Soil organic matter and global environmental change: The contribution of GCTE-SOMNET to recent research

Matière organique du sol et changement global : la contribution de GCTE – SOMNET aux recherches récentes

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Soil organic matter (SOM) plays a central role in nutrient (N, P, S, K) availability, soil stability and the flux of trace greenhouse gases between land surface and the atmosphere. It represents a major pool of carbon within the biosphere, estimated at about 1400-2200 x 10^{15} g globally (Post et al., 1982; Batjes, 1996), roughly two to three times that in atmospheric CO₂, and acts as both a source and a sink for carbon and nutrients.

To facilitate scientific progress in predicting the effects on SOM of changes in land-use, agricultural practice and climate, the need for a network of SOM modellers and long-term dataholders was recognised. To fulfil this scientific need, the global Soil Organic Matter Network (SOMNET) was established during 1995 under one-year's funding as a Special Topic of NERC's TIGER programme. SOMNET has since attracted contributions from 29 leading SOM modellers and over 70 long-term experimentalists from all around the world (Smith et al., 1996a; Powlson et al., 1997; Smith et al., 1996b, 1997c; see Figure 1). SOMNET's continuing development is funded by the UKBiotechnology and Biological Sciences Research Council, and in Europe by the European Commission.
SOMNET has rapidly become internationally recognised as an important scientific initiative in the following ways: a) SOMNET has been adopted by the IGBP's GCTE programme as a Core Project of its focus on Soil Organic Matter, b) SOMNET has been invited to participate in the IPCC's Joint Working Group (with OECD) on Methodologies for Establishing National CO$_2$ Inventories (Paustian et al., 1997), c) long-term datasets and models selected from SOMNET have been used to complete the most comprehensive evaluation of soil organic matter models undertaken to date (Smith et al., 1998a), in a process begun at a NATO-funded Advanced Research Workshop held at IACR-Rothamsted (Powlson et al., 1996). In this exercise, nine leading SOM models were compared for performance (Smith et al., 1996e) in simulating twelve datasets representing different land-uses (arable, grassland, forestry), climatic zones and management practices. Only three models were able to simulate all land-uses for the duration of each experiment (RothC, CENTURY and SOMM) and a group of six models (RothC, CENTURY, DAISY, CANDY, NCSOIL and DNDC) performed significantly better than did three others (Smith et al., 1998 a & b). SOMNET data is now being used to improve the Rothamsted Carbon Model (Falloon et al., 1998a & b).

In addition to the model comparison exercise we have also used European datasets from SOMNET (see Smith et al., 1996c) to estimate the potential for carbon sequestration in agricultural soils in the European Union (Smith et al., 1997a) and the wider Europe (Smith et al., 1997b, 1998d). Figure 2 shows the potential for carbon mitigation using six scenarios when applied to the whole of Europe (to as far east as the Baltic States).

**Figure 2** Carbon mitigation potential of various agricultural management options in Europe
Values in Figure 2 are for the whole of Europe excluding most of the former Soviet Union but including Belorus and the Ukraine (total land area = 490 M ha; arable land area = 135 M ha; SOC content to 30 cm in arable land = 7.18 Pg). All values were estimated using a) soil carbon contents as described in Smith et al. (1997a, c; 1998d), and b) relationships between yearly changes in soil organic carbon content and management practices revealed by relevant European field experiments. No-till assumes conversion of all arable agriculture to no-till (Smith et al., 1998d). Animal manure figures are for application of animal manure at 10 t ha\(^{-1}\) y\(^{-1}\) to all arable land (Smith et al., 1997a, b). Sewage sludge figures are for application of sludge at 1 t ha\(^{-1}\) y\(^{-1}\) which would be sufficient to cover about 11% of arable land in Europe (Smith et al., 1997a, b). Straw figures are for the incorporation of all cereal straws into the land on which the crops were grown. There is sufficient to provide an incorporation rate of about 5 t ha\(^{-1}\) y\(^{-1}\) (Smith et al. 1997a, b). Afforestation is for natural woodland regeneration on 30% arable land which is the upper limit predicted to be surplus to arable requirements by 2010. It includes the carbon mitigation potential of the wood produced assuming 50:50 biofuel:bioproduct utilization of the wood (Smith et al., 1997a, b). Ley-arable (or mixed cropping) figures are for extensification of arable agriculture (leaving current grassland at present level). The predicted 30% surplus of arable land by 2010 could be used to allow less intensive use of all land. The pasture or ley phases could then be used for less intensive animal production by raising pigs and poultry in outdoor units (Smith et al., 1997a, b). These results show that agronomically realistic scenarios could sequester upto 10% of the anthropogenic CO\(_2\) produced in Europe each year or upto 2% of that produced globally (Figure 2). The SOMNET data has also been used data to estimate the potential consequences of land-use change following the British BSE crisis (Smith et al., 1996d).
The SOMNET project has yielded over 60 peer-reviewed scientific papers. These have appeared in a book of proceedings (of the NATO ARW; Powlson et al., 1996), a Geoderma Journal Special Issue (of the SOM model evaluation and comparison; Smith et al., 1998b) and in other peer-reviewed journals (e.g. Molina & Smith, 1997, Smith et al., 1998c & e). The project has also yielded a book of model and experimental metadata (Smith et al., 1996b) and a metadata database containing detailed information on all long-term experiments and SOM models mounted for free global access on the World-Wide-Web (Smith et al., 1996a) at URL http://saffron.res.bbsrc.ac.uk/cgi-bin/somnet. For further information please contact: Dr Pete Smith, Soil Science Department, IACR-Rothamsted, Harpenden, Herts, AL5 2JQ, U.K. Tel: +44 (0)1582 763 133 . FAX: +44 (0)1582 760 981. Email: pesmith@bbsrc.ac.uk.

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Keywords: SOMNET, GCTE, soil organic matter, long-term experiments, models, carbon sequestration
Mots clés : SOMNET, GCTE, matière organique du sol, expérimentation de longue durée, modèle, sequestration du carbone