How much SOM is needed for sustainable agriculture?

Soil organic matter (SOM) is generally considered *the* indicator of soil health. It stores nutrients and water to promote plant growth, thus limiting leaching; provides energy for decomposers that increase nutrient availability; and adds structure that improves drainage and reduces erosion. These benefits form the basis of policies for organizations, such as the US Department of Agriculture and the UN Food and Agriculture Organization, that advocate for sustainable land management based on the premise, "the more SOM, the better". We applaud the fact that there are national- and global-level policies on building healthy soils but contend that these policies are ineffectual because they do not provide specific, implementable management goals. Scientists and policy makers need to move beyond qualitative descriptions to quantitatively link SOM amounts directly to agricultural outcomes.

Effective soil management requires targets for SOM levels as well as prescribed farming techniques for achieving them. We argue that the information that land managers need is quantitative: how much SOM is required to achieve desired production and environmental goals, and how can these targets be reached? This viewpoint could easily be missed among the 568 pages of the National Research Council's 2010 report on sustainable agriculture (www.nap.edu/read/12832/chapter/1). On page 36, the report states, "…measures of [SOM] are a cornerstone of most sustainability and soil quality assessments…However, the numerical level that would be considered good, or what change in [SOM] levels constitutes a significant functional change, has not been established".

Building quantitative targets requires research that directly links SOM amounts to agricultural outcomes – currently, the evidence linking SOM to yield is weak. Positive relationships between SOM levels and soil properties, such as nutrient and water storage capacity, are used to conclude that more of these resources are available for crop growth. However, independent of other factors (eg organic inputs), direct evidence showing that higher SOM amounts increase crop yields is thin to non-existent. Elucidation of direct relationships between SOM amount and desired socioeconomic, agricultural, and environmental outcomes is required to establish specific policies on soil health that can be effectively translated into management targets.

Once relationships between SOM levels and agricultural outcomes are established, research must show whether and how desired targets can be met and sustained within a given setting. Multiple environmental and management factors determine SOM amounts, and so efforts that increase and protect SOM in one location may not apply under a different set of conditions. Targets, strategies, and feasibilities will differ, for instance, between Midwestern US farmers and smallholder tropical agriculturalists. And within each of those contexts there exists a broad spectrum of needs: for instance, building SOM in marginal soils and maintaining SOM in productive fields will require different approaches. Developing such approaches is daunting because SOM amounts are affected by multiple ecosystem properties, all interacting with soil biology. However, models for SOM management are based on outdated ideas emphasizing the chemical composition of plant inputs and physicochemical soil properties as primary determinants of SOM dynamics. New knowledge needs to be refined and represented in models that provide management prescriptions for building and maintaining SOM.

Land management practices – such as conservation tillage – that emphasize the buildup of SOM are meant to generate (but do not necessarily yield) a win–win outcome: improvements in soil fertility and sequestration of atmospheric carbon. More than 50% of the Earth's land surface is dedicated to agriculture, and SOM is the largest terrestrial stock of carbon. Yet carbon sequestration as an ecosystem service may have overshadowed research needs for other critical services provided by soils. We argue that a renewed emphasis on the potential contribution of SOM to food security and landscape health, through services such as drought resilience and decreased sediment and nutrient losses to freshwater systems, could help to determine SOM targets that are optimal for near-term local, as well as longer-term global, outcomes.

We do not question the basis of the assumption that SOM is intimately tied to soil health. Yet translating this assumption into practical knowledge requires quantitative data showing how increases in SOM amounts affect agricultural outcomes. Acquiring such data requires implementing standardized long-term experiments, in different climates and with treatments representing major soil and crop management practices, where SOM changes and agricultural outcomes are measured. Through the setting of SOM targets, and the development of strategies to achieve them, land managers can make decisions about the feasibility of meeting these targets. By gaining a more thorough appreciation of the steps, benefits, and costs of improving soil health, human societies can play a more effective role in moving toward a sustainable agriculture.

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