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Clarifying Carbon: plants, soils, and carbon?

With so much interest in the potential to sequester carbon in vineyard soils, it is important to understand how carbon makes its way into the soil. With this knowledge, steps can be taken to maximise the amount of carbon that enters, and is retained in, the soil.

“The good news is, if you are growing plants, be them vines, cover crops or other vegetation, you are already in the business of capturing carbon from the atmosphere and storing it in your soil!”

What is carbon?

On the surface, this is a relatively simple question; carbon is the sixth element on the Periodic Table. Perhaps a better question is: in what chemical ‘forms’ do we find carbon? Carbon is found in many different compounds, which are often referred to as ‘forms’ of carbon. An atom of carbon, be it in a glucose molecule in a berry, or a cellulose molecule in the trunk of a vine, is still a carbon atom. However, these two ‘forms’ of carbon behave very differently in the environment. So, from a carbon sequestration perspective, it is not only the amount of carbon that matters, but also the ‘form’. Carbon can be found in both organic and inorganic forms; here we focus on organic carbon.

How do plants capture carbon?

Photosynthesis is a complex, and arguably the most important, biological process. Using the energy of the sun, through a series of complex yet elegant biochemical reactions, plants capture carbon dioxide (CO_2) from the atmosphere, and convert it into stored energy in the form of carbohydrates. Once the carbon is captured by plants it can then be used to power their growth and development. Likewise, it also provides a source of energy for the organisms that eat and decompose plant materials. As such, photosynthesis provides the energy for most life on Earth, and lies at the heart of the global carbon cycle.

Labile carbon

- refers to forms of soil organic carbon that have rapid turnover times; that is, they can be readily oxidised, leading to release of CO_2 from the soil to the atmosphere. Examples include glucose, fructose and other simple sugars.

Recalcitrant carbon

- refers to soil organic carbon that is resistant to decomposition. Recalcitrant carbon can take many years (even millennia) to decompose. Examples include cellulose, lignin and charcoal.

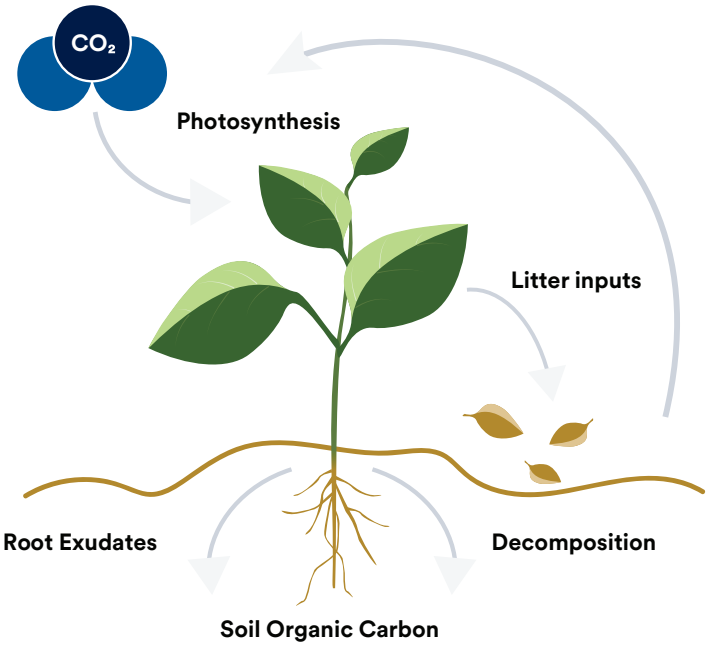
How does carbon enter the soil?

Carbon in plants can enter the soil through a variety of pathways. Plant roots exude carbon rich compounds into the rhizosphere – that soil in contact with plant roots. Once in the rhizosphere, these exudates can be consumed by soil microbes. Plant tissues entering the soil, be it via the death and decomposition of roots, or the fall of plant litter onto the soil surface, represent another pathway for carbon to enter the soil. Soil invertebrates play an important role in breaking plant materials into smaller fragments and moving them into the soil profile, where they can be colonised and further decomposed by microbes.

What happens to plant derived carbon in the soil?

Once in the soil, many organisms go to work on plant residues, to extract the energy they contain. This process of decomposition results in the loss of some carbon to the atmosphere (via respiration), but it also sees carbon being assimilated into the bodies of those organisms. As a result, carbon can move into progressively more stable forms of carbon that can be retained, or sequestered, in the soil. As noted above, the tougher and more recalcitrant the forms of carbon, the longer they will be retained in the soil. Moreover, the better protected these carbon containing materials are, for example if they are encased in soil aggregates, the less likely they are to be lost to the atmosphere.

Carbon Pathways into Soil



What can we do to sequester carbon in the soil?

To build carbon in soil we need to:

Maximise carbon inputs: increasing plant cover (e.g. cover crops) means more photosynthesis, and therefore, more carbon captured from the atmosphere. Adding carbon rich materials (e.g. compost) to the soil can also help increase soil carbon.

Minimise soil disturbance: cultivation of the soil can expose previously protected carbon to potential loss. It also disturbs soil biota and breaks up their delicate networks in the soil, thereby reducing their ability to help process and store carbon.

The global carbon cycle.

Soil may represent that largest terrestrial sink for carbon on the planet, but this is only a small part of the carbon story. While there are steps we can take to sequester carbon in the soil, prevention is better than cure. That is, the potential to sequester carbon in the soil should not be overstated, and it is important to view carbon sequestration as part of a wider solution that seeks to minimise our carbon footprint in other ways, such as reduced fuel use, and more efficient use of resources (e.g. fertiliser management). That said, aside from potentially helping to off-set carbon emissions, increasing levels of carbon in soil provides many other co-benefits, but that is a story for another day...

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