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Soil Microbial Carbon Sequestration

Introduction

There are many challenges facing agriculture in the modern day, such as increasing population, scarcity of resources, and increasing population to feed. As demand increases, agriculture soils feel more and more strain from intensive practices. However, research has identified soil as one of our most valuable resources in addressing climate change. Currently, most agricultural soils are very degraded compared to a natural and healthy soil. David Johnson of New Mexico State University says that "we currently have very degraded soils in terms of physically, chemically, but mostly biologically," and that "microbes restore this balance" in the soil (Berger 2019).

One way to improve soil health is to increase the amount of carbon in the form of soil organic matter (SOM) in the soil. It was long believed that plant matter in soil played the largest role as stable carbon in the soil. However, it is now believed that SOM consists of a "significant proportion of microbial necromass (i.e. dead biomass residues)" (Gougoulias 2014). When the microbes die, the residue soil carbon is stable in the soil than . Many complexities of the carbon sequestration process remain poorly understood, despite years of research and the significant impact of this process on global climate. We should seek to understand how microorganisms contribute to carbon sequestration, so we can reduce the effects of climate change.

Chemistry

Carbon sequestration mainly begins with the removal of carbon dioxide (CO2) from the atmosphere by plants. Afterwards, plants that die are decomposed by processes in the soil that include microorganisms. A variety of microorganisms contribute to the buildup and retention of soil carbon including various chemoautrophic bacteria, which also synthesize organic compounds from carbon dioxide. When plant or animal matter is broken down it takes the form of a desirable product called humus, which is a form of soil organic matter from the microbial activity in soil. Humus is the very complex material that remains after microbes have broken down plant and animal inputs. Humus is a valuable resource for carbon sequestration because "if undisturbed, humus can store soil carbon for hundreds to thousands of years. This makes humus a very important carbon sink" ("5A: Soil, Carbon and Microbes." 2018)

The chemistry of humus is not fully understood, however it "can be broken down into recognizable classes, such as polysaccharides, polypeptides, altered lignins, etc" (Hayes et al., 2017). It is important that we understand as much as possible about humus, because of its potential to address climate change. There are several factors that affect the formation of soil humus, such as temperature, pH, and vegetation to name a few. However, when humus is formed it will stay in the soil due to its resistance to decomposition, which allows for a build up and of humus and long term sequestration in soils (Ontl et al., 2012).

Microbial Ecology and Diversity

All organisms that interact with the soil play a part in maintaining its quality, and therefore its ability to sequester and store carbon. For example, ants and earthworms dig tunnels through soil and help aerate it. Fungal hyphae physically bind soil particles together, creating stable aggregates that trap soil organic matter from leaching, which creates a range of benefits such as helping increase water infiltration and water holding capacity of the soil. Fungi and bacteria are also important decomposers, digesting organic matter into forms that other organisms can use (Ingham). There are many organisms involved with moving carbon into the soil, such as mycorrhizal fungi. Current research indicates that plants with mycorrhizal connections can transfer up to 15 percent more carbon to soil than their non-mycorrhizal counterparts (Schwartz). The relationship between fungi and plants is a key part of sequestering carbon from the atmosphere and into the soil. In addition, decomposers are also key to the buildup of soil carbon, as they break down hard to digest materials into compounds that are accessible to other soil organisms and processes.

Other research has found that the amount of microbial necromass, or dead microorganisms, could account for a huge part of the soil carbon reservoir. Some scientific models suggest that the size of the microbial necromass carbon pool could be about 40 times that of the living microbial biomass carbon pool in soils. If it is assumed that microbial living biomass carbon is 2% of the total soil organic carbon, carbon in the necromass would account for 80% of the organic carbon in soil (Liang, 2010). The point being that it is important to promote soil health and strong communities of microorganisms, because they provide benefits to the soil health whether dead or alive!

Large Scale Implications

As of 2016, 37% of the world's land was involved in agriculture ("Agricultural Land (% of Land Area)" 2016). This large amount of land contributes to the food, fiber, and fuel that human civilization consumes. Current farming practices today are often much more efficient and more environmentally friendly than in terms of the past. However, in the future agriculture must focus on improving soil health as much as possible because of the increasing threats to agricultural productivity and human civilization. The soil is not being used to capture and store carbon form the atmosphere, even though there is potential to store massive amounts of carbon. Farmers need to realize that it is in their best interest to focus on increasing the amount of carbon in their soils by sequestering atmospheric carbon to offset effects of climate change and building up soil organic matter to further increase soil health.

It will be imperative to implement no-till farming practices across every acre of land possible, along with planting cover crops between every cash crop rotation to improve the health of the soil after harvest. The problem is that many farmers around the world still use conventional tilling practices, which provides short term increases in crop yields but quickly degrades the soil. The intricate relationships that take place within soil form over a very long time but are instantly destroyed after a plow has cut through the soil. According to the United States Department of Agriculture, only 21 percent of all cropland in the United Sates has adopted no-till practices (Creech, 2017). No-till practices significantly reduce the impact of impact of planting seeds and preserves the delicate balance of microorganisms in the soil. The process of no-till leaves the soil layers intact, and over time allows the organic layer to grow and thicken, increasing crop yields over the long term.

Conclusion

Soil is an amazing resource, full of relationships between all kinds of organisms, including many that we do not fully understand or even know about. However, we have already found that one resource within the soil can have huge potential for addressing the urgent problem of climate change. Soil humus is a product of an incredible network of organisms in the soil and understanding how it is formed and all of its properties is an important goal for humanity.

Future research is needed on how to promote and increase the production of humus by the soil microbial community. This incredible resource has a lot of potential for helping reduce the effects of climate change, however most of its potential relies on how the soil is managed. Rattan Lal, a soil scientist from the Ohio State University, states that with no-till practices it is possible to sequester 500 to 2,000 pounds of carbon per acre per year. He adds that there is financial incentive for farmers to increase soil carbon, because they can see an increase of $16 per acre with just an increase of 500 pounds of soil carbon (Nickel, 2017).

Now more than ever, we need techniques to pull carbon dioxide out of the atmosphere and sequester it as carbon. From reducing the effects of climate change, to increasing crop yields to feed humans, there are many reasons to grow soil carbon levels.We must advance research that identifies which microorganisms can sequester the most amount of carbon in soils. In addition, we must promote a strong and diverse community of microbes because they play a key part in adding carbon to the soil, whether through decomposing other organisms or acting as a medium of carbon storage themselves through microbial necromass. We need soil microorganisms more than ever to increase agricultural productivity and get past the great challenge of climate change.

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