Modelling Impact of Climate Change and Management Practices on Greenhouse Gas Emissions from Arable Soils

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Abstract: The objective of this study was to estimate the impact of climate change on greenhouse gas (GHG) emissions under different management practices using the DNDC (denitrification-decomposition) biogeochemistry simulation model. Comparison of DNDC model outputs for baseline and future climate scenarios for 2030 and 2050 provides insight into how gas emissions (N_2O, CH_4 and CO_2) may change in different crop management practices. In the study, future N_2O, CH_4, and CO_2 fluxes were estimated from commonly used crop rotation in eastern Poland under conventional (mouldboard plowing) and conservation tillage (chisel plowing). In the research, "tillage" was used for conventional tillage and "reduced tillage" for conservation tillage. One 4-year crop rotation has included corn, rapeseed and spring and winter wheat, where emissions were estimated per hectare for each crop. According to the generated data, the baseline mean annual air temperature (1971-2000) was 8.1^{o}C (C2000). Under C2030 climate scenario, average annual temperature increased by 1^{o}C, while under C2050 by 1.7^{o}C. The baseline mean yearly precipitation in Grabow according to generated data was 631 mm (C2000). The mean yearly precipitation for the future climate was simulated to decrease only by 1.0% in C2030 scenario and about 1.2% in C2050 scenario. Results of our study present that the use of reduced tillage has decreased the N_2O emissions by 19-23%, 16-20% and 18-22%, respectively in C2000, C2030 and C2050 scenarios compared with tillage. Increase of temperature and decrease of precipitation has reduced N_2O emissions in both conventional and conservative systems by 6% (C2030) and by 12% (C2050) in comparison with C2000.

In the studied complete 4-years crop rotation, assumed climate change in future scenarios have led to lower C accumulation rates. The highest carbon accumulation rates were found in conservation tillage. The differences were 45-53%, 15-17% and 14-16%, respectively in C2000, C2030 and C2050 scenarios compared to a conventional system.

Increase of temperature and decrease of precipitation might reduce net global warming potential (GWP) by 2% in the 2030 climate scenario and by 5% in the 2050 scenario in conventional tillage with reference to the baseline scenario. In the case of conservation tillage, reductions of GWP by 5% and by 10% were estimated. The use of conservation tillage results decreased the GWP by 17-19%, 16-18% and 15-17%, respectively in the C2000, C2030 and C2050 scenarios. The research has shown that change in climate conditions has declined biomass production of winter wheat and corn, which may suggest that a larger area would be needed for these crops to maintain production at the same level.

Keywords: greenhouse gas emissions, DNDC, nitrous oxide, carbon sequestration, tillage, reduce tillage