

Climate-Smart Soils

Adapting Agriculture for Extreme Weather Events

1. **Prince Kumar**

Division of Soil Science and Agricultural Chemistry, ICAR-IARI, Pusa Campus, New Delhi-110012

2. **Ann Theresa Jose**

Division of Soil Science and Agricultural Chemistry, ICAR-IARI, Pusa Campus, New Delhi-110012

3. **Ankit Kumar**

Division of Soil Science and Agricultural Chemistry, ICAR-IARI, Pusa Campus, New Delhi-110012

4. **Indu Chopra**

Division of Soil Science and Agricultural Chemistry, ICAR-IARI, Pusa Campus, New Delhi-110012

Received: August, 2024; Accepted: September, 2024; Published: October, 2024

Introduction

In recent years, the effects of climate change have become undeniable. More frequent and intense weather events such as droughts, floods, heatwaves, and storms are wreaking havoc on agricultural systems around the world. Farmers face increasingly unpredictable conditions, putting global food security at risk. As we grapple with these challenges, an often-

overlooked solution is right beneath our feet: soil. **Climate-smart soils** offer a promising way to build resilience in agricultural systems and adapt to extreme weather events. In this article, we'll explore how improving soil health can help farmers and ecosystems withstand the growing threats posed by climate change.

Understanding Climate-Smart Soils

Climate-smart soil refers to soil management practices that enhance the ability of soils to adapt to and mitigate the impacts of climate change. These practices aim to make agricultural systems more resilient to extreme weather events, such as droughts, floods, and heatwaves, while also contributing to the reduction of greenhouse gas emissions. The concept of **climate-smart soils** revolves around improving soil management practices to make agriculture more resilient to climate variability and extremes. Healthy soils act as natural buffers, capable of retaining more water during droughts, draining better during floods, and providing nutrients that help crops thrive even under harsh conditions. Moreover, they play a critical role in mitigating climate change by storing carbon.

To understand how soils can help combat climate impacts, it's essential to first look at their composition and functions. Soils are a mixture of minerals, organic matter, water, and air. Healthy soils teeming with life-including bacteria, fungi, and other microorganisms-perform several critical functions:

- **Water retention and drainage:** Soils act like sponges, absorbing water during heavy rainfall and releasing it slowly during dry periods.
- **Nutrient cycling:** Healthy soils provide essential nutrients to plants, enhancing their growth and ability to withstand stress.
- **Carbon sequestration:** Soils are one of the largest carbon

- sinks on the planet, storing carbon that would otherwise contribute to greenhouse gas emissions.

The Growing Threat of Extreme Weather Events

Extreme weather events have increased in both frequency and intensity, disrupting farming practices and challenging the agricultural sector. Droughts, for example, can lead to water scarcity, crop failure, and soil degradation. On the other hand, intense rainfall and flooding can wash away topsoil, leading to erosion and the loss of essential nutrients. Additionally, shifting weather patterns may extend growing seasons in some regions while shortening them in

others, making it difficult for farmers to plan their crop cycles. These conditions not only harm crops but also degrade the very foundation of agriculture: soil. Extreme heat accelerates the breakdown of organic matter, reducing soil fertility. Heavy rains and floods, meanwhile, contribute to erosion and nutrient depletion. Without proper soil management, the capacity of agricultural lands to produce food diminishes significantly.

Soil Solutions for Drought Resilience

One of the most pressing challenges for agriculture is drought. As water becomes scarcer in many regions, ensuring that soils can hold and retain moisture is vital for maintaining crop productivity. Here are some strategies to make soils more drought-resistant:

- **Organic Matter Enrichment:** Organic matter such as compost or cover crops adds structure to soil, increasing its ability to retain water. Soils rich in organic matter act like sponges, storing moisture that plants can access during dry periods. Farmers practicing regenerative agriculture often rely on these techniques to enhance soil health.
- **Mulching:** Applying a layer of mulch over soil helps reduce water evaporation and

maintain cooler soil temperatures. Mulch also protects soil from erosion, particularly during sudden downpours, and supports the growth of beneficial soil organisms.

- **Minimum Tillage:** Tilling disrupts the soil structure, leading to compaction and reduced water infiltration. No-till or reduced-till farming preserves the soil's natural structure, improving its water-holding capacity and resilience to droughts.
- **Deep-Rooted Plants:** Introducing crops with deep root systems, such as perennial grasses, helps enhance soil structure by creating channels that improve water infiltration. These deep roots can also access water that is stored deeper in the soil, helping plants survive dry conditions.

Soil Solutions for Flood Resilience

While drought is a major concern, the other side of the coin is extreme rainfall and flooding. Healthy soils can play a key role in mitigating the damage caused by floods, preventing erosion, and reducing waterlogging.

- **Improving Soil Structure:** Well-structured soils have better porosity, which allows water to drain quickly during heavy rains. Adding organic matter and promoting biological activity through cover crops or rotational grazing improves soil structure and enhances its ability to absorb excess water.

- **Erosion Control Practices:** Techniques like contour plowing, terracing, and maintaining vegetative cover on fields help protect soil from being washed away during floods. Cover crops, for instance, provide ground cover that reduces soil erosion and maintains soil health.
- **Wetland Conservation:** Wetlands act as natural buffers by absorbing excess water and filtering pollutants. Conserving wetlands or creating artificial wetland areas on farms can help manage floodwaters while benefiting biodiversity and soil health.

Climate Change Mitigation through Carbon Sequestration

Aside from helping agriculture adapt to extreme weather events, climate-smart soils also offer a powerful solution to combat climate change itself. Soils store a massive amount of carbon more than the atmosphere and all living plants combined. Through carbon sequestration, soils capture carbon dioxide from the atmosphere and store it in organic matter, where it remains for long periods.

Farmers can enhance soil carbon sequestration through practices like:

- **Cover cropping:** Cover crops, such as clover or legumes, not only protect the soil

Policy and Farmer Action

To fully realize the potential of climate-smart soils, farmers, researchers, and policymakers must work together. Investing in soil health requires both financial and educational support, as many farmers may not be familiar with the best practices for building resilient soils. Governments and organizations can provide incentives for adopting regenerative agriculture

Conclusion

As extreme weather events become more frequent, the need for climate-smart agriculture has never been more urgent. By focusing on soil health, we can create resilient farming systems that can better withstand the challenges of climate change. Healthy soils not only support crop productivity during droughts and floods but also play a crucial role in mitigating climate change through carbon sequestration. In the face of an uncertain future, the answer to

from erosion but also capture carbon and increase organic matter in the soil.

- **Agroforestry:** Integrating trees and shrubs into agricultural systems promotes carbon storage in both biomass and soils.
- **Rotational Grazing:** Livestock management practices like rotational grazing encourage the growth of deep-rooted plants, which sequester more carbon in the soil.

techniques, promote soil health initiatives, and fund research on new soil management practices. Additionally, farmers play a critical role in shaping the future of agriculture. By adopting climate-smart soil practices, they not only protect their livelihoods but also contribute to global efforts to reduce greenhouse gas emissions and adapt to climate change.

resilient agriculture may lie in the soil beneath our feet. As we continue to explore the potential of climate-smart soils, it's clear that the path forward will require innovative thinking, collaboration, and a commitment to sustainable land management. Farmers, researchers, and policymakers must come together to ensure that our soils remain fertile, productive, and capable of supporting life for generations to come.