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The Effects of Climate Change on Soils

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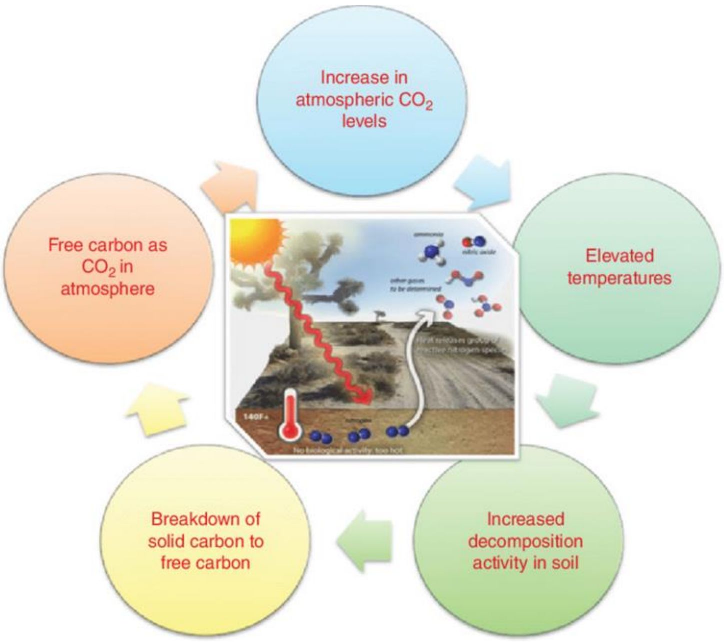
INTRODUCTION

Global temperatures are expected to rise 1.1 to 6.4°C during the twenty-first century, according to the Intergovernmental Panel on Climate Shift, and precipitation patterns will change as a result of climate change. Through the carbon, nitrogen, and hydrologic cycles, soils are closely related to the atmosphere–climate system. As a result, altered climate will have an impact on soil processes and qualities, as well as the climate itself. Since the beginning of time, climate change has been a worldwide phenomenon. Over the last decade, climate change has grown in importance as a scientific and political issue.



Despite the fact that climate change is a slow process involving minor changes in temperature and precipitation over a long period of time, these slow changes in climate have an impact on numerous soil processes, especially those connected to soil fertility.

Changes in soil moisture conditions, as well as increases in soil temperature and CO_2 levels, are projected to be the main effects of climate change on soils. The impacts of global climate change on soil processes and properties that are critical for improving soil fertility and productivity are expected to vary. The main effects of climate change are projected to be an increase in CO_2 levels and a rise in temperature.

Effects of climate change on Soil fertility and productivity

Climate change drivers like precipitation, temperature, and CO_2 are projected to have varying effects on soil processes and qualities that are important for soil fertility and productivity. These impacts of climate change elements, however, cannot be considered independently because one factor influences the other, resulting in a complicated effect. Furthermore, depending on the magnitude of climate change, soil qualities, and climatic factors, all of these effects will be highly region-specific. India has 12 soil orders, as well as 15 agroclimatic zones with a wide range of seasons, crops, and farming methods. Climate change, now that it is a fact, will have direct and indirect effects on soil development processes and qualities relevant to agricultural production, affecting the livelihoods of millions of people across the country.

Nutrient availability and acquisition in plants

The availability of nutrients to plants in the soil is determined by soil chemical characteristics, as well as the location of the ion relative to the root surface and the length of the nutrient's travel through the soil to reach the root surface. Temperature and moisture regimes in the root zone are affected significantly by variations in air temperature and precipitation. Given that moisture and temperature are the key regulators of nutrient availability and root growth and development, and that nutrient acquisition is governed by carbon allocation to roots, it is fair to predict that process results will reflect the changing environment. The nature and extent of change in these two metrics will vary depending on the site and soils. It has been claimed that climatic change will have the greatest impact on nutrient utilisation efficiency through direct effects on root surface area and inflow rate.

Soil nutrient transformation

Plants receive their nutrients from the soil solution pool, and nutrients must be in solution in order to move around in the soil. Moisture and temperature play a big role in biological transformation between organic and inorganic pools, hence global climate change could have a significant impact on N and P concentrations in solutions. Greater CO_2 may not have a direct influence on N mineralization, but it can cause increased N mineralization, which leads to an increase in solution phase N. Increased temperature accelerates adsorption/desorption reactions, while variations in soil moisture may further influence reactions by altering the ionic strength of the soil solution.

Carbon dynamics in soil

Increases in CO_2 concentration are thought to affect the release of root-derived substances both quantitatively and qualitatively. Plants that are exposed to higher CO_2 levels have a lower allocation of N-rich metabolites and a higher allocation of C-rich metabolites to root exudates. It leads to an increase in microbial activity and, as a result, CO_2 production, which could have a detrimental impact on the build-up of organic C in soils and, as a result, on potential soil sequestration. The priming effect, which occurs as a result of increased microbial activity in soil at elevated atmospheric CO_2 concentrations, has been demonstrated to have major negative feedback on global change processes and will lower soil sequestration capability. Several investigations utilising C isotope tracers have shown that elevated CO_2 plant growth conditions enhance the generation of CO_2 in the rhizosphere by roots and microorganisms. The increase in CO_2 respiration in the rhizosphere could be significantly more than the increase in root biomass.

Mycorrhizal association response

Increased mycorrhizal colonisation due to enhanced plant demand for nutrients, combined with increased C absorption rates, are common effects of increased atmospheric CO2 concentrations on soil microbial community structure. Because plant demands for N and P will rise in parallel with C assimilation rates, plants will allocate more photosynthates belowground to roots and mycorrhizal fungi to help meet this increasing nutrient requirement. In mycorrhizal plants cultivated under elevated CO2 concentrations, increased fine root mass and mycorrhizal infection promote increased P absorption. It would seem reasonable to assume that when CO2 levels are high, mycorrhizal fungi will become more active. As soil nutrients become more restricting to plant growth and C becomes less limiting to plant growth, biomass will increase. However, the literature on this subject isn't usually consistent.

Biological activities in the soil

Because diverse plant–soil systems have extremely distinct patterns of plant C allocation, soil microorganisms' responses to changes in plant productivity under higher CO2 are highly variable. Under increasing CO2, microbial biomass, gross N mineralization, microbial immobilisation, and net N mineralization exhibit a lot of variation. However, with elevated CO2, rates of soil and microbial respiration are often faster, implying that increased plant growth increases the quantity of carbon entering the soil, driving soil microbial activity. Increased C availability boosts microbial growth and activity because soil microorganisms are frequently C-limited**.** It is widely expected that increases in soil C availability caused by CO2 will enhance fungal biomass more than bacterial biomass. It's due to higher levels of dissolved organic C in the rhizosphere and higher levels of dissolved organic N in soil water. Because fungi play such a crucial role in organic matter breakdown, nutrient cycling, plant nutrition, and soil aggregate formation, changes in fungal communities could have a significant impact on soil functioning. Furthermore, because fungi have a greater C/N ratio than bacteria and hence have a lower requirement for nitrogen, reduced N availability at rising CO2 may help to explain these increases in fungus. Bacteria and fungus, which eat soil organic matter first, provide food for a variety of small predators and grazers, such as protozoa, nematodes, and arthropods, who make up the soil food web. As a result, an increase in bacterial growth caused by increased C allocation at rising atmospheric CO2 levels may be accompanied by an increase in grazing, resulting in a larger microbial biomass turnover. As a result of increased grazing, nutrients are recycled more quickly from the microbial biomass, increasing the flow of nutrients to the plant.