ROLE OF AGRICULTURAL MANAGEMENT IN MITIGATING GREENHOUSE EMISSIONS

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Analyses of Northern Hemisphere carbon fluxes indicate that a number of ecosystem processes jointly contribute to source and sink exchanges of CO_2 which affect the net carbon sequestered from the atmosphere. These processes (e.g., CO_2, N_2O, CH_4, and H_2O dynamics) exhibit high variability in time and space with the largest variability corresponding to human land management events. Therefore, the spatial and temporal incorporation of land management information is needed to properly represent net carbon and other GHG fluxes.

Agricultural soils are responsible for the majority of US N_2O emissions and estimated emissions from agriculture have increased over 5% during the past decade. This general increase was due primarily to increases in synthetic fertilizer use, managed manure production, and soybean-cropped area. Year-to-year fluctuations are largely a reflection of annual variations in climate, synthetic fertilizer consumption, and crop production. Nitrous oxide is produced naturally in soils through the microbial processes of nitrification and denitrification. Soil management practices can increase the availability of mineral N in soils and increase nitrification and denitrification rates above background levels. Management practices that impact N_2O emissions include: application of synthetic fertilizers, managed livestock manure and sewage sludge, production of N-fixing crops and forages, retention of crop residues, and cultivation of histosols (i.e., soils with a high organic matter content, otherwise known as organic soils).

Current modeling advances have included representation of key biogeochemical and physical processes affecting emissions of N_2O. Incorporation of land use management which modifies these fluxes are now included in our modeling analysis and significant improvement in quantifying N_2O emissions has resulted. Total N_2O emissions include direct soil emissions from nitrification and denitrification and indirect emissions from: 1) volatilization and subsequent atmospheric deposition of applied N; and 2) surface runoff and leaching of applied N into groundwater and surface water. In addition to N amendments, other agricultural soil management activities, such as irrigation, drainage, tillage practices, and fallowing of land, can affect fluxes of N_2O (as well as other greenhouse gases) to and from soils. Current emission rates for major cropping systems (i.e., wheat, corn, soybean) are simulated. Potential mitigation options will be presented based on these model analyses.

New management systems are being designed to enhance carbon sequestration, however, our analysis indicates that these estimates may be lower when full biogeochemical cycle considerations are made. We simulated 20 years of conventional agriculture contrasted with different treatments for the globe at 2-degree resolution. A 10-year daily weather file for each cell that included at least 5% agriculture by area was used to drive simulations of wheat, corn and soy. The initialization portion of the simulations included historical cropping rotations, improvement of crop varieties, traditional tillage practices, and N fertilizer applications beginning in 1950 that were gradually increased to modern levels. Treatments consisted of varying soil tillage, varying amount and timing of fertilizer applications, and application of nitrification inhibitors. During the years when corn was planted, fertilizer was applied all in a single application or in 2 applications (split N application) of 1/2 each.

Output files for SOC, N gas (N_2O, NO_x, N_2) emissions, N leached, CH_4 uptake, plant N uptake, and grain yields were compiled and used to calculate average yearly values for these parameters. The change in SOC (DSOC) after 20 years of a particular management practice is assumed to represent net C exchange between the atmosphere and the soil because it integrates CO_2 fixation from photosynthesis and CO_2

losses from SOC decomposition. N_2O emissions and CH_4 uptake were converted to CO_2-C equivalents by using molecular stoichiometry and assuming that N2O and CH4 have 311 and 25 times, respectively, the global warming potential of CO_2 on a per molecule basis. We also assumed that the production of each gram of N fertilizer resulted in the release of 0.8 g CO_2-C. GHGnet was calculated by summing the DSOC and the CO_2-C equivalents of N_2O, CH_4, and N fertilizer production. GHGnet does not represent a full GHG accounting because the CO_2 costs of farm equipment operation, transportation of products, and other factors were not included. Emissions of NO_x, N_2O, and N_2 were summed to obtain total N gas losses.

N-Loss Reduction Results For Croplands

Figure 1 presents globally averaged results for the year 2020, showing percent deviations from the non-irrigated baseline case for yields, direct N_2O, indirect N_2O and total N_2O emissions for the N-inhibitor case, the precision fertilization case, and three different percent N reduction (70%, 80%, 90%) cases. Mitigation scenarios assume immediate and full adoption beginning in year 2000. Results indicate that agricultural systems are currently net sources of major greenhouse gases, but that improved management practices can enhance carbon sequestration and reduce N losses.

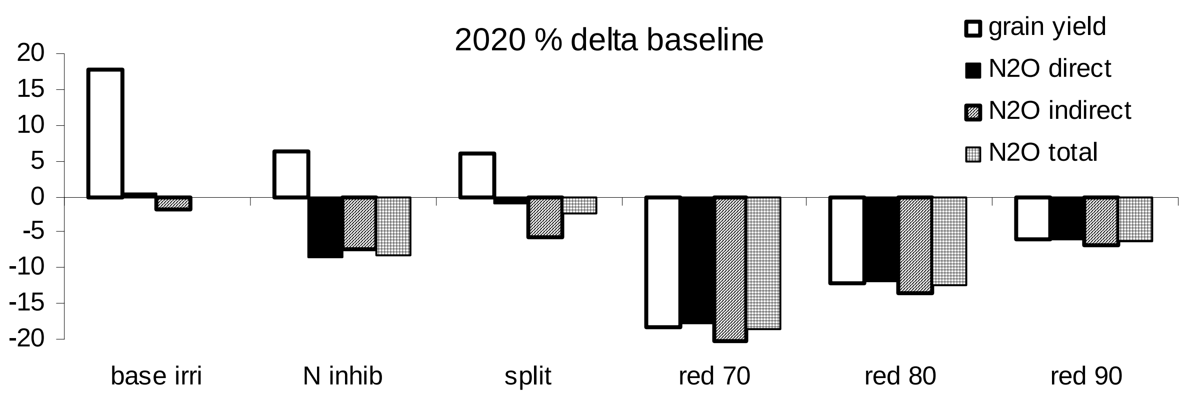

Fig. 1: Globally averaged DAYCENT Results for Yields and N2O Emissions under Baseline and Mitigation Scenarios