

Carbon flux in no-till and conventional-till systems

By Margaret Ribey

In the age of dependence on fossil fuels, determining ways to sequester some of the carbon released during fuel combustion are being investigated. Agricultural soils have been identified as being a potential carbon sink. This is particularly true when conventional-till is converted to either a conservation-till or no-till system. Less soil disturbance associated with conservation-till or no-till results in less soil organic carbon (SOC) loss when compared to conventional-till systems. Soil organic carbon (SOC) refers to the carbon contained in organic matter; which is about 58% C by weight.

According to 76 long-term experiments in the United States, the Center for Research on Enhancing Carbon Sequestration in Terrestrial Ecosystems (CSiTE) and the US Department of Energy have determined that converting from conventional-till to no-till has the potential to sequester 337 ± 108 kg-C ha⁻¹ per year in agricultural soils to a depth of 30 cm (more specifically 100–500 kg-C ha⁻¹ per year in the Canadian prairie region). The research also indicated that conservation-till (i.e. full width tillage which retains a minimum of 30% residue cover) did not significantly increase C sequestration over conventional-till. Researchers have assumed that C sequestration could continue at an average rate of 337 kg-C ha⁻¹ per year for 20 years after converting from conventional-till to no-till. The rate of C sequestration was assumed to then decline at a constant rate for another 20 years, with SOC reaching a new steady-state 40 years after conversion to no-till.

Interestingly, the sequestration that does occur in the conversion from conventional-till to no-till is mainly (85%) located within the top 7 cm of the soil profile (West and Post, 2001). Deen and Kataki (2003) also studied the distribution of SOC in the soil profile for no-till and conventional-till systems in Ontario (Canada). The researchers noticed that the SOC concentration and storage was highest for No-till in the top 0-5cm of the soil profile. However, at depth, the previous finding did not hold true and was actually reversed. Deeper in the soil, SOC concentrations and storage were higher for conventional-till than for no-till. The high SOC concentrations at depth seemed to be associated with the depth that a tillage implement incorporates the plant material (Deen and Kataki, 2003; VandenBygaart et al, 2002).

The net flux of C into the atmosphere depends on agricultural inputs (pesticides, fertilizers, lime, seed), tillage practices, and machinery and fuel use. All these factors influence C release and need to be added together to calculate the net flux of C release into the atmosphere (C release-C sequestration). The net C-flux will be lower in no-till when compared to conventional-till partially because there is less tractor fuel consumption due to fewer passes over the field. Table 1 was adapted from West and Marland (2002) and it helps quantify C emissions from conventional and no-till systems.

Table 1. Average net carbon flux into the atmosphere for US agriculture with changes in tillage practices

System	Conventional Till (kg C/ha/yr)	No-Till (kg C/ha/yr)
C sequestration in soil	0	-337
C emissions from machinery	69	23
C emissions from inputs	99	114
Net C Flux	168	-200

Note: A negative net C flux indicates that soil C sequestration is greater than C release to the atmosphere.

One will note that the net carbon flux for inputs in no-till is higher. This is mainly due to higher requirements for herbicides and nutrients (N, P, K). Clearly, these values will change based on the crop grown (typically in a wheat fallow rotation, there is no C sequestration with the conversion from conventional to no-till (West and Post, 2001)) and the region of production. But in general, no-till will contribute to lower C emissions and higher C sequestration than Conventional-till.

With this information in mind, producers must be careful about changing their tillage practices. Moving from no-till to Conventional-till, or intermittent use of tillage implements in fields which most years are planted no-till, will release large amounts of C to the atmosphere. If agriculture wants to be recognized as an overall carbon sink, we must be aware of where in the field the carbon is being stored and be sure to manage it appropriately.

Notes:

Deen, W. and Kataki, P.K. 2003. Carbon sequestration in a long-term conventional versus conservation tillage experiment. *Soil and Tillage Research*. 74:143-150.

VandenBygaart, A.J., Yang, X.M., Kay, B.D., and Aspinall, J.D. 2002. Variability in carbon sequestration potential in no-till soil landscapes of southern Ontario. *Soil and Tillage Research*. 65:231-241.

West, T.O. and Marland, G. 2002. A synthesis of carbon sequestration, carbon emissions, and net carbon flux in agriculture: comparing tillage practices in the United States. *Agriculture, Ecosystems, and Environment*. 91:217-232.

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