BEHAVIOR OF METHYL ISOTHIOCYANATE IN SOIL AFTER APPLICATION OF METAM SODIUM AND METAM POTASIUM

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Introduction

Preplant soil disinfestation for management of soilborne pests is crucial for the production of many crops. Methyl bromide (MB) and metam sodium (42% sodium N-methyl dithiocarbamate) have been the most widely used fumigants in agriculture in the USA and around the world. Several formulations of methyl isothiocyanate (MITC) generators are being used to control soilborne fungal pathogens and weeds. Recently, metam potassium (K-Pam HL, 54% potassium N-methyldithiocarbamate) was introduced to the market as a new MITC generator. To ensure effective application of metam potassium and the best utilization of the generated MITC, it is necessary to compare its fate and behavior in soil relative to metam sodium. This study was conducted to: 1) determine MITC generation and degradation rates in soil; 2) evaluate the phase partition and transformation of two metam formulations applied to different soils; 3) investigate the mobility and volatilization potential of MITC after application of Vapam HL and K-Pam HL by shank injection and surface and sub-surface irrigation systems.

Methods

Two commercially formulated products [Vapam HL (sodium methyldithiocarbamate 42%) and K-Pam HL (potassium N-methyldithiocarbamate 54%)] were used as test fumigants in this experiment.

Transformation in soil. The generation and degradation of Vapam HL and K-Pam HL were determined in non-sterile and in autoclaved soils. A Vapam HL or K-Pam HL solution containing 420 mg MITC L^{-1} was applied to soil and MITC concentration in the vials was determined by GC after 1, 4, 7, 14, 21, 28, and 38 days at two temperatures (20^{o}C and 30^{o}C). The first-order kinetic equation was used to calculate the degradation rate constant: $C=C_oE^{-kt}$**,** where C is the MITC concentration (mg kg^{-1}) at time t, C_o is MITC the initial concentration (mg kg^{-1}), and k is the first order rate constant (d^{-1}). The half-life ($t_{1/2}$) was calculated as 0.693/k.

Volatilization and diffusion study

Stainless steel columns [70cm (length) × 12.5 cm (id)] were packed with soil. The columns were sealed and Vapam HL or K-pam HL was applied to the soil at the equivalent field application rate (75 gal/ac). The applications were done to mimic soil surface drip, sub-surface drip at 30 cm depth, and shank injection at 30 cm depth. MITC concentrations were measured by GC at 0, 30, and 50 cm depths at different time intervals.

Results

This study showed that metam formulation had no significant effect on MITC adsorption by soil. The degradation of the generated MITC in a non-sterile soil was affected by temperature and followed first-order kinetics with half-life ($t_{1/2}$) of 4.9 and 2.4 d at 20 and 30°C, respectively (Figure 1). Air drying of the non-sterile soil may have suppressed microbial activities and resulted in higher half life values than those found in fresh soils. The degradation of the generated MITC in an autoclaved soil was slightly affected by temperature. The long half life values in autoclaved soil ($t_{1/2}$ of 48 and 56 d at 20 and 30°C, respectively) indicate that MITC degradation is mainly controlled by biological activities.

The column studies showed that MITC generation and movement in soil were identical for the two metam formulations (Vapam HL and K-Pam HL). The soil column studies confirmed that metam formulation had no significant effect on diffusion and movement of MITC, regardless of the application method (Figures 2-3).

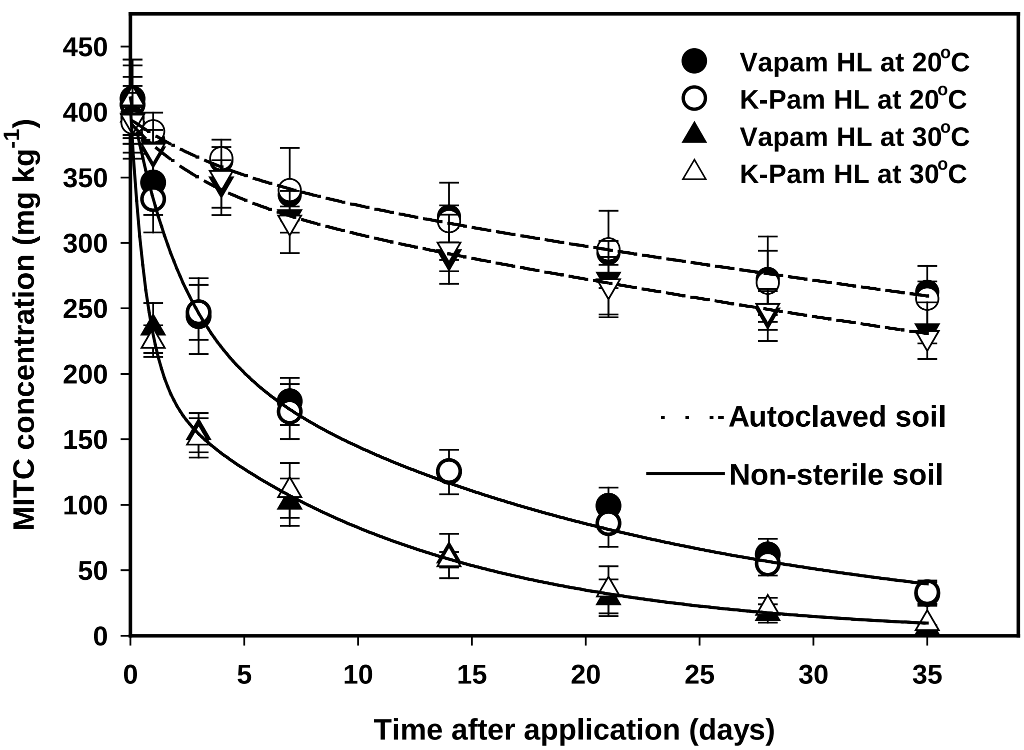

Figure 1. MITC concentration in closed system after application of Vapam HL and K-Pam HL to non-sterile and autoclaved soils at two temperatures (20°C and 30°C).

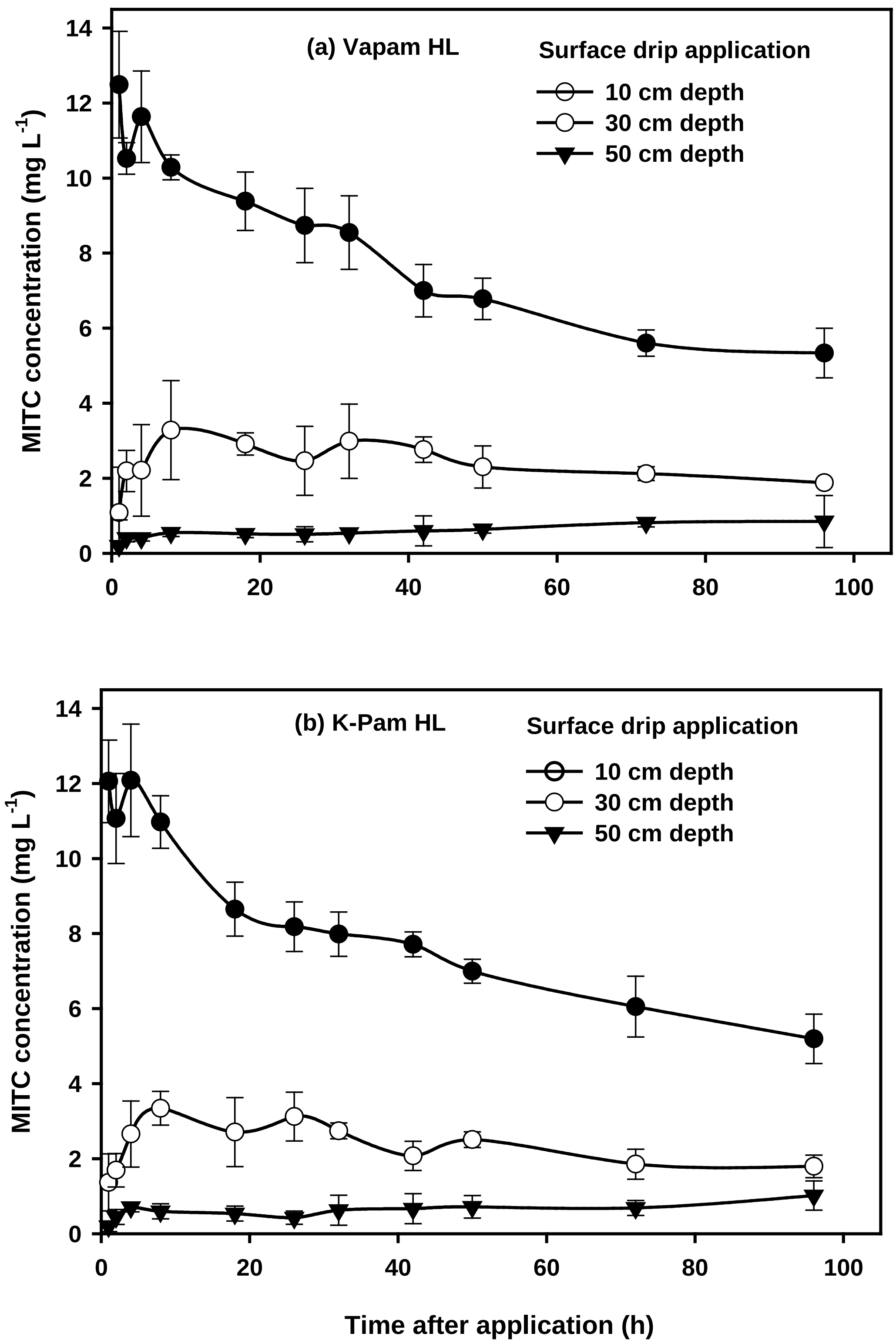

Figure 2. MITC concentrations at three depths (10, 20, and 30 cm) in soil columns after application of Vapam HL and K-Pam HL by surface drip irrigation systems.

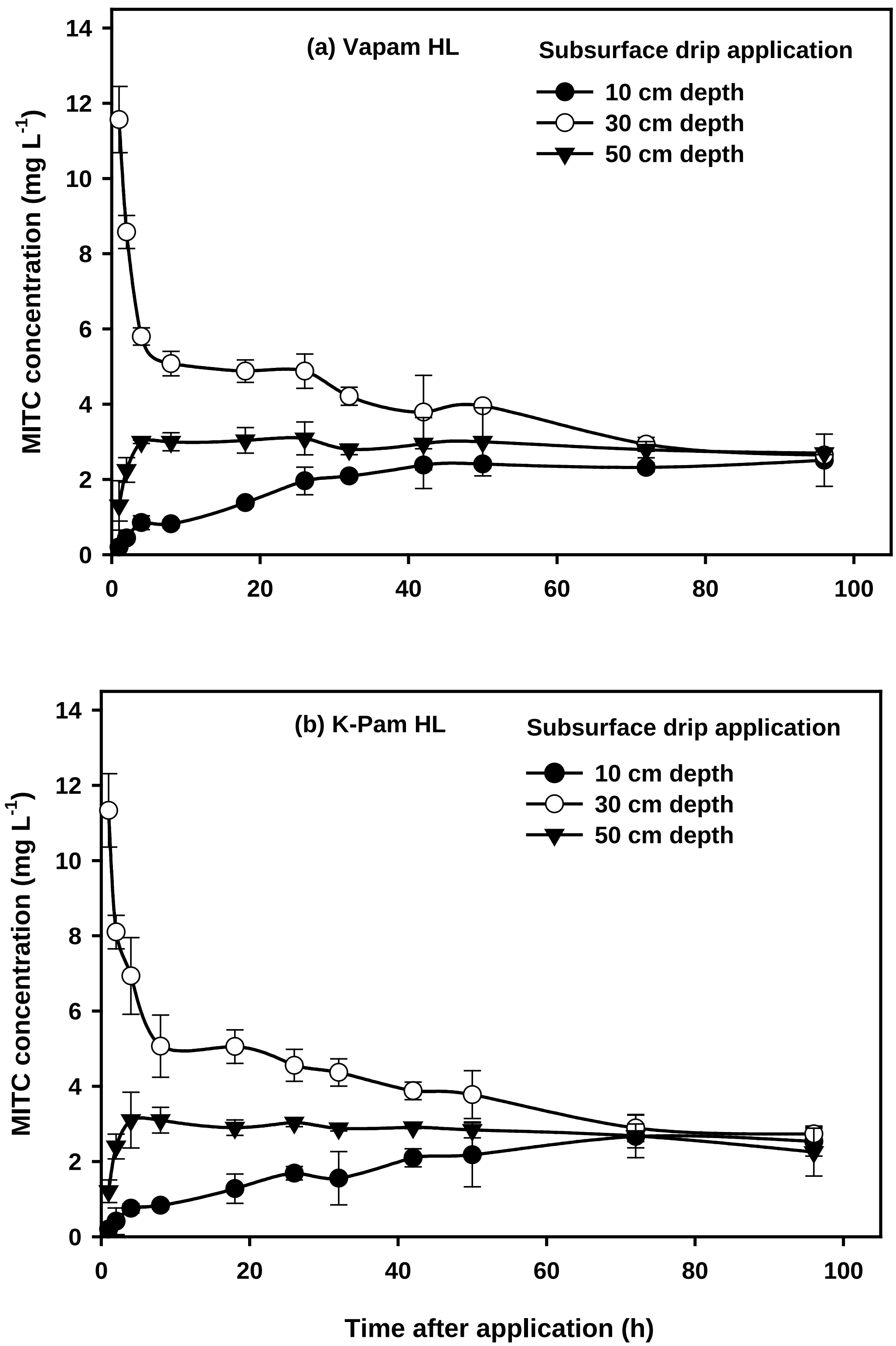

Figure 3. MITC concentrations at three depths (10, 20, and 30 cm) in soil columns after application of Vapam HL and K-Pam HL by subsurface (30 cm) drip irrigation systems.

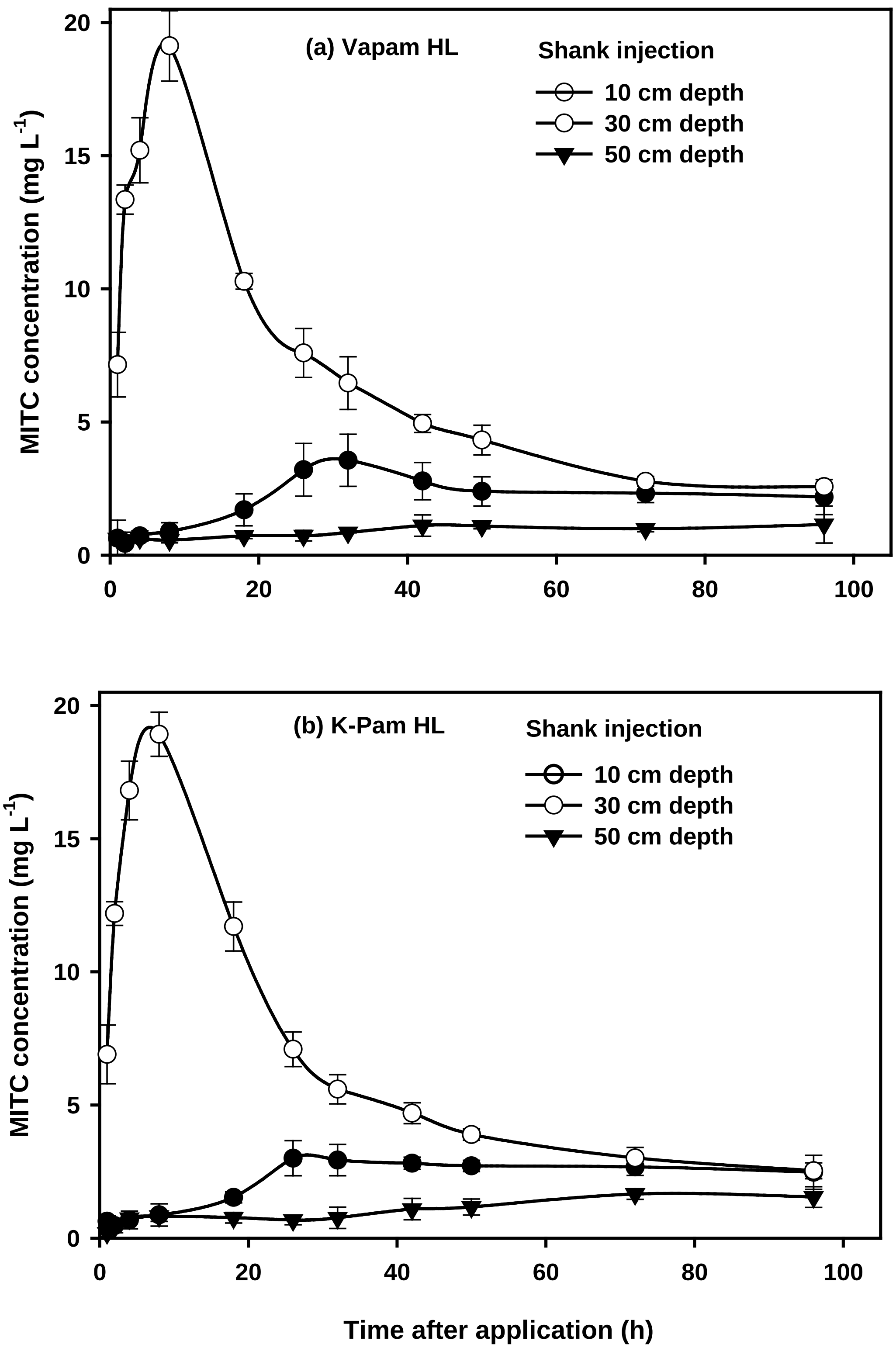

Figure 4. MITC concentrations at three depths (10, 20, and 30 cm) in soil columns after application of Vapam HL and K-Pam HL by shank injection at 30 cm depth.