Carbon credits from tilled and no-tilled winter wheat

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Under the Pacific Northwest temperate climate and rainfall-limited dryland agriculture, a question of interest is the ability of wheat-based cropping systems to increase the storage of soil organic carbon (SOC) when conventional tillage (CT) practices are replaced by no-tillage (NT) or reduced tillage (RT).

As shown in Figure 1, NT management leaves residue biomass on the ground, while CT mostly incorporates these residues into the soil. Residue biomass is partially incorporated in RT, depending on tillage intensity. Thus, a key difference between CT and RT practices is that the former redistributes residues within the soil depth affected by tillage, while the latter concentrates residue accumulation on the topsoil. In addition, NT and RT reduce disturbance of the tilled soil layer, which reduces oxidation of SOC and carbon dioxide (CO_2) emissions.

To the extent that nitrous oxide (N_2O) emissions are significantly different between tillage management practices, the CO_2 equivalent of these emissions could affect the relative carbon footprints of the three tillage practices.

IMPACT

N_2O emissions constitute two-thirds of the winter wheat carbon footprint. No-till increases soil carbon sequestration in winter wheat drylands relative to conventional tillage, particularly on high rainfall areas. However, the dollar value of carbon credits resulting from reduced tillage is unlikely to be high enough to provide incentive for the adoption of reduced tillage practices. More efficient use of nitrogen fertilization can contribute to decreasing the carbon footprint independently of tillage management.

Differences in fuel consumption are also a factor when comparing management practices. Therefore, a life cycle assessment (LCA) approach considering several factors affecting the carbon footprint—not only SOC sequestration (storage)—is of interest when elucidating the potential for carbon credits derived from tillage reduction.

A crop simulation and LCA-based assessment of carbon credit potential in wheat systems in the Pacific Northwest was conducted. Table 1 summarizes the locations (representative of high, intermediate, and low rainfall zones) and crop rotations included in this study.

A cropping systems simulation model (CropSyst) was used for the assessment. The use of computer modeling ensures that the performance of the tillage practices is evaluated under the same set of environmental conditions. It also allows evaluation of changes during a long time span (in this case 30 years). It also accounts for progression toward a new equilibrium of SOC after the practices change. CropSyst is a comprehensive, process-oriented, multi-year, and multi-crop simulation model that can track daily crop growth and yield, as well as changes in soil water, soil nitrogen, SOC, and emissions of CO_2 and N_2O in response to climatic conditions and tillage intensity.

In addition to soil emissions, a standard LCA approach was used to estimate the emissions associated with agricultural inputs such as fuel, fertilizers, and pesticides. The carbon credit is evaluated as the reduction of carbon dioxide equivalent (CO_2e) emissions from all contributing sources. For example, N_2O is a

Figure 1. *Conventional tillage (left) increases soil disturbance and oxidation of soil organic carbon (SOC) compared to no-till management (right).*

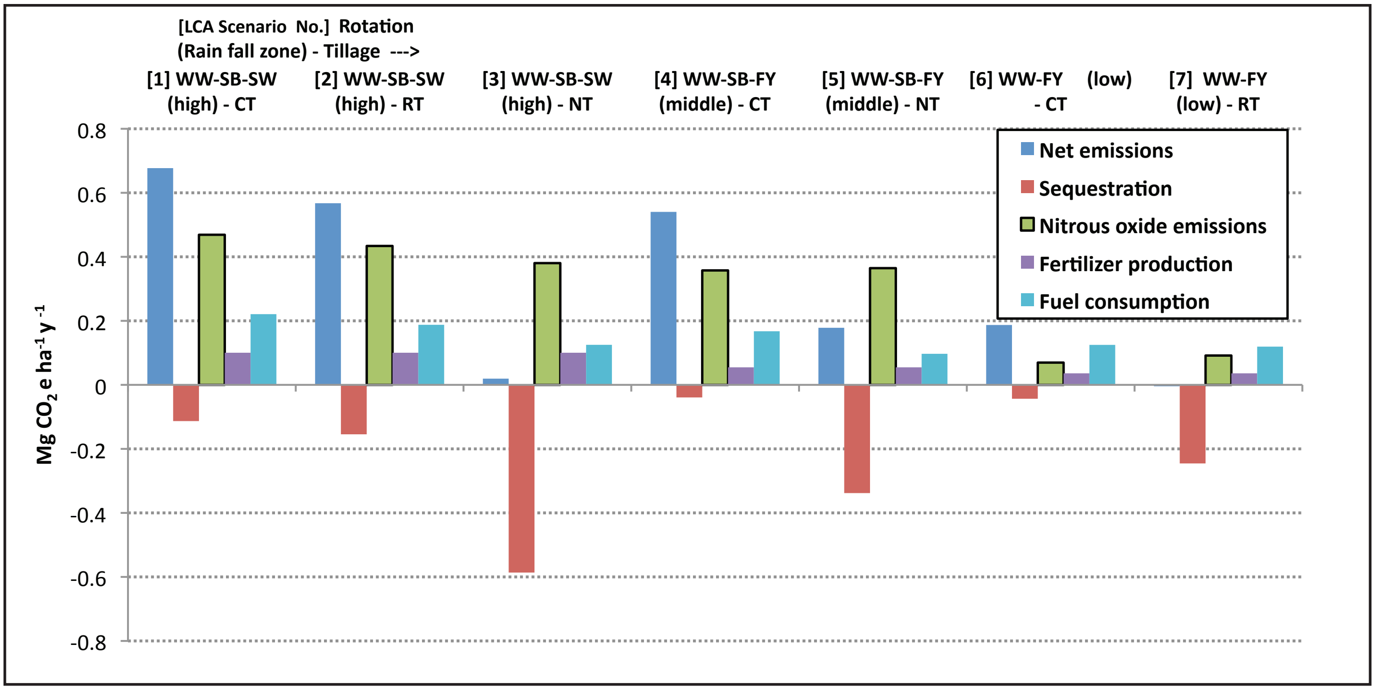

Figure 2. *Emission of equivalent carbon dioxide under different rainfall zones and tillage intensities for typical winter-wheat rotations in Washington.*

greenhouse gas that has 298 times the effect of CO_2 on potential global warming. Therefore, 1 gram of N_2O counts as 298 grams of CO_2 equivalent.

Figure 2 shows the CO_2 equivalent results for all locations, cropping systems, and tillage managements. Relative to conventional tillage, SOC storage increased with tillage reduction. SOC storage was higher in the high rainfall zone, and it decreased as lower rainfall limited residue production. The emission of N_2O was not significantly different in response to tillage.

The soil N_2O emissions and emission contribution from fertilizer production decreased in the lower rainfall areas as less N fertilization was used. Emissions associated with fuel consumption decreased with decreasing rainfall, biomass production, and tillage. In the low rainfall zone, there was little difference in fuel consumption between CT and RT, as mechanical weed control was replaced with chemical weed control. Emissions from other auxiliary processes such as equipment and pesticide production (not shown) were less than 2% of total emissions.

Assuming a carbon credit value of $2.50 per ton of CO_2 equivalent reduction (the historically low carbon credit in 2011), conversion from CT to NT in the high rainfall zone would generate $1.63 per hectare per year on average, while the medium and low rainfall zones would generate values of $0.90 and $0.45 per hectare, respectively. These figures are low. Even with a larger carbon credit value, they are unlikely to create additional incentives for tillage reduction. Improved management leading to reduced nitrogen fertilization could reduce N_2O emissions and the carbon footprint regardless of tillage management, particularly in the high rainfall zone.