

Soil Science

Name: _____ Hour _____ Date: _____

Date Packet is due: _____ Why late? _____ Score: _____

Day of Week Date

If your project was late, describe why

Overview: In this unit, students will investigate the factors that affect the capacity for soils to support plant growth and productivity.

Main Questions

- What roles do soils play in supporting plant growth and productivity?
- What does an “ideal soil” look like?
- How do different soil properties affect the ability to support plant growth?

Weekly Schedule

Monday:

- Soil Recipe Lab
- Model development – What is does a healthy soil look like?

Tuesday:

- Nutshell Video & Notes
- Class discussion & revisions of explanations

Wednesday:

- Soils Kool-Aid Lab

Thursday:

- Review
- Group Quiz

Friday:

- Weekly Reflection
- Career & Community Connections

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Semester Schedule

Week 1: Introduction & Lab Safety

Sustainable Soils

Week 2: Sustainable Ag

Week 3: Soil Science

Week 4: BMPs

Week 5: Unit Project

Plant Physiology

Week 6: Roots

Week 7: Stems

Week 8: Leaves

Week 9: Plant Systems

Week 10: Unit Project

Plant Environments

Week 11: Light

Week 12: Temperature

Week 13: Water

Week 14: Biodiversity

Week 15: Unit Project

Gardening

Week 16: Gardening 101

Week 17: Final Project

Week 18: Final Exam



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Soil Science Unit, Horticulture Course



KBS LTER

Kellogg Biological Station
Long-term Ecological Research

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Day 1: Soil “Recipe” Lab

Introduction: In this activity, you will be trying to create an ideal soil mixture for plant growth. Your group will try different combinations of soil types and additions to create what you think will be the “ideal soil” for plant growth and productivity.

Materials Needed: sand; topsoil; soil high in clay and/or silt content (if possible; often a school’s grounds or custodial department will have this on hand for use in athletic fields); mulch; other various soil amendments (such as vermiculite, perlite, etc.); tubs or buckets (one per group for mixing); a scoop or cup. You will also need store-bought potting soil (this is used only for comparison).

Directions:

1. As a group, use the spaces below to create a list of the five most important qualities that you think are necessary for soil to support plant growth and productivity. Briefly support this with reasoning – explain why each quality is necessary for soil to support plant growth.

2. Using your list from above, use the resources provided by your instructor to create this kind of soil sample. You do not need to use each of the ingredients but you should use at least two of the ingredients available. Continue adding ingredients to your soil mixture until you feel comfortable that your mixture achieves the criteria you established in the previous question.
3. When all of the groups are ready, compare your soil sample with another group. Using the spaces below, compare and contrast the criteria your group used and your group’s soil mixture with the other group. Briefly described what you had in common and where your groups differed.

Commonalities: _____

Differences: _____



4. Is there anything that you would change about your description now that you've seen another group's criteria and sample? Is there anything you failed to consider earlier or anything that you think was incorrect or incomplete? Briefly explain below:

5. Compare your soil blend to a small sample of store-bought potting soil that your teacher will provide. Briefly described what you had in common and where your groups differed.

Commonalities: _____

Differences: _____

6. After each of the groups have had some time to revise their descriptions of "ideal soil", compare your descriptions with the rest of the class. As a class, try to determine the considerations on which everyone agrees, and try to reconcile where groups disagree with each other. Be sure to use evidence when considering disagreements between different groups – why do different groups have different stances?
7. In the space below, try to create a full list of criteria for what makes a soil ideal for plant growth. Use as much space as you need (you do not necessarily need to use all of the space provided):



Day 2: Notes & Discussion

Introduction & Directions: In this activity, you will begin by watching a short video about soil science. This will help to clarify some of the questions you may have had yesterday. After the video, you will look at a short slideshow presentation that will provide you with specific information about this topic. Your instructor may decide to deliver the presentation as a classroom lecture or they may allow you to read the notes individually or in small groups (depending on your previous experience and capabilities with this content). After you have watched the video and finished with the slideshow, you will work in small teams to answer the questions listed below. You should take notes in a notebook, online, on a dry erase board, or on scratch paper so that you are prepared to deliver your responses during the class discussion that will follow. *Note: your instructor may assign your group to answer specific questions if time is limited.*

URL Links

YouTube Video: <https://www.youtube.com/watch?v=knrmCbctGEA>

Slideshow Presentation: XXXX (or visit www.factsnsf.org and use the menu bar).

Discussion Questions:

1. What are soils? How are soils created? How long does this process take?
2. How do soils support and enable plant growth and productivity?
3. Briefly describe the three primary kinds of soil particles and their comparative sizes.
4. What is a loam?
5. What type of soil particle is ideal for plant growth and productivity?
6. How does the size of a soil particle relate to its surface area?
7. What is soil compaction? What is porespace?
8. How does soil particle size relate to each of the following? 1) Compaction; 2) Porespace; 3) Nutrient losses due to runoff; 4) Ease of nutrient absorption by plants
9. What is the cation exchange capacity (CEC) of soil? Why is this important?
10. How does soil particle size relate to CEC? How does soil leaching relate to CEC?
11. What is soil pH and why does it matter?
12. Briefly define each of the following and describe how they are related: 1) Soil structure; 2) Aggregates; 3) Granular soil
13. How can you tell if a soil sample has an appropriate amount of soil structure? What problems can occur if soil does not have appropriate soil structure?
14. True or false: plants depend on soil for their food. Explain.
15. Briefly describe the three key nutrients that soil provides to plants and describe their role in plant growth & productivity.
16. Briefly describe each of the following and how they are related: 1) Soil Organic Matter; 2) Humus
17. What are five benefits provide by SOM that improve plant growth and productivity?
18. What are four key benefits provided by abundant and diverse soil microbial communities?
19. What most affects whether or not soil microbial communities are abundant and diverse?
20. How does the color of soil relate to the health of the soil? Explain.
21. In your own words, describe 7 ways to assess the health of a soil sample and its capacity for enabling plant growth and productivity.



Day 3: Soil Kool-Aid Lab

based on the activity by Dr. Dirt - <https://www.doctordirt.org/teachingresources/soilfilter>

Introduction: In this activity, you will investigate the relationship between soil particle sizes and the capacity for a soil sample to allow water movement and remove impurities.

Materials Needed (per group): six 3 oz. and four 5 oz. disposable cups per group; toothpicks; sand (such as playground sand; if possible, remove small particles by running it through a fine sieve); potting soil; grape Kool-Aid; tap water.

Directions:

1. Use a tooth pick to poke holes in four of the 3 oz. paper cups. Place a toothpick at the bottom of each of the 5 oz. cups.
2. Fill two of the 3 oz. cups with holes with sand until it is two-thirds full.
3. Fill the two remaining 3 oz. cups with holes with topsoil until it is two-thirds full.
4. Add grape Kool-Aid to one of the remaining 3 oz. cups.
5. Add a small amount of top soil and tap water to the remaining 3 oz. cup to create a “dirty water” sample.
6. Before proceeding, answer the questions below.

Pre-Lab Questions:

1. How do the soil particle sizes differ between the sand and the topsoil? Explain using the following terms: *sand, silt, clay*.

2. How does the porespace differ between the sand and the topsoil?

3. Briefly define *Cation Exchange Capacity* in your own words. Then explain how you think CEC differs between the topsoil and the sand.

4. How might the differences in porespace and CEC affect the ability of water to move through the sand compared to the topsoil?



5. In a moment, you will be pouring the dirty water and grape Kool-Aid into each of the cups of soil. The dirty water and Kool-Aid will drip through the soil and out the bottom of the smaller cup into the larger cup. In the space below, hypothesize how these different water mixtures will respond differently to each of the soil samples.

Dirty Water: _____

Kool-aid: _____

Directions:

1. After making sure that each 5 oz. cup has a toothpick at the bottom, place each of the 3 oz. cups of sand and topsoil into a 5 oz. cup.
2. Begin with the cups of sand. Pour the 3 oz. cup of grape Kool-Aid into one of the cups of topsoil. Pour the dirty water into the other cup of topsoil. Allow a few minutes for the water to completely move through the soil.
3. Re-fill your 3 oz. cups with grape Kool-aid and with dirty water (try to achieve a similar level of ‘dirtiness’ as the first time).
4. Repeat Step 2 by pouring the water samples into the cups of sand. Allow a few minutes for the water to completely move through the sand and then answer the questions below.

Post-Lab Questions:

1. Briefly compare the water samples after they moved through the sand and topsoil particles:

Kool-aid w/ Topsoil: _____

Dirty water w/ Topsoil: _____

Kool-aid w/ Sand: _____

Dirty water w/ Sand: _____

2. How was this similar or different from your hypothesis? _____

3. How does this relate to the differences in the porespace between the topsoil and the sand? _____

4. How does this relate to the differences in the CEC between the topsoil and the sand? _____



5. In the space below, draw the comparative particle sizes and porespace for the topsoil and the sand samples.
6. How might the results be different if humus was added to either of these soil samples? _____

7. How might the results be different if these soil samples were compacted? _____

8. Which of these soil samples is at greatest risk for erosion? Why? _____

9. Which of these soil samples is at greatest risk for nutrient leaching? Why? _____

10. Which of these soil samples likely has the greatest microbial biodiversity? Why? _____

11. Which of these samples would be better for groundwater purification? Why? _____

12. How might greater levels of soil microbial diversity affect waste removal? _____



Day 4: Review & Assessment

Directions: you will begin by reviewing the unit objectives in your small groups. For each objective, rank it as a 1 (*completely unsure*), 2 (*somewhat unsure*), or 3 (*completely sure*) based on your comfort with that objective. After a few minutes of review, your instructor will lead a whole-class review. This is your chance to ask any questions you still might have about the concepts in this unit. Begin with anything you ranked as a “1”.

After you have completed the unit review, you will be taking an individual multiple choice quiz and/or a group short answer quiz. These quizzes may be graded in class to help you better understand the question and the correct answer.

Unit Objectives:

1. What are soils? How are soils created? How long does this process take?
2. How do soils support and enable plant growth and productivity?
3. Briefly describe the three primary kinds of soil particles and their comparative sizes.
4. What is a loam?
5. What type of soil particle is ideal for plant growth and productivity?
6. How does the size of a soil particle relate to its surface area?
7. What is soil compaction? What is porespace?
8. How does soil particle size relate to each of the following? 1) Compaction; 2) Porespace; 3) Nutrient losses due to runoff; 4) Ease of nutrient absorption by plants
9. What is the cation exchange capacity (CEC) of soil? Why is this important?
10. How does soil particle size relate to CEC? How does soil leaching relate to CEC?
11. What is soil pH and why does it matter?
12. Briefly define each of the following and describe how they are related: 1) Soil structure; 2) Aggregates; 3) Granular soil
13. How can you tell if a soil sample has an appropriate amount of soil structure? What problems can occur if soil does not have appropriate soil structure?
14. True or false: plants depend on soil for their food. Explain.
15. Briefly describe the three key nutrients that soil provides to plants and describe their role in plant growth & productivity.
16. Briefly describe each of the following and how they are related: 1) Soil Organic Matter; 2) Humus
17. What are five benefits provide by SOM that improve plant growth and productivity?
18. What are four key benefits provided by abundant and diverse soil microbial communities?
19. What most affects whether or not soil microbial communities are abundant and diverse?
20. How does the color of soil relate to the health of the soil? Explain.
21. In your own words, describe 7 ways to assess the health of a soil sample and its capacity for enabling plant growth and productivity.



Day 5: Career Connections

Directions: Begin with a group and class discussion about the topics of this week. What is still unclear? What is still confusing? What seemed most important to remember? How does this relate to horticulture?

If time allows, you will also have time to work on one or two semester projects:

The Garden Project involves creating your own garden as a group. Your instructor will provide you with more details, but in a nutshell you will work as part of a team to plan, design, and create some kind of garden. This might be a community garden, a school-based garden, or a container garden. The goal is to utilize the knowledge and practices that you gain over the course of this semester to maximize the productivity and sustainability of your garden.

The Adopt a Farmer Project involves working with a farm, greenhouse, or community garden in your community in order to determine some new methods that they could try to improve the sustainability of their operation. Your instructor will provide you with more details about this project.



Soil Science Individual Quiz

Name: _____ Hour _____ Date: _____ Score: _____ / _____

Directions: This quiz should be completed on an individual basis. A 3x5 notecard with handwritten notes can be used on this quiz.

- 1. Which of the following best describes how soils are formed?**
 - a. As plants and animals break down, the carbon in their bodies turns into minerals that plants eat to survive.
 - b. Over thousands of years, rocks are weathered down to small particles that mix with small amounts of decaying organic matter and living organisms.
 - c. As animals consume plants, they convert the plant matter into minerals. The feces from the animals then forms the soil.
 - d. Over thousands of years, carbon dioxide in the air turns into minerals that fall to the ground and form soil.

- 2. This is the largest soil particle.**
 - a. Clay b. Silt c. Sand d. Loam

- 3. This has the smallest amount of porespace for air and water.**
 - a. Clay b. Silt c. Sand d. Loam

- 4. This is the least likely to undergo compaction but is at most risk for erosion.**
 - a. Clay b. Silt c. Sand d. Loam

- 5. This is the most ideal soil for plant growth and productivity.**
 - a. Clay b. Silt c. Sand d. Loam

- 6. This consists of an even mixture of different sizes of soil particles.**
 - a. Clay b. Silt c. Sand d. Loam

- 7. This generally has the lowest Cation Exchange Capacity (CEC).**
 - a. Clay b. Silt c. Sand d. Loam

- 8. The higher the cation exchange capacity (CEC) of a soil sample, the...**
 - a. Weaker the soil's capacity is to hold onto water and nutrients.
 - b. Stronger the soil's capacity is to hold onto water and nutrients.
 - c. Greater the risk of nutrient leaching.
 - d. Greater the porespace.

- 9. How do factors such as porespace and compaction of soil affect plant growth?**
 - a. Compacted soils reduce the availability of water and oxygen to plant roots.
 - b. Soils with large amounts of porespace enable roots to absorb more water and soil.
 - c. Soils with small amounts of porespace are less likely to undergo nutrient leaching.
 - d. Compacted soils have less porespace, which reduces the availability of water, nutrients, and oxygen.
 - e. All of the above are accurate statements.



10. Which of the following is an accurate statement in regards to soil pH?

- a. pH is a measure of the soil particle size; a pH of 7 indicates that the soil is a loam.
- b. pH indicates how acidic the soil is; a pH of 7 indicates that the soil is highly acidic.
- c. pH is a measurement of how much organic matter can be found in soil; a pH of 7 indicates that the soil has moderate amounts of organic matter
- d. pH indicates how basic or acidic the soil is; a pH of 6 (slightly acidic) is ideal.

11. An ideal soil structure would be...

- a. Clumpy – it easily forms aggregates that hold their shape.
- b. Loose – the soil does not form aggregates and does not hold its shape at all.
- c. Granular – the soil forms small crumbly aggregates.
- d. Solid – the soil is impermeable, like cement.

12. This the nutrient that plants depend upon most for water uptake.

- a. Nitrogen
- b. Phosphorus
- c. Potassium
- d. All of the above
- e. None of the above

13. This the nutrient that plants need to form the amino acids needed to assemble proteins.

- a. Nitrogen
- b. Phosphorus
- c. Potassium
- d. All of the above
- e. None of the above

14. This the nutrient is a key component of DNA; it is necessary for maturation & root development.

- a. Nitrogen
- b. Phosphorus
- c. Potassium
- d. All of the above
- e. None of the above

15. This is what plants consume as their primary source of food and energy.

- a. Nitrogen
- b. Phosphorus
- c. Potassium
- d. All of the above
- e. None of the above

16. Which of the following is NOT something that is provided by soil organic matter?

- a. Increases the amount of porespace in the soil.
- b. Provides greater access to nutrients in the soil.
- c. Reduces the risk of both erosion and compaction.
- d. Serves as a source of energy as a source of the plant's food.
- e. Sequesters carbon in the soil, reducing the amount of atmospheric greenhouse gases.

17. Which of the following is the most important determinant of the biodiversity and abundance of soil microbial communities?

- a. Particle size
- b. Availability of NPK
- c. Porespace
- d. Abundance of soil organic matter

18. In general, the _____ the biodiversity of soil microbes, the better.

- a. Greater
- b. Lower

19. Explain your answer to the previous question: _____

20. In general, the _____ the color of the soil, the better.

- a. Darker
- b. Lighter

21. Explain your answer to the previous question: _____



Soil Science Group Quiz

Names (F&L): _____

Hour _____ Date: _____ Score: _____ / _____

Directions: This quiz should be completed in your assigned groups. A 3x5 notecard with handwritten notes can be used on this quiz. Each person should take turns writing an answer. Those not writing should be actively working together to create their group's answer. Those who are not actively involved in answering every question may be asked to complete this quiz alone. Record the writer's name after each question.

- 1. Briefly summarize how the size of soil particles in a soil sample affect the ability of that soil to support plant growth. Be sure to address all of the following: porespace, nutrient leaching, cation exchange capacity, soil structure, loam.**

Writer's Name: _____

- 2. People often assume that plants "eat" soil. What is wrong with this assumption? What specific roles do soils actually play in supporting plant growth and productivity?**

Writer's Name: _____



- 3. Besides minerals, soils are comprised of decomposing organic materials and living organisms such as bacteria and fungi. How important are these aspects of soil to plant productivity? Explain by summarizing the roles that they play in soils.**

Writer's Name:

- 4. How would you know if an area had healthy soils? Summarize 7 characteristics of healthy soil.**

Writer's Name:



Appendix: Soil Recipe Lab

Introduction: The purpose of this activity is to help students reflect on previous ideas and prior knowledge in regards to soil science. Many students have had the opportunity to plant seeds either at home or as part of a classroom activity and will enter this unit with existing ideas about the role of soils and the properties of a “good soil”. This activity is meant to help student make those ideas more explicit, challenge those ideas, and try to reach a consensus across the class as to what properties are necessary in soil for plant productivity.

Directions: you will need to provide students with multiple soil types (sand, silt, and clay if possible). Sand can easily be acquired from a home supply store (ask for playground sand if unsure). A garden supply store may also be able to provide specific kinds of soil types. School maintenance departments often have specific kinds of soil, particularly for athletic fields (e.g. baseball/softball fields often use a heavy clay-based soil to build up the pitcher’s mound; sand is often necessary for the jumping pits for track and field) – an email to your grounds director or head custodian may be helpful for this.

You should also acquire a loamy topsoil as well as a standard potting soil. This should be kept separate from the other ‘ingredients’ until after students have had the chance to compare their soil sample with other groups. The store-bought potting soil is meant to be a ‘standard of comparison’ to help students identify how their ideas differ and identify aspects or characteristics that they may not have considered.

A key component of this activity is to provide students with the opportunity for evidence-based argumentation. It is ok if students do not have fully-developed ideas at this point – encourage students to work together to reach a consensus on their ideas about soil based on evidence and prior knowledge. Remind students that they can change or modify their ideas as the week progresses (and their ideas should change as more information becomes available).



Appendix: Soil Kool-Aid Lab

Introduction: In this activity, students will compare the soil filtration capacity of soils with large particles (sand) in comparison to soils with smaller particles (topsoil).

Directions: begin by having students answer the pre-lab questions on the first page of the activity. These are designed to help students recall what they have already learned in regards to soil particle size, porespace, and cation exchange capacity. Using this knowledge, students should be able to develop an explanatory model to explain the relationships between these concepts. It would be helpful if time allows to have students briefly explain these relationships in a whole-class discussion.

In this lab, students will be pouring both purple Kool-Aid and muddy water through the soil samples. The varying levels of cation exchange capacity should result in slight differences in the ability of the soil samples to remove the “impurities” from these water samples. Students should be able to grasp that larger soil particles have less capacity to attract these substances (the Kool-Aid ingredients and the soil particles in the muddy water) but that large soil particles also provide more rapid drainage and larger porespace. Students should be guided in recognizing that there is a tradeoff in regards to soil particle size and plant productivity – small particle sizes are less susceptible to runoff and leaching, but also provide less porespace for nutrient exchange and aeration. Vice versa, large particle sizes are more susceptible to runoff and leaching, but provide more porespace and aeration that supports root growth and development.

For the final questions on the last, you as the instructor can decide whether to have students complete the questions individually, in their small groups, or as a whole class (utilizing strategies such as a jig-saw, gallery walk, or fish bowl discussion).

NOTE: This may be an ideal opportunity to have students plant radishes that they will need for the Roots Unit investigation, as the radishes will need some time to germinate and grow. Refer to that week’s curriculum and appendix for more details.