Effect of Organic Matter Application on Soil Carbon Sequestration in Japanese Agricultural Land

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Effect of Organic Matter Application on Soil Carbon Sequestration in Japanese Agricultural Land

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Abstract

Recently, in addition to improve soil quality or productivity, soil carbon sequestration for mitigating greenhouse gas emission has been highlighted. Huge amount of carbon is stored in soil and increase in it means decrease in atmospheric CO_2, hence it mitigates climate change. To increase SOC, two options would be possible: 1) increase inputs and/or 2) decrease outputs through decomposition. Application of organic matter such as compost or green manure is an option for increasing carbon inputs to soils. On the other hand, no-tillage can be considered as an option for decreasing outputs (decomposition) of SOM. Generally, changes in SOC through management changes need long time to be detected. Long-term field experiments are ,therefore, needed to detect changes in SOC. Long-term experiments revealed that organic matter application enhances soil carbon accumulation but the rate of changes in soil carbon is different among sites because many factors control organic matter decomposition and accumulation. SOM models are ,therefore, a useful tool for predicting changes in SOC through changes in management practices or by future climate change. We validated the Rothamsted carbon (RohC) model by using long-term field experiments in Japan and the model was modified for Andosols and paddy soils while it did not need any modification for other soils. By using the well validated model, we can estimate the potential of soil carbon sequestration in the future. Evaluation of greenhouse gas emission (or removal) together with other gases (CH_4 and N_2O) to calculate global warming potential (GWP), and evaluation of fossil fuel use in agricultural practices should be required, too.

Soil carbon and climate change

Soil organic matter (SOM) is one of important index of soil quality. SOM improves soil physical, chemical and biological properties and consequently improve soil productivity. Therefore, farmers have been making a great effort to increase SOM in their soils. Recently, in addition to improve soil quality or productivity, soil carbon sequestration for mitigating greenhouse gas emission has been highlighted (Lal, 2004). Huge amount of soil organic carbon (SOC) is stored in SOM, and carbon is cycling among soil, vegetation and atmosphere (Figure 1). Increase in SOC therefore means decrease in atmospheric CO_2, hence it mitigates climate change.

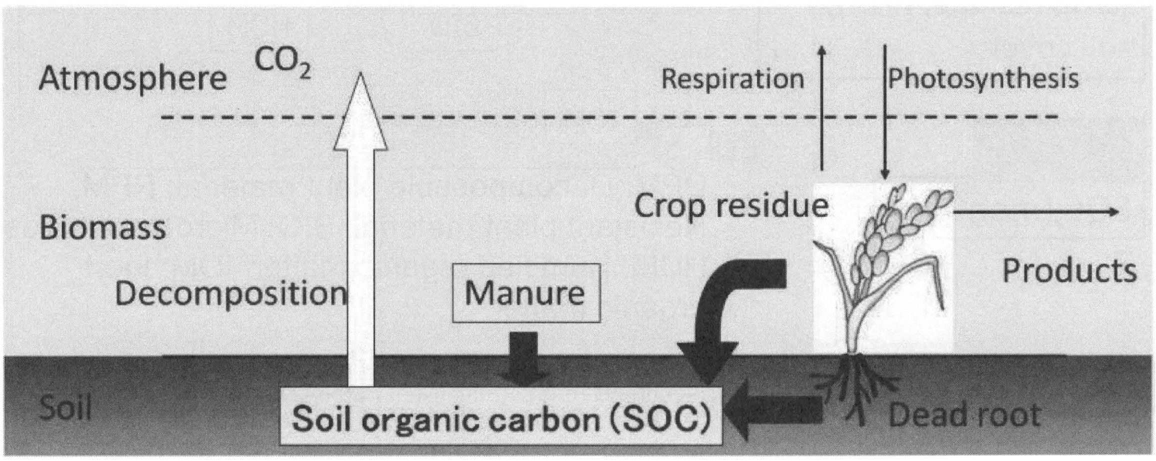

Figure 1. Carbon cycle around soil.

Management practices for increasing soil carbon

To increase SOC, two options would be possible: 1) increase inputs and/or 2) decrease outputs through decomposition. Application of organic matters such as compost or green manure is an option for increasing carbon inputs to soils. On the other hand, no-tillage or reduced tillage can be considered as an option for decreasing outputs (decomposition) of SOM.

Monitoring and modeling SOC

Generally, changes in SOC through management changes need long time to be detected. Long-term field experiments are, therefore, needed to detect changes in SOC. Long-term experiments revealed that organic matter application enhances soil carbon accumulation but the rate of changes in soil carbon is different among sites because many factors such as temperature, moisture, soil texture, tillage or organic matter application rate, etc. control organic matter decomposition and accumulation.

SOM models, which involve important factors of SOM turnover, are a useful tool for predicting changes in SOC through changes in management practices or by future climate change. Among published SOM models, we used the Rothamsted carbon (RohC) model (Coleman and Jenkinson, 1996; Figure 2) because it is one of the widely-used SOM models in the world having high reliability and needs fewer inputs than other models. We thus validated the RothC model by using long-term field experiments in Japan (Figure 3). The model was modified for Andosols (Shirato *et al.* 2004) and paddy soils (Shirato and Yokozawa 2005) so that changes in SOC with time can be well simulated on the plot scale while it did not need any modification for other soils (Shirato and Taniyama, 2003).

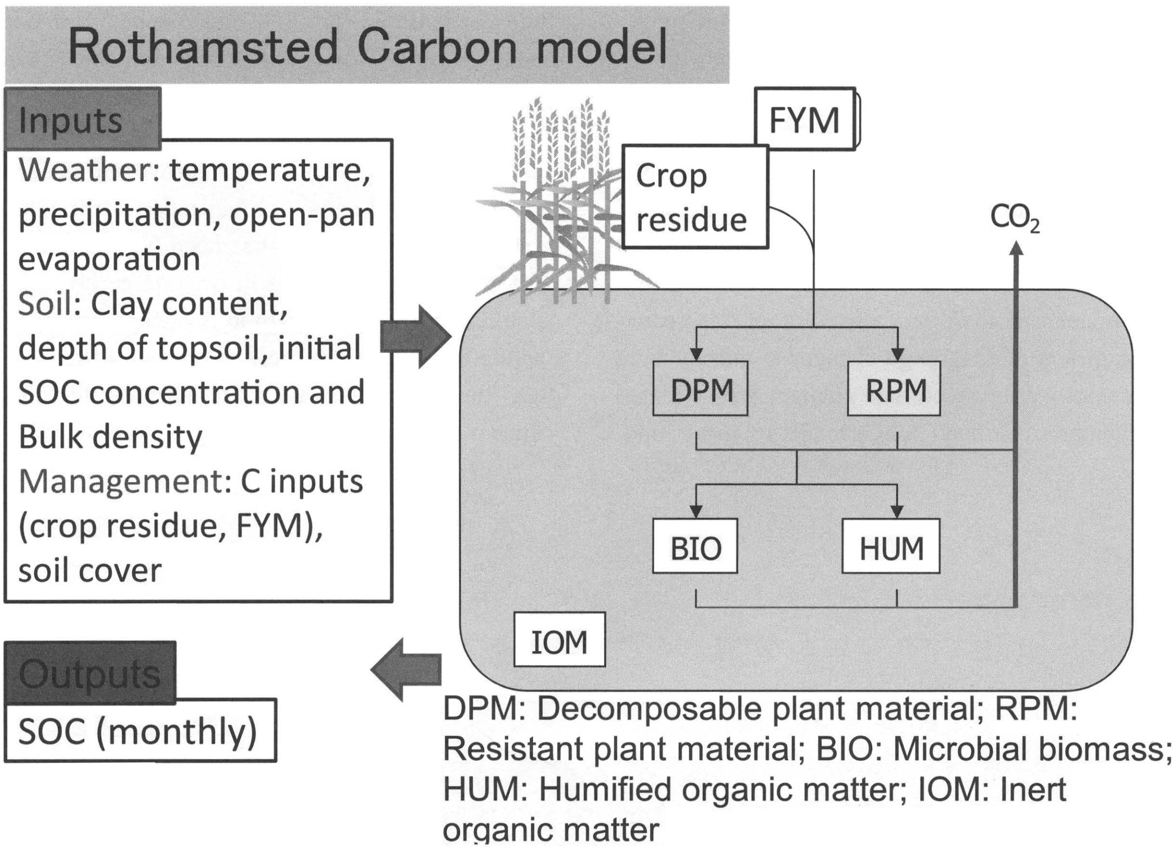

Figure 2. Structure, inputs and outputs of the Rothamsted Carbon (RothC) model.

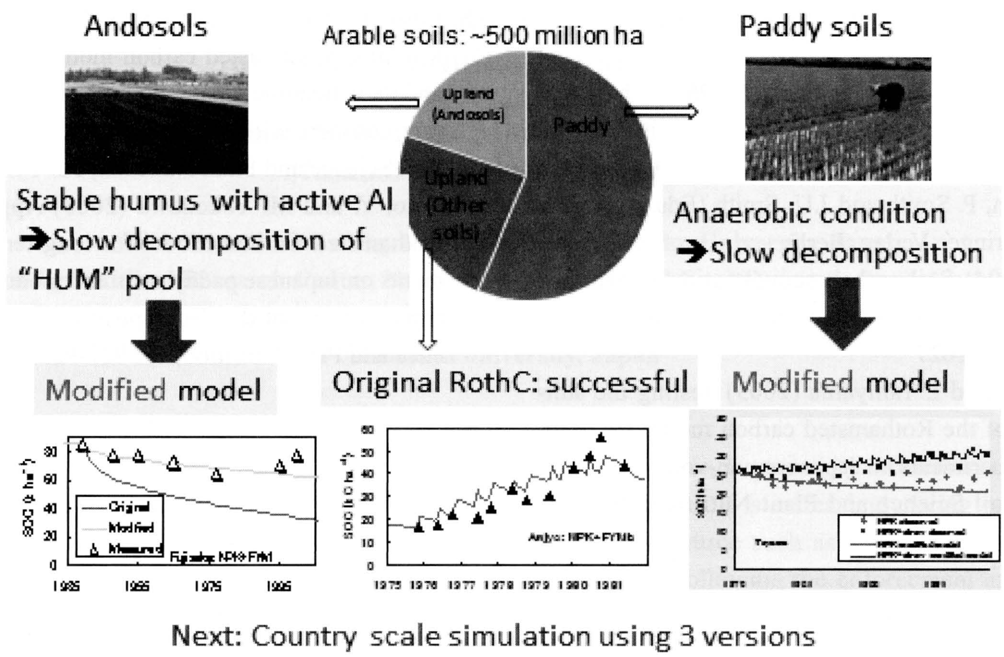

Figure 3. Validation and modification of the RothC model in Japanese arable soils.

Future target

By using the well validated model, we can estimate the potential of soil carbon sequestration in the future (Figure 4). We have developed a simulation system, by linking the RothC model and databases of weather, soil, land use and agriculture activity, for simulating changes in SOC with time by management and climate change.

Evaluation of greenhouse gas emission (or removal) together with other gases (CH_4 and N_2O) to calculate global warming potential (GWP), and evaluation of fossil fuel use in agricultural practices (e.g. fertilizers, pesticides, machinery use, etc.) should be required, too, because soil carbon sequestration and other gas emission often have a trade-off relationship.

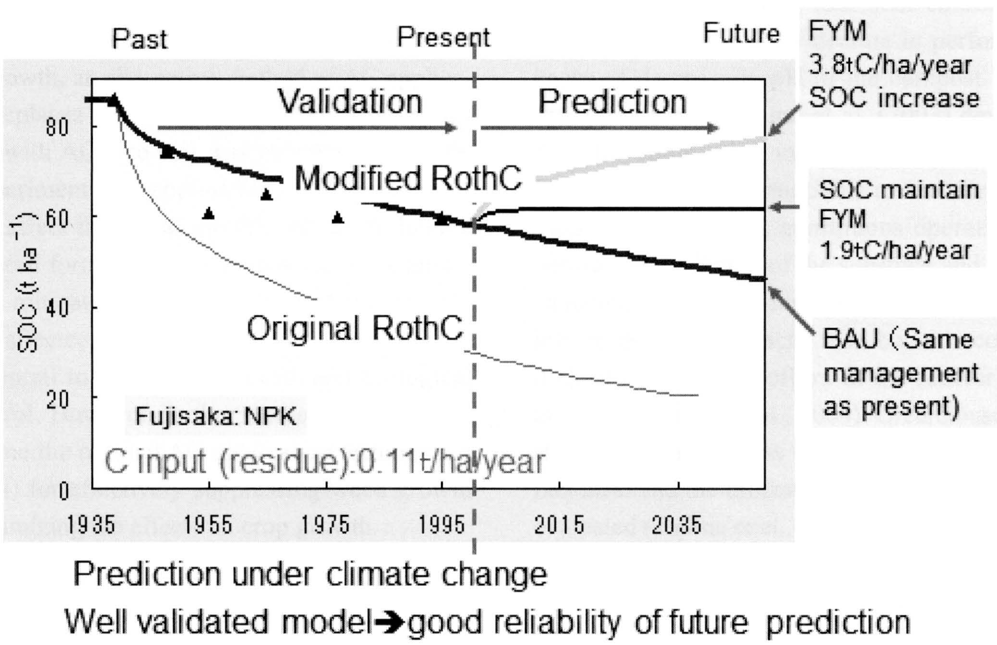

Figure 4. Example of future prediction by using the RothC model.

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