Soil Respiration

UVM Soil Health Research and Extension Center

What is soil respiration?

Soil respiration is an indicator of biological activity that reflects the general capacity of soil to support life. From microorganisms such as bacteria, fungi, and archaea to larger organisms like nematodes, protozoa, microarthropods, and plant roots, almost all soil organisms respire carbon dioxide (CO_2) (Figure 1). These organisms perform vital processes such as breaking down organic material or cycling nutrients.

The SHREC Lab estimates potential soil biological activity by conducting a CO_2 burst test. This test measures CO_2 that organisms release after a soil sample is dried and rewetted in the lab. This measure describes the level of microbial activity.

Soil respiration is best interpreted in combination with other soil tests SHREC offers that, together, can give a better sense of a soil's biological health. For example, this test alone cannot identify which organisms are present in the soil or whether they are beneficial or harmful.

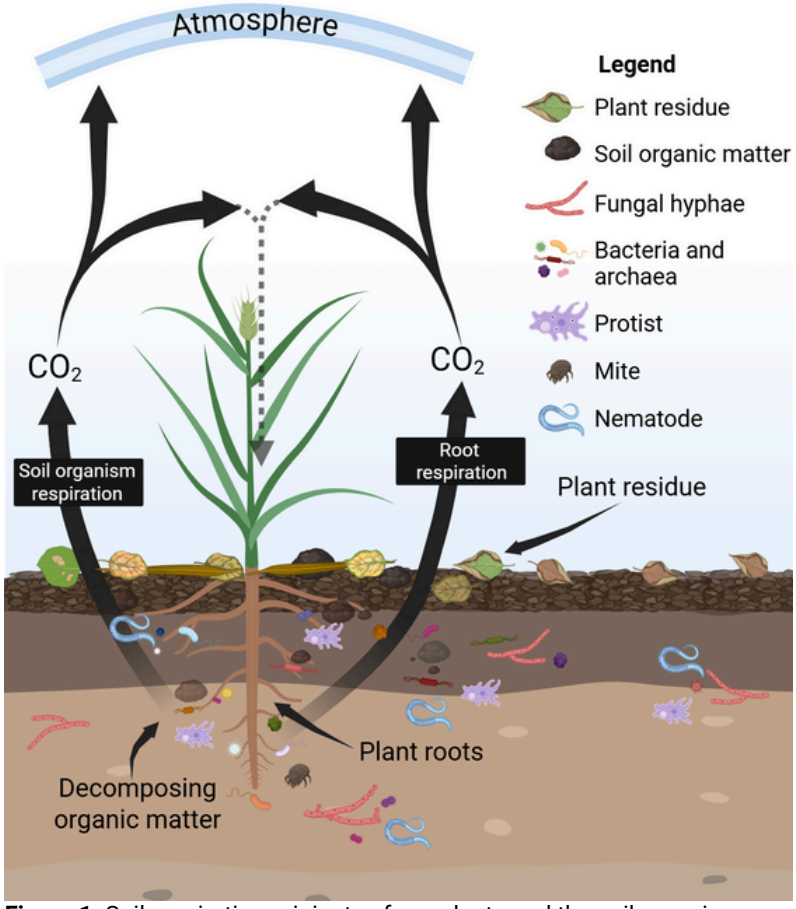

Figure 1: Soil respiration originates from plants and the soil organisms. Organisms respire CO_2 for a variety of reasons including plant growth, decomposition of organic matter by bacteria and fungi, and transformation of nutrients into forms available to plants. Created with BioRender.com.

What affects soil respiration?

Soil respiration fluctuates within and among days and weeks. It is very sensitive to soil conditions at the time of sampling. For best results, avoid sampling immediately after management events like tillage, heavy rain, or drought.

To track long-term changes in soil health, it's best to sample at the same time each year. The following factors can affect soil respiration:

- **Climate:** Like most organisms, soil organisms need warmth and moisture, but not too much of either.
- **Soil texture:** Like most crops, most soil organisms thrive in medium-textured, silty loamy soil. These soils tend to have good porosity, aeration, higher available water capacity, and organic matter protected by aggregation.
- **Organic matter** adds microbes to soil and provides habitat for soil organisms.
- **Aggregation** improves living conditions for soil organisms, increasing pore space and therefore available, air, water, and nutrients as well as increasing and improving habitat.

Basic protocol for CO_2 Burst Method

- Air-dried soil, ground to < 2mm, is placed in a small, perforated dish and positioned on top of two filter papers at the bottom of a wide-mouth, pint-sized mason jar.
- A small beaker containing 0.5M potassium hydroxide (KOH) is placed inside the jar on top of a platform to trap CO_2. Deionized water is carefully pipetted along the inner wall of the jar to rewet the soil
- The jar is immediately sealed and incubated at room temperature for 4 days. Following incubation, an electrical conductivity (EC) meter is used to quantify the amount of CO_2 absorbed by the KOH trap. EC declines linearly as CO_2 is absorbed

Understanding scoring

Respiration values are reported in mass of CO_2 respired per mass of soil. Increased respiration suggests an increased capacity for biological activity in soil due to higher abundance of organisms and increased availability of organic matter. However, an excessively high respiration rate could mean that soil organic matter is being burned off quickly, or that plants are experiencing

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stress or disease. A low respiration rate can indicate low biological activity, a lack of available soil organic matter with sufficient nitrogen content, or unfavorable soil environmental conditions (Figure 2). For example, your soil may receive a low score if sampled under drought conditions, prolonged flooding, or suboptimal temperatures.

Samples from Vermont farms that are submitted to SHREC will be used to inform the interpretation of soil respiration measurements based on management practices, geography, and soil type. SHREC aims to have a Vermont-specific scoring system (high, intermediate, and low values) in place as soon as an adequate quantity of representative soils has been processed. Until that time, statistics across all SHREC samples will be included in lab reports to provide a general frame of reference for individual results.

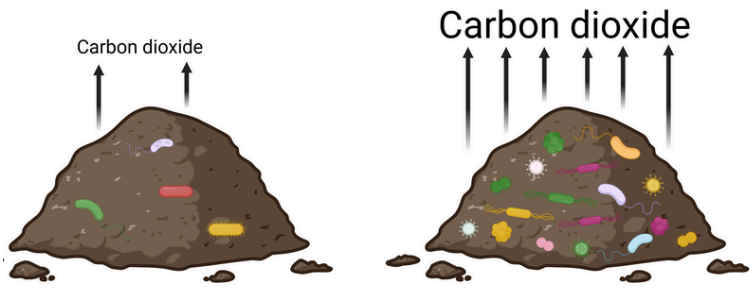

Figure 2: Greater abundance and activity of soil microbes generate greater amounts of CO_2 through their respiration. Inspired by Kaminsky et al. 2021. Created with BioRender.com.

How to improve soil respiration

- **Add organic matter** such as cover crops, high residue crops, manure or compost.
- **Reduce use of pesticides** that can harm soil organisms (pesticides, herbicides, and fungicides). Application of herbicides can result in temporary bursts of respiration because dying plants provide a short-term pulse of sugars and protein available for microbes.
- **Reduce soil disturbance,** including tillage and heavy traffic. These disrupt microorganisms and degrade their habitat by destroying aggregates and compacting the soil. Tillage often causes an immediate burst in respiration that does not last.
- **Keep soil pH in check;** soil pH must be in the ideal range, between 5.5 and 8, for soil organisms to thrive. Extreme pH can be harmful.

Sources

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