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Regenerative Soil Management in Agriculture: Unleashing Carbon Sequestration and Climate Mitigation Potential

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Abstract

Soil is an integral part of the global carbon cycle and a key factor in climate regulation. This review identifies regenerative soil management (RSM) as a revolutionary approach under climate-resilient agriculture for increasing soil carbon sequestration, restoring degraded lands, and developing resilience against environmental stresses. Leading RSM practices—such as conservation tillage, agroforestry, biochar incorporation, green manuring, and composting—not only improve soil structure and soil fertility but also allow for long-term stabilization of atmospheric CO_2 in soil organic matter. Developing studies indicate that RSM can potentially raise soil organic carbon (SOC) content by up to 1.5% annually, which is a considerable input towards global climate change mitigation goals. The review also brings to the fore the central role played by soil microbiota, particularly arbuscular mycorrhizal fungi, in facilitating carbon stabilization and nutrient cycling. Cutting-edge predictive tools, including RothC and CENTURY models, provide strong frameworks for simulating SOC dynamics under various regenerative scenarios. However, widespread scaling up of RSM is constrained by insecure land tenure, low farmer uptake, and policy support deficits. This review suggests the incorporation of RSM in national climate action plans, sustainable development agendas, and carbon trading schemes. Notably, it provides a region-specific analysis of the feasibility of RSM in arid and semi-arid areas, where it has immense potential in reversing desertification, improving soil health, and supporting food security. The novelty of this study is its integrative approach that connects biophysical processes and socio-economic enablers to demonstrate the co-benefits of soil rejuvenation for climate resilience, biodiversity conservation, and rural livelihoods.

Keywords: Regenerative agriculture, soil carbon, carbon sequestration, climate change, agroecology, land restoration.