Quantifying Root Carbon Rhizodeposition from Bioenergy Cropping Systems in the Midwest United States

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Project Goals: Quantifying and predicting ecosystem-level carbon (C) cycling processes are critical steps toward assessing the overall sustainability of bioenergy and bioproduct feedstocks. While aboveground C cycle components are routinely evaluated *in situ*, belowground C components remain physically and technically challenging to study and therefore remain poorly understood. Rhizodeposition of water-soluble, low-molecular weight C compounds via root exudation, sloughing, and mucilage may represent a substantial transfer of C from plants to soil, but this flux is seldom represented in ecosystem C budgets and models. Moreover, rhizodeposition C may provide a labile energy source for soil microbes, which provides an important link between cycling of C and other critical soil nutrients such as nitrogen. Our goal was to quantify C rhizodeposition in key bioenergy cropping systems to reduce uncertainty in empirical C budgets and improve ecosystem-scale predictive models.

The potential for bioenergy cropping systems to mitigate net carbon (C) emissions through soil C sequestration represents a major sustainability benefit over fossil fuels. Most empirical research has indicated that perennial biofuel cropping systems enhance soil C sequestration rates over their annual counterparts. However, the mechanisms underpinning this phenomenon are often speculative, and therefore predictive ecosystem models may not capture these dynamics accurately. Although root rhizodeposition of soluble C compounds may account for a substantial portion of net primary productivity in bioenergy cropping systems, it is not well-represented in many C budgets and ecosystem models due to the paucity of *in situ* empirical studies. We collected water-soluble root rhizodeposition C from miscanthus, switchgrass, bioenergy sorghum, and maize cropping systems near the peak of two growing seasons in Central Illinois. In addition, we collected root cores to scale specific root rhizodeposition rates to the ecosystem level. On most dates, bioenergy sorghum had significantly higher specific root rhizodeposition rates than miscanthus, and bioenergy sorghum often had higher specific root rhizodeposition rates than maize and switchgrass. Bioenergy sorghum that was fertilized at a typical nitrogen (N) rate trended toward lower specific root rhizodeposition rates than unfertilized bioenergy sorghum, but this pattern was not statistically significant. After scaling by root biomass, average ecosystem-level rhizodeposition was approximately 450 mg C m^{-2} d^{-1}, with no consistent differences observed among the bioenergy cropping systems. Our preliminary estimate indicates that root rhizodeposition accounts for approximately 2% to 7% of annual net primary productivity in both perennial and annual cropping systems. Thus, although the root rhizodeposition C flux is not likely the primary input for soil C sequestration, it nonetheless may play a substantial role in nutrient cycling and therefore warrants explicit attention in ecosystem C budgets and models.

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