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Potentiality of Carbon Sequestration Through Agriculture

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INTRODUCTION

Carbon sequestration through agriculture is an increasingly vital strategy in the global effort to mitigate climate change. As atmospheric carbon dioxide (CO₂) levels continue to rise, the need for effective methods to capture and store carbon becomes more urgent. Agricultural lands, which constitute over one-third of the world's arable land, hold significant potential for carbon storage through various soil management practices.

Recent reports from the Intergovernmental Panel on Climate Change (IPCC) emphasize that even with substantial reductions in anthropogenic carbon emissions, efforts to sequester previously emitted carbon are essential for stabilizing atmospheric CO₂ levels. Traditional approaches to carbon capture, such as Carbon Capture and Storage (CCS) and reforestation, have garnered attention, but the role of soils as carbon sinks has been less explored.

Soil carbon sequestration involves the transfer of atmospheric carbon into the soil through plant photosynthesis, where it is stored as soil organic matter (SOM). This process is influenced by various factors, including soil type, climate, and agricultural practices. Effective management strategies can enhance the soil's ability to sequester carbon by increasing carbon inputs and minimizing losses.

What is Carbon Sequestration?

Carbon sequestration refers to the process of capturing and storing atmospheric CO₂. This can occur naturally through biological processes, such as photosynthesis, where plants absorb CO₂ and convert it into organic matter. In agricultural contexts, carbon sequestration primarily occurs in soils, where carbon is stored as soil organic matter (SOM).

Importance of Carbon Sequestration

The importance of carbon sequestration cannot be overstated. As atmospheric CO₂ levels rise due to human activities, such as fossil fuel combustion and deforestation, the need for effective carbon drawdown strategies becomes increasingly urgent. Sequestering carbon in soils not only helps mitigate climate change but also enhances soil health, improves agricultural productivity, and provides co-benefits such as increased biodiversity and improved water retention.

Mechanisms of Carbon Sequestration in Agriculture

1. Soil Management Practices

Agricultural practices significantly influence the amount of carbon sequestered in soils. Key practices include:

- **Reduced Tillage:** Conventional tillage disrupts soil structure, leading to the release of stored carbon. Conservation tillage and no-till practices minimize soil disturbance, helping to maintain soil aggregates and protect carbon from microbial decomposition.
- **Cover Cropping:** Growing cover crops during fallow periods increases biomass inputs to the soil, enhancing carbon inputs and improving soil structure. Cover crops also prevent erosion and improve soil fertility.
- **Crop Rotation and Diversity:** Diverse cropping systems can enhance soil carbon sequestration by introducing a variety of root structures and organic matter inputs. This diversity can improve soil microbial activity and resilience.
- **Organic Amendments:** Adding organic materials, such as compost or manure, can significantly increase soil organic carbon levels. These amendments improve soil structure and nutrient availability, promoting healthy plant growth.

2. Soil Biological Processes

Soil microorganisms play a crucial role in carbon sequestration. They decompose organic matter, transforming it into stable forms of carbon that can persist in the soil for extended periods. Key processes include:

- **Microbial Decomposition:** Soil microbes break down plant residues into smaller carbon molecules, which can be protected within soil aggregates or chemically bound to soil minerals.
- **Soil Aggregation:** The formation of soil aggregates protects carbon from microbial attack. Stable aggregates can sequester carbon for long periods, especially when undisturbed.
- **Mycorrhizal Associations:** Arbuscular mycorrhizal fungi (AMF) form symbiotic relationships with plant roots, enhancing nutrient uptake and increasing carbon inputs to the soil through root exudates.

3. Land Use Changes

Converting degraded or marginal lands to restorative agricultural practices can enhance carbon sequestration. Practices such as reforestation, agroforestry, and the restoration of wetlands can significantly increase carbon stocks.

Benefits of Carbon Sequestration in Agriculture

1. Climate Mitigation

Increasing soil carbon stocks is a vital strategy for mitigating climate change. By sequestering carbon, agricultural systems can help offset greenhouse gas emissions and contribute to global climate goals.

2. Improved Soil Health

Higher soil organic carbon levels improve soil structure, enhance nutrient availability, and increase water retention. This leads to healthier crops and greater resilience to climate variability.

3. Enhanced Agricultural Productivity

Practices that promote carbon sequestration often lead to increased agricultural productivity. For example, improved soil health can result in higher crop yields and reduced input costs.

4. Biodiversity and Ecosystem Services

Increasing soil carbon can enhance biodiversity by providing a more favorable environment for soil organisms. Healthy soils support diverse plant and animal communities, contributing to ecosystem resilience.

Challenges to Carbon Sequestration in Agriculture

1. Economic Barriers

The adoption of carbon-sequestering practices can be hindered by economic factors. Farmers may be reluctant to invest in practices that require upfront costs without immediate financial returns.

2. Knowledge Gaps

There is still much to learn about the dynamics of soil carbon sequestration. Research is needed to better understand how different practices affect carbon stocks across various soil types and climates.

3. Policy and Institutional Support

Effective policies and incentives are crucial for promoting carbon sequestration in agriculture. Current frameworks may not adequately support the adoption of sustainable practices.

Opportunities for Enhancing Carbon Sequestration

1. Research and Development

Investing in research to develop innovative agricultural practices and technologies can enhance carbon sequestration. This includes breeding crops with deeper root systems and improving soil management techniques

2. Education and Training

Providing farmers with education and training on sustainable practices can facilitate the adoption of carbon-sequestering methods. Extension services can play a vital role in disseminating knowledge.

3. Market Mechanisms

Creating market mechanisms for carbon credits can incentivize farmers to adopt practices that sequester carbon. This could include payments for ecosystem services or participation in carbon trading schemes.

4. Collaborative Approaches

Collaboration among farmers, researchers, policymakers, and NGOs can foster the development and implementation of effective carbon sequestration strategies. Partnerships can enhance knowledge sharing and resource allocation.

CONCLUSION

Carbon sequestration through agriculture presents a significant opportunity to mitigate climate change while enhancing soil health and agricultural productivity. By adopting sustainable practices that increase soil carbon stocks, farmers can contribute to global climate goals and improve their resilience to climate variability. However, overcoming economic, knowledge, and policy barriers is essential for realizing the full potential of carbon sequestration in agricultural systems. Continued research, education, and collaboration will be crucial in advancing these efforts and ensuring a sustainable future for agriculture and the environment.