Evaluation of Management Practices for Climate Change Mitigation

Methodology Recommendations

SCOPE

This document provides guidance on the best practices for measuring greenhouse gas emissions and soil organic carbon in agricultural systems.

OVERVIEW

Evaluation of management practices for their role in climate change mitigation can be made from knowing their impact on carbon dioxide (CO_2) and non-CO_2 greenhouse gas (GHG) fluxes above the agricultural field under study and changes in soil organic carbon (SOC) stock over a period of several years. Accordingly, here we describe the two main methods of determining the net greenhouse gas balance (NGHGB) of a management practice. Positive values of NGHGB mean a practice is adding GHGs to the atmosphere (contributing to global warming) and negative values mean a practice is removing GHGs from the atmosphere, thus mitigating climate change.

Method 1: For plot-scale experiments continuing for 5–10 years

This method relies on the ability to measure SOC stock change accurately over 5–10 years, since the magnitude of annual SOC change (ΔSOC) is small relative to the total soil C stock.

NGHGB is expressed as:

$$\text{NGHGB} = \text{SOC change} + \text{Non-CO}_2\text{ GHG emissions} \quad (1)$$

It is reported in terms of CO_2 equivalent and is calculated as follows (Shang et al., 2021):

$$NGHGB_{CO2equiv} = -\frac{44}{12} \times \Delta SOC + 298 \times F_{N2O} + 34 \times F_{CH4} \quad (2)$$

where F_{N2O} and F_{CH4} are positive mass fluxes of N_2O and CH_4 from the field. The two fluxes must be weighted by their global warming potentials (GWPs). 298 and 34 are the GWPs for N_2O and CH_4, respectively, on a mass basis relative to CO_2 at a 100-year time horizon without the feedback effect (IPCC 2006). F_{N2O} and F_{CH4} are measured by automated or manual chambers at the plot scale or by using micrometeorological techniques (e.g., the eddy-covariance (EC) and flux-gradient techniques) at the field scale.

When a management practice increases SOC, ΔSOC is positive. When a management practice decreases SOC, ΔSOC is negative. The 44/12 multiplier puts the ΔSOC on a CO_2 mass basis.

In this method, SOC is measured by CO_2 loss on ignition, after taking samples with bulk density determined to 1 metre depth.

In the case of hedgerows, shelterbelts and agroforestry practices, equation (1) requires the addition of an above-ground biomass term as follows:

$$NGHGB_{CO2equiv} = -\frac{44}{12} \times (\Delta SOC + \Delta C_{AGB}) + 298 \times F_{N2O} + 34 \times F_{CH4} \quad (3)$$

where ΔC_{AGB} is the increase in above-ground biomass which can be obtained using direct measurements or allometric relationships (tree growth curves) (Amichev et al., 2017). In the case of hedgerows and shelterbelts, ΔC_{AGB} should be scaled to the net agricultural-field area.

Method 2: Based on measuring C inputs and outputs at the field scale

This method relies on the ability to measure net ecosystem exchange (NEE, i.e. CO_2 flux), non-CO_2 GHG fluxes continuously using the EC or flux-gradient techniques, and C imports (e.g. applied C amendments) and exports (e.g., crop harvested C) into the field (Pow et al., 2020). Negative values of NEE represent net CO_2 uptake and positive values represent CO_2 loss to the atmosphere. Non-CO_2 GHG fluxes can be measured using either EC or chambers depending on the availability of fast-response non-CO_2 GHG analyzers. In this method, $NGHGB_{CO2equiv}$ is given by

$$NGHGB_{CO2equiv} = \frac{44}{12} \times NECB + 298 \times F_{N2O} + 34 \times F_{CH4} \quad (4)$$

where NECB is the net ecosystem carbon balance of the field and is given by

$$NECB = NEE - C_{inputs} + C_{outputs} \quad (5)$$

where C_{inputs} and $C_{outputs}$ are carbon imports and exports, respectively, to the field under study. NECB is positive if the field is losing carbon and negative if it's gaining carbon. This method is non-invasive and has the advantage of being able to obtain daily, seasonal, or annual NGHGB values. This method can also be used in agroforestry plantations (Jassal et al., 2013).

The evaluation of management practices outlined here is solely focused on climate change mitigation and does not consider the impact on crop production. It has been observed (e.g., Shang et al., 2021) that in some cases when a management practice is more focussed towards minimizing CO_2 and non-CO_2 GHG emissions and/or maximizing soil C sequestration, there may be some reduction in crop yield, thereby adding an unintended cost to obtaining environmental benefits through soil and crop management. Also, this evaluation does not take into account any additional costs involved in the implementation of a given management practice. A full evaluation Thus a climate change mitigation management practice with significant yield reduction and/or high costs of implementation will not be acceptable to the farmers for economical reasons.

References

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Acknowledgements

This research summary was prepared by Amy Norgaard and the BC Agricultural Climate Adaptation Research Network (ACARN) technical working group on climate change mitigation. ACARN would like to thank those who shared information about their previous and continuing research projects.

This project was supported by the Investment Agriculture Foundation of BC, with funding provided by Agriculture and Agri-Food Canada programs.

IAF Investment Agriculture Foundation