Soil Carbon Sequestration and Greenhouse Gas mitigation in Agriculture

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1. Introduction

Agriculture, Forest and Other Land Use (AFOLU) sector contributes about a quarter of global greenhouse gas (GHG) emission [1] though its contribution is small in Japan [2]. In addition, technologies to reduce GHGs from agriculture sector are not expensive [3]. It is therefore worth reducing GHGs from this sector. It includes soil carbon (C) sequestration and mitigation of methane (CH_4) and Nitrous oxide (N_2O) emissions.

2. Soil Carbon Sequestration

Increasing soil C means decreasing atmospheric CO_2 in cropland because C is cycling among three pools in cropland and "biomass" C pool can be considered as constant in longer term (Fig. 1). This is not the case in forest where biomass pool increases with tree growth in long-term. Soil C sequestration is a strategy to achieve food security through improvement in soil quality in cropland [4]. It is therefore considered as a win-win situation: climate change mitigation and sustainable agricultural production. Soil management such as manuring, cover crop, no- or reduced- tillage etc. is effective for increasing soil C [1, 2, 4].

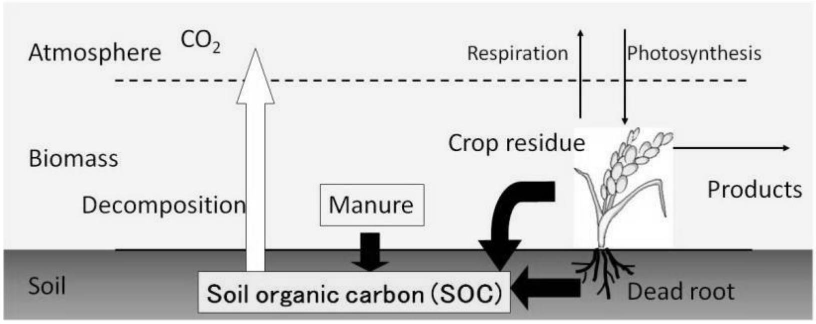

Fig. 1. Carbon cycling around cropland

Long term datasets of field observation are valuable because changes in soil C are generally slow and difficult to detect it in short term. Importance of long-term field experiments [5] should be highlighted more. On the other hand, modelling approach is effective for future projection and/or wider area evaluation on the effect of changing agricultural management and/or changing climate. A number of soil organic matter (SOM) models have been published [6]. Among them, the RothC [7], CENTURY [8] and DNDC [9] have been widely used, but the use of these models was limited in Asia. They have been mainly developed and applied in European countries and the U.S. The RothC, which was developed in the U. K., was recently tested in Japan [10, 11, 12], China [13] and Thailand [14]. The country-scale calculation system using this model [15, 16] was developed in Japan, which uses three different versions of the modified RothC: normal version [7], Andosols version [11] and paddy soils version [12]. It was adopted in National Greenhouse Gas Inventory Report (NIR) of Japan [2] from 2015.

3. CH_4 and N_2O

CH_4 is produced in paddy field where soils are submerged during rice cropping period and soils are reduced. Water management and/or organic matter management is important for its mitigation. Potential of mitigation of CH_4 was estimated at global scale [17]. On the other hand, for example, extending period of mid-season drainage was found to be effective for reducing CH_4 emission [18] and it is expected to be widely spread because it is cheap and easy. Modelling approach is progressed for CH_4, too. DNDC-Rice model [19] was developed and it was applied for country-scale simulation [20], too.

N_2O is produced from nitrogen in soil which derived from chemical and organic fertilizers. It is therefore important that reduction in N application rate is a basic option to reduce N_2O emission. Appropriate application rate of N fertilizer and organic matter is therefore effective. On the other hand, a change in fertilizer type such as nitrification inhibitor was found to be effective for its mitigation, too [21].

4. Mitigation of total GWP: Life Cycle Inventory Analysis

Although it is basically “win-win” situation between sustainable agricultural production and soil C sequestration, it is easy to imagine the trade-off between CO_2 mitigation by soil C sequestration and increase in other GHGs (CH_4 and/or N_2O) emission caused by increasing organic matter input to soils. It is therefore important to evaluate these three GHGs totally by using GWP (Global Warming Potential) of each gas. Fossil fuel consumption derived from agricultural machinery, plastic film, fertilizer, pesticide etc. should be included, too. There are still only a few examples [22, 23] of the study on life cycle inventory analysis on GHGs in agriculture in Japan.

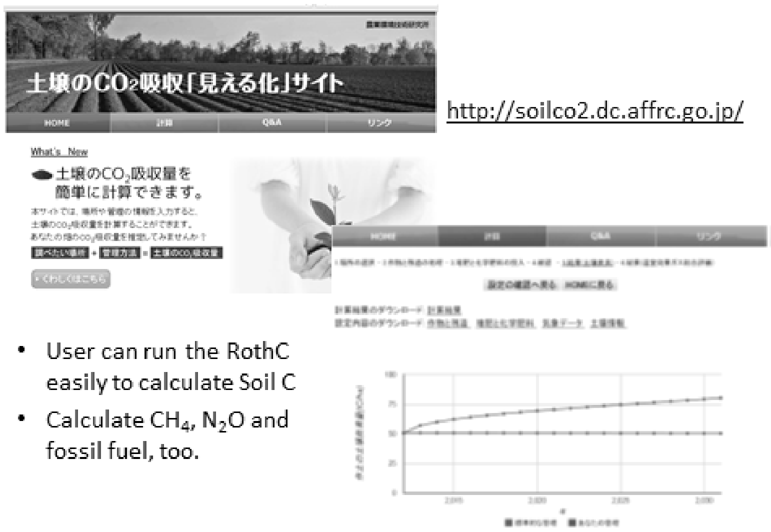

Fig. 2. Decision-support tool “Visualization of GHGs from soils” on the web

A web-based decision support tool “Visualization of GHGs from soil” (Fig. 2) was published where user can easily calculate changes in soil C, CH_4 and N_2O emission, and fossil fuel consumption. This tool is expected to be used by farmers to make their products more valuable such like “environmental friendly products”.

5. Conclusions

Soil C sequestration is basically win-win relationship with sustainable soil fertility maintenance. There are a lot of valuable long-term experiments on going and it is important to continue them. Modelling approach has been progressed based on such field observation. As to CH_4 and N_2O, mechanisms of emission and mitigation options have been understood to some extent, and modelling studies progressed, too, but the basic process study is still necessary. Collaboration between model and monitoring studies will be a key in this research field. The mitigation of total GWP is important for GHGs. Total evaluation of GHGs with life cycle CO_2 inventory analysis is therefore necessary. “Visualization” of GHG emission by web- based application is useful tool for supporting farmers’ decision on soil management to achieve sustainable food production and environmental friendly agriculture.

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