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CQESTR Simulation of Soil Organic Matter Dynamics in Long-term Agricultural Experiments across USA

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Soil organic matter (SOM) has important chemical (supplies nutrients, buffers and adsorbs harmful chemical compounds), biological (supports the growth of microorganisms and micro fauna), and physical (improves soil structure and soil tilth, stores water, and reduces surface crusting, water runoff) functions. The loss of 20 to 50% of soil organic carbon (SOC) from USA soils after converting native prairie or forest to production agriculture is well documented. Sustainable management practices for SOC is critical for maintaining soil productivity and responsible utilization of crop residues. As crop residues are targeted for additional uses (e.g., cellulosic ethanol feedstock) developing C models that predict change in SOM over time with change in management becomes increasingly important. CQESTR, pronounced "sequester," is a process-based C balance model that relates organic residue additions, crop management and soil tillage to SOM accretion or loss. The model works on daily time-steps and can perform long-term (100-year) simulations. Soil organic matter change is computed by maintaining a soil C budget for additions, such as crop residue or added amendments like manure, and organic C losses through microbial decomposition. Our objective was to simulate SOM changes in agricultural soils under a range of soil parent materials, climate and management systems using the CQESTR model. Long-term experiments (e.g. Champaign, IL, >100 yrs; Columbia, MO, >100 yrs; Lincoln, NE, 20 yrs) under various tillage practices, organic amendments, crop rotations, and crop residue removal treatments were selected for their documented history of the long-term effects of management practice on SOM dynamics. Simulated and observed values from the sites were significantly related ($r2 = 94\%$, $P < 0.001$) with slope not significantly different from 1. Recent interest in crop residue removal for biofuel feedstock prompted us to address that as a management issue. CQESTR successfully simulated a substantial decline in SOM with 90% of crop residue removal for 50 years under various rotations at Columbia, MO and Champaign, IL. An increase in SOM following addition of manure was also well simulated. However, the model underestimated SOM for a fertilized treatment at Columbia. We estimated that a minimum of 8.0 Mg/ha/yr of crop residue and organic amendments (4.0 Mg C ha/yr) was required to prevent a decline in SOM at the Morrow Plots in Champaign, IL. More studies are needed to evaluate the CQESTR model's performance in predicting the amount of crop residue required to maintain the SOM concentration in different soils under a wide range of management and climatic conditions. Given the high correlation of simulated and observed SOM changes, CQESTR can be used to consider a wide range of scenarios before making recommendations or implementing proposed changes. CQESTR in conjunction with the local conditions can guide planning and development of sustainable crop and soil management practices.