Effects of Conservation Tillage and Slope Geometry on Soil Erosion

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During precipitation events, the detachment and downslope transport causes erosion of topsoil material (red shading in figure at right). Some of that material may be deposited in lower elevation areas (blue shading in figure at right) or may be lost into adjacent surface water. Conservation tillage practices, which are aimed at minimizing soil disturbance and retaining above-ground cover, are designed to reduce erosion by enhancing soil cohesion, slowing flow velocities, and shear stresses on the soil surface. Large-scale soil erosion models, such as the Revised Universal Soil Loss Equation (RUSLE), conceptualize these processes broadly, but information is lacking on how the orientation of conservation tillage relative to hillslope incline affects erosion processes. To quantify the association between tillage and hillslope orientations, we performed a plot-scale experiment at the Virginia Tech Urban Horticulture Center. We implemented four practices, including full (conventional tillage), no-till, and strip till with the strips oriented parallel to versus perpendicular to the land surface direction, on isolated 3 m x 3 m (n = 3 plots per treatment). Starting in September 2024, we repeatedly scanned the plots using a handheld LiDAR unit and quantified soil erosion and deposition via digital elevation model (DEM) differencing. Deposition and erosion were found to differ significantly between tillage treatments and were associated with hillslope orientation (Kruskal-Wallace p-value <0.001, Bartlett p-value <0.001). At the cm-scale, slope orientation and incline were not correlated with erosion and deposition (Ordinary Least Squares Regression p-values 0.751 and 0.690). Comparison against RUSLE-based estimates show their tendency for underestimation, suggesting the limitations of current soil erosion modeling.

Keywords: Soil Erosion, RUSLE, LiDAR, Conservation Tillage