Cultivation and Tillage

Summary: In this lesson, students cultivate or till a garden bed and conduct an investigation on the impact cultivation and tillage on crop health. They start by reviewing the process of photosynthesis, and the requirements plants have for growth. This lays the foundation for them understanding why soil health is so critical to plant health. Then students will begin an investigation in which they will plant starts in both tilled and un-tilled soil. Over the next few weeks, they will continue to make observations to track the impacts of tilling and cultivating on crop health. This is the third of a 12-lesson series in which students will explore the basic ecological principle of interdependence through the lens of common organic farming practices.

Time: 75 minutes

Materials:

- Garden Fork
- Garden Rake

Vocabulary:

- **Cultivation:** the process of working the top sections of soil to maintain soil fertility to grow plants.
- **Tillage:** Digging deep into the soil to break it up. 4-6 inches is considered shallow tillage while 8-10 inches is deep tillage. Sometimes referred to as *deep cultivation*.
- **Photosynthesis:** The process by which plants and some other microorganisms use sunlight to create their own food from carbon dioxide (CO_2) and water (H_2O).
- **Aeration:** The process of decreasing the density of a substance (such as soil) and integrating more oxygen into it.
- **Compost:** decayed organic material (such as dead plants and food scraps) often used as fertilizer for plants.
- **Fertilizer:** a natural or chemical substance often added to soil to increase its nutrient-content.

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Teacher Notes:

- This lesson involves setting up an investigation comparing the effect of tilling and cultivating on crop health. Students will plant starts in both cultivated and uncultivated soil, and then track their observations over the weeks that follow. There will be opportunities built-in to subsequent lessons for students to make note of their observations.
- Take some time to read the definitions of the key terms we will be learning today to familiarize yourself or the class with keywords that will be covered in the lesson.
- The "READ" sections of this lesson plan can be used as talking points or a script to introduce activities. Please note, these sections simply provide brief introductions to the topics. We recommend using your experiences to add more information and context to the topics being covered.
- If teaching asynchronously or assigning the lesson plan as homework, for the sections that instruct students to READ, consider recording you reading the sections aloud and sending the recording to students. This adaptation offers a helpful strategy for differentiating learning that supports all students.
- The "THINK or DISCUSS" sections of the activities provide some great prompts for informal conversations. Consider asking your students these questions as they are gardening. You could also create a "question board" with the different questions and have students informally choose different questions to answer while they garden.
- Optional—as an added activity you could create a public space where students can share the things they notice during each of the rotations. This could take the form of a board with chart paper or markers where students can write down their answers to the questions labeled "NOTICE." This extra activity supports students to glean observations from their classmates and learn from one another.
- For more information on the practices of organic farming, see the Center for Agroecology and Sustainable Food Systems curriculum on Organic Farming and Gardening Skills.

Teacher Notes Continued

- This lesson begins by asking students to develop descriptions of the processes of tilling and cultivating through observing the practices in action. This prompt is designed to support students in continuing to develop the skill of close observation—a critical skill in science.
- You may choose to deepen the layers of investigation in this lesson by adding compost to some of the starts and not others. Students will be investigating compost at the end of this unit, and starting the investigation now will allow them to gather data on the impact of compost on crop health by the time you get to the compost lesson. If you do choose to do this, you should have four distinct sections of plant starts: uncultivated soil without compost, uncultivated soil with compost, cultivated soil without compost, and cultivated soil with compost.

References:

Garden Cultivation and Tillage (2015). In Brown, M.; Miles. A. & Perez. J. (Eds.) *Teaching Organic Farming and Gardening* (pp. 31-95). Retrieved from https://casfs.ucsc.edu/about/publications/Teaching-Organic-Farming/PDF-downloads/1.2-tillage.pdf

Estimating soil moisture by feel and appearances (n.d). *United States Department of Agriculture*. Retrieved from https://www.wcc.nrcs.usda.gov/ftpref/wntsc/waterMgt/irrigation/EstimatingSoilMoisture.pdf

Evaluating soil moisture before field preparation and planting (n.d). *Iowa State University Extension*. Retrieved from https://crops.extension.iastate.edu/encyclopedia/evaluating-soil-moisture-field-preparation-and-planting

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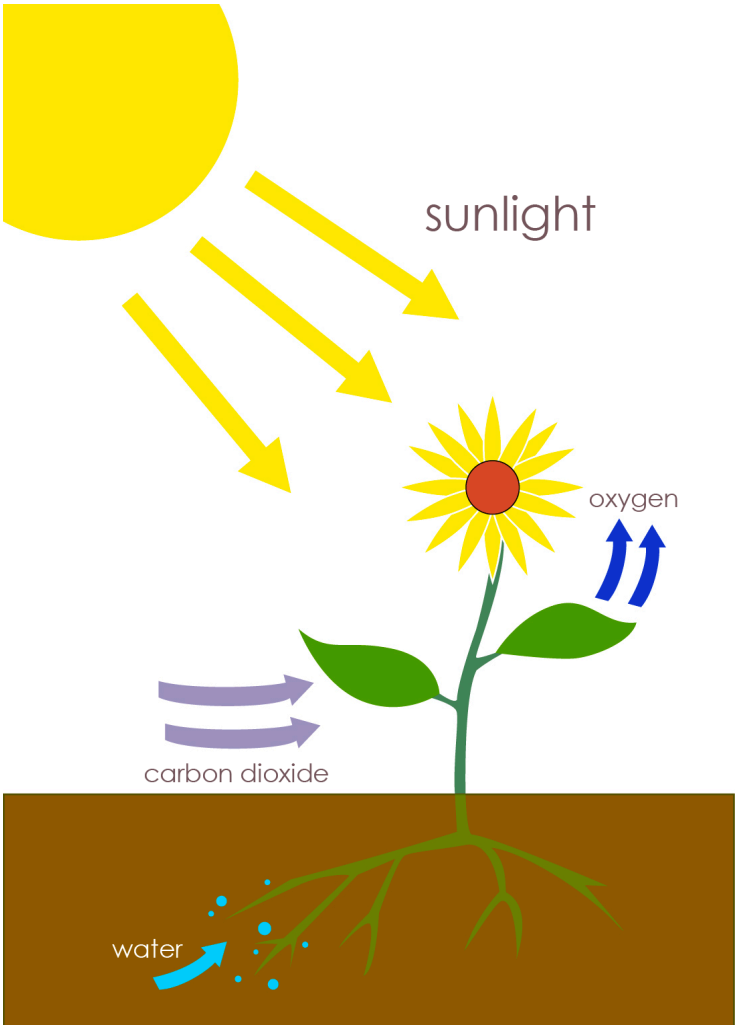
READ: In the previous lesson, we began considering the garden as an "ecosystem". You learned how every aspect of an ecosystem is interconnected and looked at the different abiotic and biotic factors that make up the garden ecosystem. You also collected some observations on how these factors interact and began to develop hypotheses on how these interactions may impact the garden crops. In today's lesson, we'll focus on just one factor of the garden ecosystem: **the soil.**

The soil is at the foundation of any garden ecosystem. Plants rely on the soil for the nutrients and water they need to grow. In turn, all other organisms in the ecosystem rely on plants to get the energy they need to survive. How do plants provide other organisms with energy? Through the process of photosynthesis. **Photosynthesis** is a process in which plants turn the energy from the sun into sugars.

Photosynthesis

$CO_2 + H_2O + \text{energy} \rightarrow C_6H_{12}O_6 + O_2$

carbon dioxide + water + sunlight → glucose (sugar) + oxygen



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Plants use some of these sugars for themselves as a source of energy for growth and maintenance. They store any unused sugars in their roots or fruit. As humans, we benefit firsthand from this process. Consider carrots, beets, and potatoes—all examples of roots we eat. Or tomatoes, apples, squash, and oranges—all examples of fruits we eat. These sugar-rich plant parts have been bred by generations of farmers to taste delicious. They also provide us with energy when we eat them. **In fact, all the energy that you, or any other animal, has ever used came originally from the sun, by way of plants**. Without plants (and other organisms such as certain kinds of bacteria that create energy from the sun), humans and all other animals would not be able to survive!

But for this entire process to work, **plants don't just need sunlight, they also need water and nutrients that they get from the soil.** Therefore, the well-being of plants (and the rest of the ecosystem) relies on the well-being of the soil. In order to stimulate the health of their soil, farmers often **till** or **cultivate** their fields. Tillage or cultivation are processes of working the soil.

Cultivating and tilling have numerous benefits for gardening:

- First, they increase soil quality by **aerating** it (decreasing the density of the soil and integrating more oxygen into it). Second, they break up the hard surfaces of soils, which allows water to better soak into the soil instead of running off the top.
- They also increase the nutrient content of soils by integrating material from the top layer of soil into bottom layers, and allowing farmers to mix in nutrient-rich soil amendments like **compost** and **fertilizers**.
- Finally, tilling and cultivating can disrupt the growth of unwanted plants ("weeds"), reducing the competition that the crops face for resources.

In this lesson, we will both put these techniques into practice, as well as explore how tilling, cultivating, and the addition of compost impact the soil and crops.

INVESTIGATE: In this lesson, we'll start an investigation to answer the questions:

- **What impact do the farming practices of tilling and cultivating have on soil? What impact do they have on crops?**
- **What impact does adding compost to a garden bed have on soil? What impact does it have on crops?**

In order to answer these questions, we are going to plant young plants in both cultivated and uncultivated beds, and then compare their growth over time. We will also be exploring the impact of compost on crops by adding compost to some of the crops in both the cultivated and uncultivated sections of the bed. Today is just the first day of this investigation. We'll continue to gather data over the lessons that follow.

OBSERVE: Make some initial observations about the bed we are going to cultivate today. You may want to record what you see on the Plant Start Investigation worksheet.

- What colors, textures, and materials do you observe in the soil?
- How does the soil smell?
- Do you notice any creatures in the soil?
- What plants are growing here? What can you observe about them? How healthy do they seem?
- How healthy does the soil seem? Explain your reasoning.
- What other observations can you make about the soil or the vegetation in this bed?

DO: Now you are going to practice tilling or cultivating the soil yourself. ***IMPORTANT: You should only till or cultivate half the garden bed you are working in. This will allow you to compare how crops grow in cultivated vs. uncultivated soil.***

Prepare the Soil: When you till or cultivate it's important that your soil is moist, but not too wet. *Touch the soil. What do you notice? Is the surface hard? Is the soil wet or moist?* You can check for the amount of water by conducting a hand squeeze test:

- Dig down at least 2 inches.
- Pull up a sample of your soil and squeeze it in your hand to form a ball.
- If the soil has the right amount of moisture it should form a ball that will fall apart when you bounce the ball in the palm of your hand.
    - If the soil is too dry, consider gently watering the area you plan to work with a hose or sprinkler, and allowing the water to seep into the soil for 10-15 minutes before beginning to work.

Cultivate or Till: Now that you checked the moisture of your soil, you are reading to till or cultivate your soil. Follow these steps to till or cultivate.

- **Cultivation:** Use a garden rake, or hand trowel to break up the surface of the soil. You should scratch or punch through the surface but not go much deeper.

  REFLECT: As you work, reflect on the questions below.

    - What do you notice about the texture, consistency, and color of the soil? Do these characteristics vary by depth? How do they change as you work?
    - What other components of a garden ecosystem might cultivating have an impact on? (For example, are there any living things that are affected by your work?)
    - Why do you think it is important only to scratch or punch through the surface of the soil when cultivating, but not go much deeper? Explain.

- **Tillage** (sometimes called "deep cultivation"): Take your garden fork and dig into the soil the full depth of the fork or 8-10 inches deep. Lift up your fork and disperse the soil across the surface. Start from one side of the bed and work towards yourself. Once you have finished the full length of the bed, use a garden rake to even out the soil and break up any remaining clumps in the soil.

REFLECT: As you work, reflect on the questions below.

  - What do you notice about the texture, consistency, and color of the soil? Do these characteristics vary by depth? How do they change as you work?
  - What other components of a garden ecosystem might tilling have an impact on? (For example, are there any living things that are affected by your work?)
  - Why do you think it is important to dig 8-10 inches deep when you till? Why do you think you disperse the deeper soil across the surface? Explain.

Plant: Plant your crop starts in both sections of the bed: cultivated and uncultivated. For half of the plant starts in each section, add compost. See this resource for support and ideas on how to transplant starts. After planting, you should have 4 sections of the bed:

Uncultivated soil / No compost	Cultivated soil / No compost
Uncultivated soil / With compost	Cultivated soil / With compost

Remember to use plant labels or other signage to clearly indicate which area of the soil is cultivated, which area is uncultivated, and which plants were planted with and without compost. You'll need to keep track of these sections so you can continue to collect data on the plants as they grow over time.

HYPOTHESIZE: Make some hypotheses on how you predict the plants in each section of the garden bed will grow. Record your hypotheses on the Plant Start Investigation worksheet.

- How do you anticipate the crops will grow in the cultivated vs. uncultivated soil? Do you think they will do better in one area vs. the other? Why?
- How do you anticipate the addition of compost will impact plant growth? Explain your answer.
- Do you think that the practices of tilling and cultivating might impact any other abiotic or biotic factors in the garden ecosystem? What about adding compost to the soil?

COLLECT DATA: Now add your initial observations about the plants and soil in each section to the first table on the Plant Start Investigation worksheet.

DISCUSS: With a partner or as a class, discuss the questions below. Support your responses with evidence from your observations.

- What do you anticipate observing in this investigation? Why?
- Do you think cultivating and tilling might have any drawbacks for the crops or other parts of the garden ecosystem? Explain your reasoning.
- Do you think you will till or cultivate your beds for your project? Why or why not?
- What questions do you still have about tilling, cultivating, or the role of soil in a garden ecosystem?

OBSERVE (optional): Now you've observed the soil and vegetation in a garden bed before it was cultivated or tilled, and immediately after. In comparison, make some observations of an area of the garden that has never been cultivated or tilled (such as a garden path).

- What do you observe about the texture, consistency, and color of the soil?
- Do you notice any creatures in the soil?
- What plants are growing here? What can you observe about them? How healthy do they seem?
- How healthy does the soil seem? Explain your reasoning.
- What other observations can you make about the soil or the vegetation here?

PLANT INVESTIGATION:

STUDENT WORKSHEET

Name: _____

Central Questions:

- What impact do the farming practices of **tilling** and **cultivating** have on soil? What impact do they have on crops?
- What impact does adding **compost** to a garden bed have on soil? What impact does it have on crops?

Procedure: Plant crop starts in both cultivated and uncultivated garden beds. Add compost to half the crops in each section when you plant them.

Initial Observations: Make some initial observations about the soil in the bed that you are going to till or cultivate.

- What colors, textures, and materials do you observe in the soil?
- How does the soil smell?
- Do you notice any creatures in the soil?
- What plants are growing here? What can you observe about them? How healthy do they seem?
- How healthy does the soil seem? Explain your reasoning.
- What other observations can you make about the soil or the vegetation in this bed?

Name: _____

Hypothesize: Make some hypotheses for how you predict the plants in each section of the garden bed will grow.

- How do you anticipate the crops will grow in the cultivated vs. uncultivated soil? Do you think they will do better in one area vs. the other? Why?

- How do you anticipate the addition of compost will impact plant growth? Explain your answer.

- Do you think that the practices of tilling and cultivating might impact any other abiotic or biotic factors in the garden ecosystem? What about adding compost to the soil?

Observe: Collect observations about the soil and plants in the data tables below. You may draw or write. Some questions you may want to consider are:

- How many plant starts are in each section?
- How do the plant starts in each section compare?
    - What do you notice about their appearance or overall health?
    - How big or tall are they?
- What observations can you make about the appearance, materials, and texture of the soil in each section of the bed?
    - Do you notice any organisms in the soil?
    - Do you notice anything about the temperature of the soil?
    - The moisture level?
    - The smell?

Name: _____

Date:

Uncultivated soil / No compost	Cultivated soil / No compost
Uncultivated soil / With compost	Cultivated soil / With compost

Date:

Uncultivated soil / No compost	Cultivated soil / No compost
Uncultivated soil / With compost	Cultivated soil / With compost

Date:

Uncultivated soil / No compost	Cultivated soil / No compost
Uncultivated soil / With compost	Cultivated soil / With compost

Name: _____

Date:

Uncultivated soil / No compost	Cultivated soil / No compost
Uncultivated soil / With compost	Cultivated soil / With compost

Date:

Uncultivated soil / No compost	Cultivated soil / No compost
Uncultivated soil / With compost	Cultivated soil / With compost

Date:

Uncultivated soil / No compost	Cultivated soil / No compost
Uncultivated soil / With compost	Cultivated soil / With compost

Date:

Uncultivated soil / No compost	Cultivated soil / No compost
Uncultivated soil / With compost	Cultivated soil / With compost

Date:

Uncultivated soil / No compost	Cultivated soil / No compost
Uncultivated soil / With compost	Cultivated soil / With compost

Analyze: Consider your observations so far.

- Do you notice any patterns in your data?

- How would you compare the overall plant growth and health across the four sections of the bed?

- What could explain your observations?

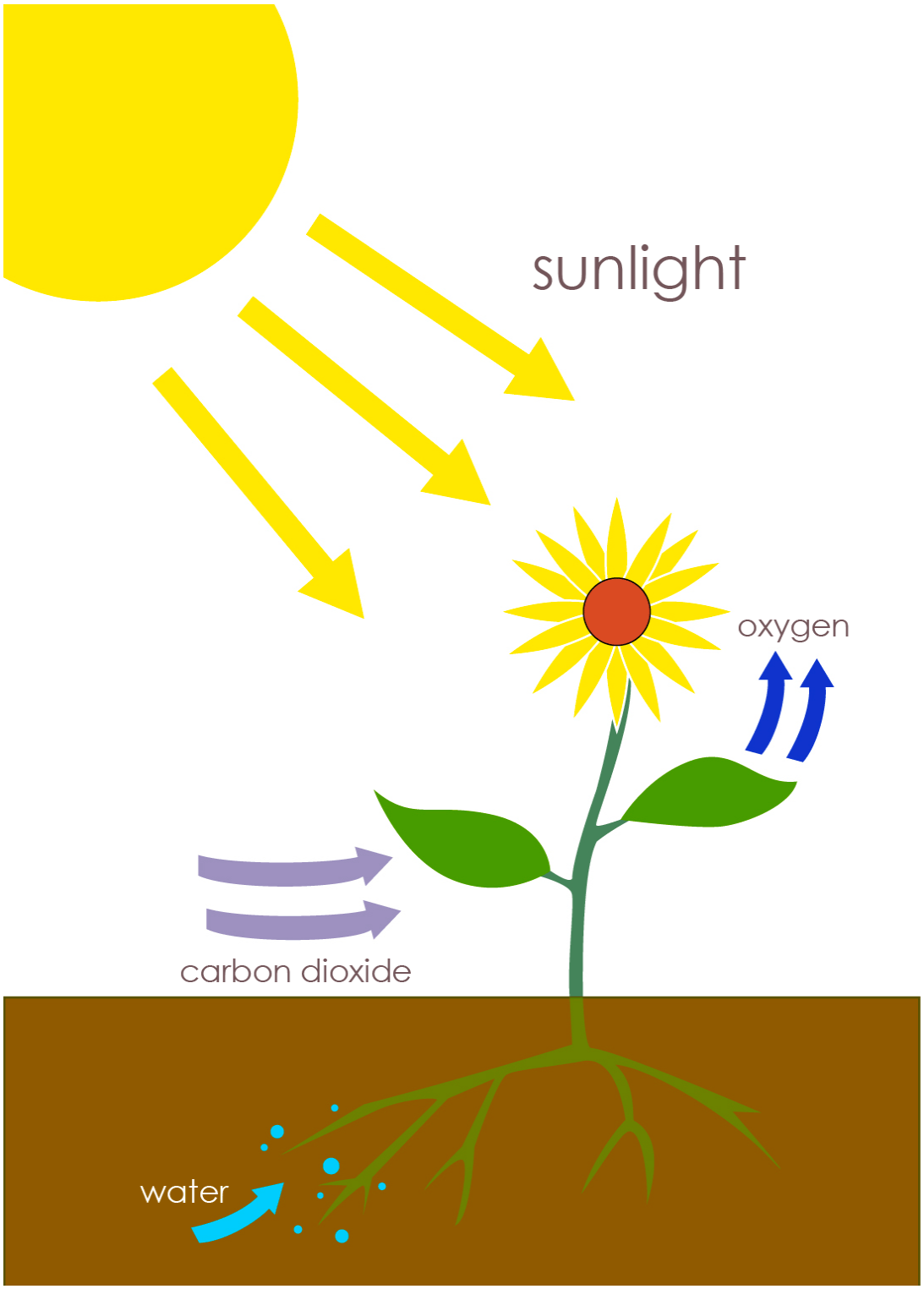
- Based on your observations, do you feel confident coming to any conclusions about the effects of tilling vs. not tilling, or adding compost vs. not adding compost on plant starts?
    - If your results are conclusive, what are they?
    - If your results are not conclusive, why might that be? Can you imagine any changes to our investigation that may have allowed your results to be more conclusive?

- What questions do you still have?

Photosynthesis

$CO_2 + H_2O + \text{energy} \rightarrow C_6H_{12}O_6 + O_2$

carbon dioxide + water + sunlight → glucose (sugar) + oxygen



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