ABSTRACT

Agricultural soils are a major source and/or sink for atmospheric greenhouse gases: nitrous oxide (N₂O), carbon dioxide (CO₂), and methane (CH₄). 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 N₂O 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 N₂O, 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 N₂O production, with 18% from abiotic processes. Inhibitor studies suggested that fungal mediated denitrification reactions under aerobic conditions were the primary mechanisms for CP-induced N₂O production. There were no significant differences in N₂O production following CP fumigation under various levels of acetylene (0 Pa, 10 Pa, and 10 kPa), suggesting that traditional nitrification and denitrification reactions did not significantly contribute to N₂O production after CP fumigation. ¹⁵N labeled studies indicated that 12% of N from CP was incorporated into N₂O. No enrichment in N₂ was observed, indicating that N₂O was a terminal mineralization product of CP. Field measurements also illustrated a 4-fold increase in N₂O emissions following MITC
fumigation. This stimulation effect was not observed in laboratory incubations under aerobic conditions.

There were slight reductions in CO₂ emissions following both MITC and CP fumigation. The initial decreases were followed by an increase in CO₂ emissions observed at 48 days resulting from the mineralization of the killed biomass from fumigation.

All fumigants tested significantly reduced CH₄ oxidation rates in historically non-fumigated soils. However, fumigation with MITC increased CH₄ oxidation rates in all historically MITC fumigated soils compared to controls. CP universally decreased oxidation capacity regardless of fumigation history.