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SCIENCE DIRECT
Soil & Tillage Research 83 (2005) 25–52
Soil & Tillage Research
www.elsevier.com/locate/still

Review

Greenhouse gas contributions and mitigation potential of agricultural practices in northwestern USA and western Canada☆

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Received 12 March 2004; received in revised form 6 January 2005

Abstract

Concern over human impact on the global environment has generated increased interest in quantifying agricultural contributions to greenhouse gas fluxes. As part of a research effort called GRACEnet (Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network), this paper summarizes available information concerning management effects on soil organic carbon (SOC) and carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) fluxes in cropland and rangeland in northwestern USA and western Canada, a region characterized by its inherently productive soils and highly variable climate. Continuous cropping under no-tillage in the region increased SOC by 0.27 ± 0.19 Mg C ha^{-1} yr^{-1}, which is similar to the Intergovernmental Panel on Climate Change (IPCC) estimate for net annual change in C stocks from improved cropland management. Soil organic C sequestration potential for rangelands was highly variable due to the diversity of plant communities, soils, and landscapes, underscoring the need for additional long-term C cycling research on rangeland. Despite high variability, grazing increased SOC by 0.16 ± 0.12 Mg C ha^{-1} yr^{-1} and converting cropland or reclaimed mineland to grass increased SOC by 0.94 ± 0.86 Mg C ha^{-1} yr^{-1}. Although there was generally poor geographical coverage throughout the region with respect to estimates of N_2O and CH_4 flux, emission of N_2O was greatest in irrigated cropland, followed by non-irrigated cropland, and rangeland. Rangeland and non-irrigated cropland appeared to be a sink for atmospheric CH_4, but the size of this sink was difficult

Abbreviations: CO_2, carbon dioxide; N_2O, nitrous oxide; CH_4, methane; SOC, soil organic carbon; SIC, soil inorganic carbon; IPCC, Intergovernmental Panel on Climate Change; NT, no-tillage; MT, minimum tillage; CT, conventional tillage; BREB, bowen ratio/energy balance; NDVI, normalized difference vegetation index; CV, coefficient of variation; SE, standard error

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0167-1987/$ – see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.still.2005.02.008

to determine given the few studies conducted. Researchers in the region are challenged to fill the large voids of knowledge regarding CO_2, N_2O, and CH_4 flux from cropland and rangeland in the northwestern USA and western Canada, as well as integrate such data to determine the net effect of agricultural management on radiative forcing of the atmosphere.
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Keywords: GRACEnet; Greenhouse gas flux; Soil organic carbon; North America

Contents

1. Introduction

Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are greenhouse gases that contribute to radiative forcing of the atmosphere. The flux of these gases from agroecosystems is highly dependent on management. Agricultural management can mitigate radiative forcing by increasing soil organic carbon (SOC), decreasing CH_4 and N_2O emissions, or increasing soil CH_4 oxidation (Mosier et al., 2003). Identification of management systems capable of mitigating radiative forcing from agroecosystems will minimize agriculture's impact on the global environment.

A complex network of mechanisms underlie the release and/or uptake of greenhouse gases from agroecosystems. Carbon dioxide is a substrate for photosynthesis, which is the key reaction whereby plants assimilate C, and at least temporarily, sequester it into the landscape (Salisbury and Ross, 1985). Carbon dioxide is also an end product of respiration reactions for both auto- and heterotrophic organisms (Paul and Clark, 1996). Processes of CO_2 uptake and emission are not tightly linked in most terrestrial ecosystems, so fundamental knowledge of both processes is required to understand the dynamics of the C cycle and how it is affected by management and the environment.

Methane can either be released or assimilated into soils, depending on the microbial community and soil moisture conditions (Schutz et al., 1990). Under anaerobic conditions, CH_4 is produced via reduction of CO_2 (Ojima et al., 1993), whereas under aerobic conditions, microbial oxidation of CH_4 causes soils to be sinks for atmospheric CH_4 (Lidstrom and Stirling, 1990). In contrast to CO_2 and CH_4, N_2O flux in agroecosystems is typically unidirectional from soils and plants to the atmosphere. Generation of N_2O in the soil may result from either nitrification or denitrification processes (Firestone and Davidson, 1989).

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