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Geoderma 123 (2004) 1–22
GEODERMA
www.elsevier.com/locate/geoderma

Review

Soil carbon sequestration to mitigate climate change

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Available online 16 April 2004

Abstract

The increase in atmospheric concentration of CO_2 by 31% since 1750 from fossil fuel combustion and land use change necessitates identification of strategies for mitigating the threat of the attendant global warming. Since the industrial revolution, global emissions of carbon (C) are estimated at 270 ± 30 Pg (Pg = petagram = 10^{15} g = 1 billion ton) due to fossil fuel combustion and 136 ± 55 Pg due to land use change and soil cultivation. Emissions due to land use change include those by deforestation, biomass burning, conversion of natural to agricultural ecosystems, drainage of wetlands and soil cultivation. Depletion of soil organic C (SOC) pool have contributed 78 ± 12 Pg of C to the atmosphere. Some cultivated soils have lost one-half to two-thirds of the original SOC pool with a cumulative loss of 30–40 Mg C/ha (Mg = megagram = 10^6 g = 1 ton). The depletion of soil C is accentuated by soil degradation and exacerbated by land misuse and soil mismanagement. Thus, adoption of a restorative land use and recommended management practices (RMPs) on agricultural soils can reduce the rate of enrichment of atmospheric CO_2 while having positive impacts on food security, agro-industries, water quality and the environment. A considerable part of the depleted SOC pool can be restored through conversion of marginal lands into restorative land uses, adoption of conservation tillage with cover crops and crop residue mulch, nutrient cycling including the use of compost and manure, and other systems of sustainable management of soil and water resources. Measured rates of soil C sequestration through adoption of RMPs range from 50 to 1000 kg/ha/year. The global potential of SOC sequestration through these practices is 0.9 ± 0.3 Pg C/year, which may offset one-fourth to one-third of the annual increase in atmospheric CO_2 estimated at 3.3 Pg C/year. The cumulative potential of soil C sequestration over 25–50 years is 30–60 Pg. The soil C sequestration is a truly win–win strategy. It restores degraded soils, enhances biomass production, purifies surface and ground waters, and reduces the rate of enrichment of atmospheric CO_2 by offsetting emissions due to fossil fuel.

Keywords: Greenhouse effect; Soil restoration; Conservation tillage; Mulch farming; Cover cropping; The global C cycle