DISTRIBUTION AND EFFICACY OF METHYL ISOTHIOCYANATE IN PLASTIC-MULCHED SOIL BEDS

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INTRODUCTION

Methyl isothiocyanate (MITC) the precursor of which is metam sodium (MS, sodium *N*-methyldithiocarbamate) is a short-term methyl bromide alternative that can be applied as pre-plant fumigant through the drip-irrigation system (drip fumigation or chemigation) in raised plastic-mulched soil. In sandy soils of southern Georgia (88% sand), the efficacy of this alternative as fumigant is dependent upon adequate wetting of the soil beds. Adequate wetting of sandy soil beds by drip irrigation is, however, impossible to achieve because of rapid drainage and poor lateral water movement. Because of this, concerns were raised on the ability of "water-based" alternatives to diffuse at toxic levels beyond the wetting area i.e. bed shoulders to affect the survival of soilborne plant pathogens. Some growers increase the amount of MS applied to circumvent this. To address this concern, field studies were performed during the spring of 2005 with the following objectives: 1) to determine the effect of the rate of MS application on the distribution of MITC in MS-treated sandy soil beds, and 2) to relate the above with the survival of *Rhizoctonia solani*, and yellow nutsedge (*Cyperus esculentus* L.). The soil was loamy sand (loamy, siliceous, thermic Arenic Plinthic Paleudults).

MATERIALS AND METHODS

Soil beds (9 m x 0.8 m x 0.2 m) were covered with black low density polyethylene film (50 : thick). MS was applied as Vapam (42% MS EC) at the rates of 147 and 295 liters ha^{-1}. The fumigant was injected into the drip irrigation system at 144,790 Pa for a duration of 8 h directly from 60-liter CO_2-pressurized cylinders containing premixed solutions of the fumigant. The treatments were arranged in a randomized complete block design with five replications.

MITC concentrations, *R. solani* and yellow nutsedge mortality were determined at: 1 = 10 cm below the emitter, 2 = 20 cm below the emitter, 3 = 20 cm away from the emitter (10 cm deep with the drip tape as the point of reference), and = 30 cm away from the emitter (10 cm deep with the drip tape as the point of reference). MITC was trapped in charcoal tubes by drawing 60 ml of soil air from each sampling port. MITC sampling was performed at 3, 12, 24, 48, 72, 120 and 240 h after chemigation. The amount of MITC on charcoal tubes was quantified by using a Hewlett-Packard 5890 gas chromatograph with a nitrogen-phosphorus detector (NPD) connected to a Hewlett-Packard 7694 headspace autosampler.

Treatment effects on pathogen and pest survival were determined by inserting one mesh packet containing 50 beet seeds artificially colonized with *R. solani* and another mesh packet containing 10 pregerminated yellow nutsedge tubers. The packets were inserted into the soil at above preselected sites and also retrieved at the above observation times after chemigation.

RESULTS AND DISCUSSION

MITC levels in MS-treated soils were higher with higher rate of MS application and decreased with time after chemigation (Fig. 1). Highest MITC levels were observed 3 h and 12 h after chemigation at 147 and 295 liters ha^{-1}, respectively. Moreover, MITC levels were lower with lateral distance from the emitter. MITC levels were highest at 20 cm below the emitter and generally higher at sites below the point of application (emitter). MITC levels were undetectable at 20 and 30 cm away from the emitter at 12-240 h after chemigation at 147 liters ha^{-1}.

The accumulated MITC concentration x time values (CT) which are areas under the MITC concentration x time curves were higher in soils applied with MS at 295 liters ha^{-1} than at 147 liters ha^{-1} (Fig. 2). CT values were also lower with lateral distance from the emitter and were always higher at sites below the emitter.

Scatter plots of natural logarithms of the CT values against *R. solani* and yellow nutsedge mortality indicate that although a 100% *R. solani* mortality was achieved at a CT value of 5 :g h cm^{-3}, a consistent efficacy was achieved at CT values ∃12 :g h cm^{-3} (Fig. 3). MITC efficacy against yellow nutsedge was inconsistent across all CT values observed. For example, 100% efficacy was achieved at CT values #10 :g h cm^{-3}, but less than 100% efficacy was also achieved at CT values ∃10 :g h cm^{-3}.

In conclusion: 1) higher rate of MS application resulted in higher MITC levels in the soil atmospheres of MS-treated soil beds but such increase did not result in higher efficacy against *R. solani* and yellow nutsedge at 20 and 30 cm away from the point of application; 2) MITC levels, MITC CT values, and *R. solani* and yellow nutsedge mortalities were higher under the emitter than at 20 and 30 cm away from the emitter; and 3) MITC can be delivered at lethal concentrations with drip-applied water downward within the soil beds but it did not diffuse laterally at toxic levels from the point of application to affect the survival of *R. solani* and yellow nutsedge. Lateral distribution of MITC in sandy soils will be studied to circumvent this limitation.

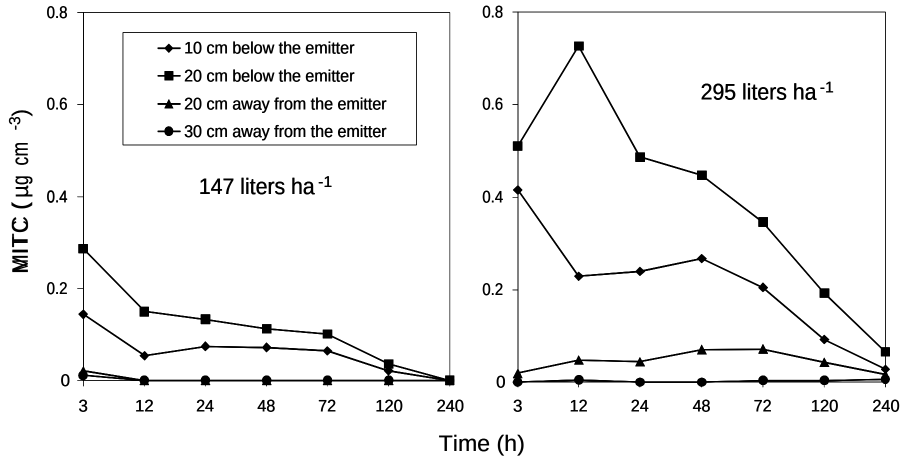

Figure 1. Distribution of MITC concentrations at four pre-selected sites of soil beds treated with two rates of MS application.

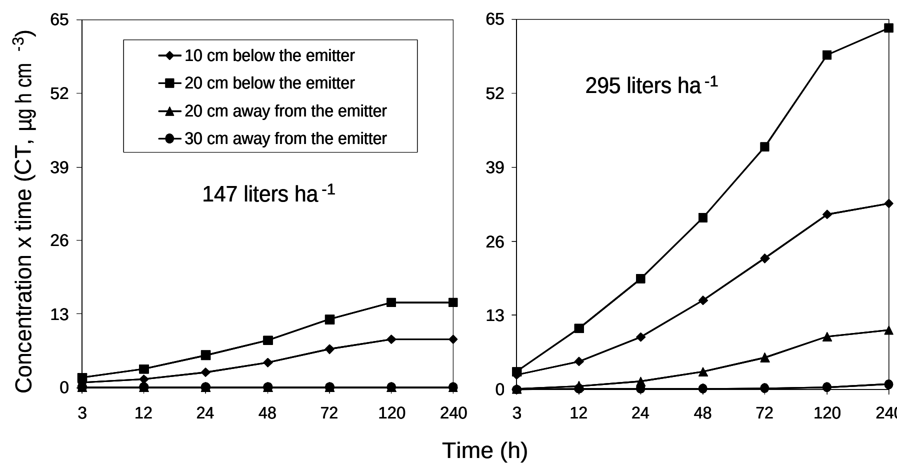

Figure 2. MITC concentration x time values at four pre-selected sites and times after MS application in soil beds treated with MS at two different rates of application.

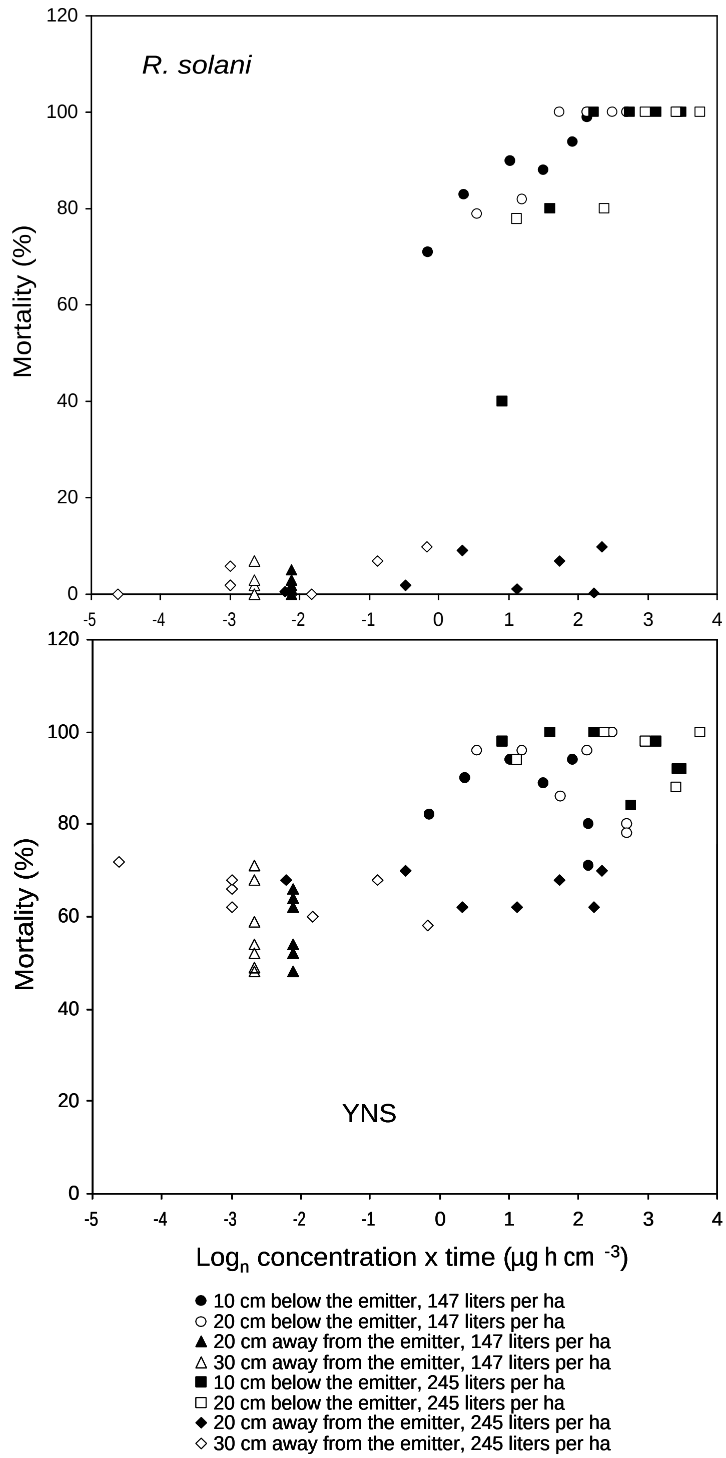

Figure 3. Relationship between $\log_n$ concentration x time product values of methyl isothiocyanate (MITC) in soil and mortality of *Rhizoctonia solani* and yellow nutsedge (YNS).