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Response to question from Senator Klyne, of the Senate Standing Committee Agriculture and Forestry regarding the relative influence of organic cropping systems on soil health and soil total carbon.

I would first like to thank Senator Klyne for this interesting question. These too parameters, soil health and total soil organic carbon are often conflated in some way. While they are strongly related, SOC is well known to be the keystone element in soil health etc., they are not the same. Essentially while farming systems that result in higher SOC invariably enhances soil health, the opposite is not necessarily true, i.e. we can influence soil health by even short-term changes in cropping practices, without necessarily changing the net total SOC (what is referred to as the standing stock of carbon) in a soil.

Soil health combines measurement of soil physical, biological and chemical properties including soil biota, soil respiration, soil protein (i.e. nitrogen supply) and aspects of soil structure (water stable aggregates, water holding capacity etc.). Unlike the total net standing stock of SOC, many of these soil health properties are highly dynamic in the short term (can respond in one season or less to a new BMP practice). This is because they are highly influenced by carbon dynamics and especially by the <u>decomposition</u> of newly added residues, or in technical terms what we call the flux of carbon. A useful analogy when thinking of soil organic carbon flux versus standing stock, is to consider them the *chequing* and the *savings* account respectively, the former is highly dynamic, while the latter turns over much more slowly. This benefit to the soil ecosystem and soil health of the flux of carbon, in particular, is noted by renowned Canadian soil scientist Henry Janzen in his influential 2006 paper, where he states *Organic matter, is more useful biologically, when it decays*. Indeed, when we incorporate organic residues in soil (from crops, cover crops, amendments etc. containing typically about 50% carbon) most (up to 70% as shown in the excellent cross-Canada tracer study of Gregorich et al. 2017) is decomposed and mineralized relatively quickly within the first year i.e. contributing to the flux of carbon or the *chequing* account while a smaller percentage ends up retained for much longer periods, 'stored' as humus like material in the soil as the more resistant SOC standing stock, or *savings* account.

As I noted in my brief presented to the standing committee, management of organic cropping systems in general requires combining, or stacking, the BMPs (diverse rotations, residues retained, return of manures and composts, and modifying the rate of tillage) that contribute to adding residues regularly to soil. Thus they are contributing substantially to an added flux of carbon in these soils. As a result, when we measure the soil health parameters noted above, they typically measure higher in organic farming systems. I cited in my brief a recent invited review of the literature I conducted on this topic. I would refer also to a lengthier review I conducted on both soil total SOC and soil health in organic farming from 2014 which is also listed below.

With respect to total SOC in organic farming I would make the following points. As cited in my 2014, and 2022 reviews, some long-term comparative trials, and some meta-analysis of the literature, have shown greater SOC under long term organic farming systems. However, research over the last twenty years in Canada directly on organic cropping and livestock farms has shown there is a diversity of intensity of management within organic farming systems. This research has shown the same built in tradeoffs, as found for all farming systems, between productivity and environmental goals, including enhancing SOC, to be evident across the spectrum of intensity of management within these organic farming sectors. Some very low input organic farming systems can be running for example nutrient (phosphorus) deficits which can lead to a reduced biomass productivity and thus reduced carbon flows on the farm. Also changing total SOC is a slow process with changes not evident (statistically demonstrated (compared to the large background soil pool and variability in total SOC) as a result of improved practices or alternative production systems evident often for up to 10-20 years (FAO, 2020). Other methodological challenges of tracking total SOC changes are discussed in my 2014 review, and also in the excellent review by Chenu et al. 2019. Thus, to improve the data on the influence of organic farming on SOC, more research, well designed and conducted over sufficient time frame, and that truly represents the range of intensity of management of organic farming systems as found in Canada, is needed.

References

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