients might be limited in Adam's field?

- Average pH in field:
- Nutrients limited by pH:

b. What nutrients might be limited in Brent's field?

- Average pH in field:
- Nutrients limited by pH:

c. What nutrients might be limited in Charles' field?

- Average pH in field:
- Nutrients limited by pH:

2. If needed, what method for amending soil pH would you advise for each farmer? When answering this question, consider the following factors (Internet research recommended):

- Cost of altering pH through addition of lime or elemental sulfur vs. cost of adding various nutrient amendments
- Cost of transportation and application of the amendment
- Options for growing crops best suited for existing soil pH
- Length of time needed for a measurable change in soil pH to occur
- Soil texture
- Form of the amendment: liquid, powder, or granular

Name ______________________________ Date ____________

*Soil Sample 1: Adam's Farm*

**Background information sent in with the soil sample:**

Adam is farming 40 acres of sweet corn in a river valley with sandy soils. He sent in his soil sample following harvest in hopes of having plenty of time to amend the soil if it is needed. He reported marginal yields from this field last year and suspects his plants were deficient in certain nutrients. Adam's access to equipment is limited, but he does use an ATV to monitor and manage his ground.

**Average pH:**

**Recommendation:**

*Soil Sample 2: Brent's Farm*

**Background information sent in with the soil sample:**

Brent has been using precision farming techniques for the last 5 years on this particular 80 acres of the 500 acres that he rents or owns. He manages soil health closely and this soil test is part of an annual program he uses to make sure he is maximizing yields on his farm ground. This field just came out of irrigated soybean production and is due to be planted to field corn in the spring. Brent has unlimited access to a variety of equipment.

**Average pH:**

**Recommendation:**

*Soil Sample 3: Charles' Farm*

**Background information sent in with the soil sample:**

Charles raises commercial hogs and row crops on his 400 acre farm. This particular soil sample comes from the "Home 40" where his hog barns are located and are on the corner of the busy intersection of his driveway and his secondary road. This sample was taken during production of irrigated field corn that he uses as feed for his hogs. He believes that his corn has been showing signs of micromineral deficiency.

**Average pH:**

**Recommendation:**