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Soil Block Mesocosms: A New Approach for Quantifying Nitrate Leaching and Nitrous Oxide Emissions from Maize Cropping Systems

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Detecting the effects of agricultural management on environmental nitrogen losses is often challenged by heterogeneity in soil and hydrological properties which result in varying drainage volume and composition among field plots. We aimed to overcome this using novel replicable experimental soil units made of defined volumes of undisturbed soil. Each “soil block mesocosm” consists of intact 1.5 x 1.5 x 1.2-m soil monoliths enclosed on sides and bottom in separate welded steel boxes, each fitted with a single pipe at the bottom to enable complete collection of drainage water and eliminate treatment mixing. Achieving undisturbed soils in the boxes was accomplished through vibrated insertion of the steel box walls into undisturbed soil and insertion of a steel floor underneath secured by seamless welds. Soil was backfilled around the steel boxes to maintain ambient temperature gradients. The soil blocks included two representative soil types from central Iowa (total n = 36) and were planted to maize under field conditions with one of three fertilizer application rates (135, 168, and 202 kg N/ha) in 2020 to test the capacity to detect relatively small changes in environmental N losses. Nitrous oxide emissions and surface soil moisture were measured either one or two times a week when soils were not frozen. Drainage water was collected following individual rain events for nitrate analysis. Variation in cumulative drainage amount and surface soil moisture among treatments and their replicates was not significant, indicating the soil blocks had relatively similar hydrological properties. We observed higher cumulative nitrous oxide emissions (3.0 ± 0.7, 4.3 ± 1.1, and 5.9 ± 1.1 kg N/ha) and cumulative nitrate leaching (14.8 ± 1.6, 17.1 ± 1.5, and 20.4 ± 1.7 kg NO3-N/ha) with increasing N fertilizer rate (135, 168, and 202 kg N/ha, respectively). The soil block mesocosm approach described here enabled detecting changes in nitrate leaching and nitrous oxide emissions with relatively small incremental changes in fertilizer rates, which was often not previously achievable with traditional field plots.

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