Nitrogen Losses Reduced from Perennial Biofuel Crops

Ethanol from corn has been the primary biofuel for liquid fuels in the United States, but perennial cellulosic biofuels are on the horizon. Intensive corn production with large fertilizer inputs leads to large losses of nitrogen into the environment, both through gas emissions of nitrous oxide and leaching losses of nitrate to ground and surface (through tile systems) waters. Nitrous oxide is an important greenhouse gas, and nitrate can contaminate drinking water supplies and leads to coastal ocean problems. The hypoxic zone that forms each summer in the Gulf of Mexico is a result of nitrate losses from the tile-drained Corn Belt of the midwestern United States.

There are few measurements of nitrogen losses on large, tile-drained fields planted with perennial biofuels in the Midwest of the United States, a likely location for biofuel production. Nitrogen budgets (to assess balances and need for fertilization) and loss measurements are needed to fully understand the response of the nitrogen cycle to the production of biofuel crops on tile-drained fields. This allows for a more complete assessment of the long-term sustainability of biofuel production systems compared with corn and soybean production.

In the January–February 2013 issue of the *Journal of Environmental Quality*, researchers report on four years of measurements of nitrogen losses during the establishment phase of perennial biofuel crops compared with conventional corn and soybean production in east-central Illinois. The biofuel crops, planted on rich Mollisols, were miscanthus, switchgrass, and mixed prairie species, all compared against a typical corn–corn–soybean rotation. Miscanthus is a highly productive grass, planted from rhizomes, that is being evaluated as a biofuel crop. Harvested biomass and nitrogen, nitrous oxide emissions, and nitrate leaching in the mid-soil profile and through tile drainage lines were all measured.

Results from a recent study in the *Journal of Environmental Quality* clearly show that biofuel crops such as switchgrass and miscanthus (shown here) have the potential to quickly and greatly reduce nitrogen losses while providing a large biomass harvest.

The authors found that perennial crops quickly reduced nitrate leaching in the mid-soil profile as well as from tile lines, so that by Year 4, each of the perennial crops had small losses. Nitrous oxide emissions also were much smaller in the perennial crops (including switchgrass, which was fertilized with nitrogen, unlike prairie and miscanthus). Overall nitrogen balances (inputs minus outputs) were positive for the corn and soybean treatment as well as switchgrass but were negative for prairie and miscanthus. Prairie and miscanthus balances were negative due to harvest of the plant biomass (and nitrogen) each winter, with no fertilizer nitrogen additions to replace it, as occurred in corn and switchgrass.

Results showed that miscanthus and prairie had very wide carbon-to-nitrogen ratios in the harvested material (as much as 257 to 1 for miscanthus). Although the largest biomass harvested during the study was from miscanthus when it was well established in Year 4 (nearly 12 Mg ha^{-1}), little nitrogen was harvested. Miscanthus efficiently moved nitrogen from leaves to root and rhizome systems after the growing season, where it could be used again the next year. The negative nitrogen balance, however, suggests that nitrogen removed by harvest in prairie and miscanthus, although small, came from the large pool of soil nitrogen and/or nitrogen fixation. If the soil is the source, this could lead to depletion of this resource without fertilization. If microbial fixation supplied the nitrogen, this would be a more sustainable input.

The authors conclude that more work is needed to fully understand the nitrogen cycle in new and exciting biofuel crops such as miscanthus, but results from this study clearly show these crops have the potential to quickly and greatly reduce nitrogen losses that have important environmental effects, while providing a large biomass harvest.

Adapted from Smith, C.M., M.B. David, C.A. Mitchell, M.D. Masters, K.J. Anderson-Teixeira et al. 2013. Reduced nitrogen losses after conversion of row crop agriculture to perennial biofuel crops. J. Environ. Qual. 42:219–228. View the full article online at https://dl.sciencesocieties.org/publications/jeq/abstracts/42/1/219

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