ABSTRACT

Agricultural soils are a major source and/or sink for atmospheric greenhouse gases: nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4). The production and consumption of these gases are directly linked to microbial activities. Soil fumigation, a common practice in agriculture to control soil-borne diseases and pests, affects a variety of soil organisms, including microbes. It was initially hypothesized that if soil fumigants were biocides there would be strictly negative impacts. However, the findings of this research indicated that there were stimulation effects as well, particularly for N_2O production following chloropicrin (CP) fumigation. This was the first study that systematically quantified impacts of soil fumigation with CP and methyl isothiocyanate (MITC) on greenhouse gas exchange.

For N_2O, increases in surface emissions from 7- to 12-fold were observed following fumigation with CP. The stimulation was confirmed in both laboratory and field experiments. Microbial activities contributed 82% to the CP-induced N_2O production, with 18% from abiotic processes. Inhibitor studies suggested that fungal mediated denitrification reactions under aerobic conditions were the primary mechanisms for CP-induced N_2O production. There were no significant differences in N_2O production following CP fumigation under various levels of acetylene (0 Pa, 10 Pa, and 10 kPa), suggesting that traditional nitrification and denitification reactions did not significantly contribute to N_2O production after CP fumigation. ^{15}N labeled studies indicated that 12% of N from CP was incorporated into N_2O. No enrichment in N_2 was observed, indicating that N_2O was a terminal mineralization product of CP. Field measurements also illustrated a 4-fold increase in N_2O emissions following MITC

fumigation. This stimulation effect was not observed in laboratory incubations under aerobic conditions.

There were slight reductions in CO_2 emissions following both MITC and CP fumigation. The initial decreases were followed by an increase in CO_2 emissions observed at 48 days resulting from the mineralization of the killed biomass from fumigation.

All fumigants tested significantly reduced CH_4 oxidation rates in historically non-fumigated soils. However, fumigation with MITC increased CH_4 oxidation rates in all historically MITC fumigated soils compared to controls. CP universally decreased oxidation capacity regardless of fumigation history.