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Commentary

The myth that no-till can mitigate global climate change

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ABSTRACT

There has been a careless use of terminology like "climate change mitigation" and "mitigate global warming" in scientific papers on no-tillage management in agriculture. This is because it has yet to be shown unequivocally that no-tillage can lead to carbon (C) sequestration let alone climate change mitigation. I briefly summarize evidence that shows that the claims of climate change mitigation through no-tillage agriculture are highly overstated.

1. Introduction

For well over a decade no-tillage has been promoted as a potentially important component in the mitigation of climate change due to soil carbon (C) sequestration (Lal et al., 1998; Lal, 2004). But can it really be a significant factor in alleviating the potential runaway train of global warming? It is one thing that no-till can sequester C in soil but it is a totally different claim that this practice could have a noticeable effect on global climate mitigation. The careless use of terminology like "climate change mitigation" and "mitigate global warming" is rampant in scientific papers and reports on no-till management in agriculture (e.g. Six et al., 2004; Neufeldt et al., 2015; Lal et al., 2007, 1998, 2011; Lal, 2004,) which can lead to false hopes of a silver-bullet solution. Use of these terms needs to be tempered because there is less-than-adequate evidence that greenhouse gas (GHG) mitigation is even realized, let alone climate change or global warming (Powlson et al., 2014; Sommer and Bossio, 2014). Powlson et al. (2014) quite rightly point out that weaknesses in sampling methodologies, assumptions and interpretations in C sequestration studies comparing no-till to conventional tillage are causing overstatements of the potential of sequestering C in no-till soils. Here I briefly expand on the issues raised by Powlson et al. (2014).

Let us look at the numbers: Anthropogenic CO_2 emissions into the atmosphere from fossil fuels and cement have increased sharply since the year 2000 from about 24 Gt CO_2 to 37 Gt CO_2 in 2014 with a large proportion of the increase attributed to China's economic growth (Global Carbon Project 2015), and these levels of increase are expected to continue for at least the next few decades (Friedlingstein et al., 2014). A recent analysis showed that the potential to gain C from improved land management practices (of which no-tillage is only a part) on cropland and pastures, optimally could offset up to 8.9% of the projected global emissions at its peak in the year 2034 with the impact decreasing to less than 2% in 2100 due to C saturation (Sommer and Bossio, 2014). However, the key word is "optimally"; for the same authors showed that a pessimistic scenario would yield a 4.3% proportion of the total emission in 2034 to below 1% in 2100. In total this would equal just 1.9 to 3.9% of the projected total emissions from 2012 to 2100. But most importantly these results were based on a scenario where it was assumed that global governments agreed on a worldwide effort to change land use and management practices towards those that turn agricultural soils into carbon sinks. This scenario is far from possible and highly unlikely for a number of socio-economic reasons that I shall forgo for the most part here (see for e.g. Giller et al. (2009) for discussion of smallholder farms in Africa). Nonetheless the key point is that the potential to offset present and future GHG emissions through conservation management practices in soils is relatively small and finite. Soil C sequestration in agricultural lands through improved land management realistically does not "buy us time until the alternatives to fossil fuel take effect" as was suggested by Lal (2004).

2. Continuous no-till?

In the U.S. no-tillage and conservation management practices are highly touted and were promoted initially to reduce erosion by water and tillage, but more recently for increasing soil C while reducing energy inputs, each with a net positive effect on the environment (Lal et al., 1998; Grandy et al., 2006). However, recent estimates claim that less than 10% of American farmers are considered "continuous no-till" practitioners (Tony Vyn, a

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professor of agronomy at Purdue University. In "Plowing Through The Confusing Data On No-Till Farming", WSJ October 15, 2012). This may be a consequence of high commodity prices, more corn-on-corn acreage and new varieties of high-residue corn making it more difficult to manage residue with no-till (Johnson reported in No-till Farmer August 2014: http://www.no-tillfarmer.com/articles/489-no-till-movement-in-us-continues-to-grow). Indeed from 1994 to 1999 the average continuous period of no-tillage in Illinois and Indiana was less than 2.5 years and in Minnesota 1.4 years determined by an extensive survey (Hill, 2001). Even a single tillage event in a long-term no-till soil can result in losses of much of the C that had been gained under previous years of no-tillage (VandenBygaart and Kay, 2004; Conant et al., 2007). If about 90% of American no-till farmers are requiring at least some tillage for maintaining optimum productivity, any C potentially stored in their soils through no-tillage has a high probability of being lost back to the atmosphere. Furthermore the practice of discontinuous no-tillage is not being captured by the U.S. National inventory of GHGs since it is assumes these producers are under continuous conservation management. Discontinuous no-till is not unique to the U.S. as farmers in many northern European regions have also required intermittent tillage of no-till to overcome its long-term limitations on productivity (Powlson et al., 2014).

3. What about N_2O?

It is often overlooked that CO_2 is only one of three GHGs that are affected by agricultural management. N_2O and CH_4 are much more potent GHGs than CO_2, about 300 and 30 times, respectively (Solomon et al., 2007). Indeed, a large majority of N_2O emissions from agriculture are a consequence of mineral fertilizer applications. N_2O emission in no-tillage compared to conventional tillage has been shown to be dependent upon soil aeration, although results can be highly variable (Rochette 2008; van Kessel et al., 2013). Nonetheless N_2O emissions could completely offset expected C gains in no-till in fine-textured soils of humid climates (Rochette, 2008). A global meta-analysis by Six et al. (2004) showed that the overall global warming potential actually increases in the first decade of no-tillage in both humid and dry climates, and that N_2O emissions drive much of it. The uncertainties were very large in their analysis; nonetheless GHG mitigation potential of no-till is highly speculative when only C sequestration is considered. CO_2 loss due to periodic tillage coupled with higher N_2O emission under short-term no-tillage (<10 years) regardless of climate would seem to be the norm rather than the exception in most cropland in the U.S. and other developed countries.

4. Let us be realistic about no-till

The benefits of no-tillage for erosion control are well established by retaining surface ground cover by residues, not breaking up soil aggregates and improving water infiltration (Montgomery, 2008). It is also clear that reducing tillage can aid in maintaining the structural quality of soil while maintaining a buffer to moisture loss under drought conditions (Kay and VandenBygaart, 2002) that may be enhanced under climate change in certain regions. But no-till advantages are not universal: A recent global meta-analysis of 5463 yield comparisons showed that generally yields are reduced in no-till compared to conventional tillage (Pittelkow et al., 2015). Also the conservation management "package" involves not simply a change in tillage implements and seeders, which are a large investment, but also often includes increased usage of mineral fertilizers and herbicides. For small holder farms in sub-Saharan Africa for instance, implementing conservation tillage can result in decreased yields, increased labour when herbicides cannot be used and a critical gender shift of labour burden to women (Giller et al., 2009), even apart from the increased costs for herbicide and mineral fertilizers.

We need to be more realistic about both the benefits and disadvantages of no-tillage that is based on sound science and fact, rather than promoting it as a false panacea for application universally to mitigate climate change. Instead the soil should be lauded as the ultimate source for the food that will feed the exploding global population in the coming centuries where no-tillage will play a large part (Lal, 2004).

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