EVALUATION OF THE HERBICIDAL AND NEMATICIDAL ACTIVITIES OF METHYL DISULFIDE - A POTENTIAL ALTERNATIVE TO METHYL BROMIDE

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ABSTRACT

The nematicidal properties of methyl disulfide [$CH_3SS\ CH_3$; dimethyl disulfide; DMDS] were evaluated in a greenhouse study with 'Young' soybean [*Glycine max*] and a sandy loam soil infested with the reniform nematode [*Rotylenchulus reniformis*]. The compound was added to the soil at rates of: 25, 50, 75, 150, and 300 mgs/Kg soil [1 mg/Kg soil = 2 Kgs/Ha]. The treated soil and controls were covered with polyethylene tarp for one week when the cover was removed, soil samples were taken for nematological analyses [salad bowl incubation technique] and soybean planted. Soybean were grown for one month when the plants were removed, soil samples were collected for nematological analyses and data on growth parameters were recorded. The roots were incubated over water for 72 hrs to determine nematode root populations. Methyl disulfide effectively reduced pre-plant nematode populations when applied at rates $\geq$ 75 mgs/Kg soil. The compound did not affect plant growth but reduced final soil populations of the nematode when applied at rates $\geq$ 50 mgs/Kg soil; root populations were suppressed only by the two highest rates. Results suggest that methyl disulfide, a compound with significant fungicidal activity, is a poor nematicide considering that it must be applied at rates above 300 Kgs/Ha for acceptable nematode control. The herbicidal properties of the compound were assessed with another greenhouse experiment of similar design but with application rates of: 100, 200, 300, 400, 500, 600, 800 and 1000 mgs/Kg soil. The soil was infested with a yellow nutsedge [*Cyperus esculentus*]. Methyl disulfide failed to control nutsedge at any of the rates used in the experiment.
Key words: dosimetry, fumigant, fungicide, methyl bromide , nematicide, nematode control, soil fumigation, soil disinfestation, soil pests, weed control,

INTRODUCTION

Fungicidal activities of simple organic sulfides and disulfides are well known [Grainage & Ahmed, 1988]. Garlic plants [*Allium sativum*] and other *Allium* spp. contain a variety of organic disulfides including methyl disulfide [CH_3SSCH_3], diallyl disulfide [$CH_2{=}CHCH_2SSCH_2CH{=}CH_2$] and dipropyl disulfide [$CH_3CH_2CH_2SS\ CH_2CH_2CH_3$] [Harborne and Baxter, 1993; Lawless, 1992]. Garlic oil which contains diallyl disulfide has considerable activity against some major phytopathogenic fungi [Bauer *et al.*,1990; Grainage & Ahmed, 1988]. Recently methyl disulfide, also known as dimethyl disulfide or DMDS, was proposed as a potential new alternative to methyl bromide for disinfestation of soils [Fritsch *et al.*, 2002] - *in vitro* studies demonstrated that the compound was fungicidal against *Phytophthora cactorum*, *Rhizoctonia solani*, *Sclerotinia sclerotiorum*, and *Sclerotium rolfsii*, Methyl disulfide is a volatile liquid at ordinary temperature and pressure, with molecular weight of 94.2, a density of 1.046, melting point at -85°C and boils at 109°C. It is insoluble in water but soluble in alcohol and ether. Its volatility and liquid nature at ordinary pressure and temperature make the compound ideal for soil fumigation. Lack of information on the nematicidal and herbicidal activities of methyl disulfide prompted greenhouse studies to evaluate the compound for such properties.

MATERIALS AND METHODS

The nematotoxic properties of an aqueous emulsion [2.5% w/v] of methyl disulfide [Aldrich, Milwaukee, WI 53201, U.S.A.] were studied in a greenhouse pot experiment with soil from a cotton field infested with the reniform nematode [*Rotylenchulus reniformis*].The soil was a sandy loam with pH 6.2, organic matter content $\leq$1.0% and cation exchange capacity $\leq$ 10 meq/100 gms soil. The compound was added pre-plant to the soil at rates of 25, 50, 75, 150, and 300 mg/Kg soil. The treated soil was mixed well and transferred to lL capacity 10-cm-diam cylindrical plastic pot. The pots with soil were covered with standard transparent polyethylene [1 mil] tarp. There were in the experiment a control and 5 treatments each with 6 replications [pots] arranged in a randomized complete block design. After one week, the coverings were removed, soil samples for nematological analyses [salad bowl incubation technique, Rodriguez-Kabana & Pope,1981] were collected and 'Young' soybean was planted [5 seed/pot]. The plants were grown for 2 months when they were removed and soil samples were collected to determine nematode populations. Data were collected on plant growth parameters and the root systems were incubated [72 hrs] to determine root populations using the same incubation technique as for the soil samples.

In another greenhouse trial a 5% aqueous emulsion of methyl disulfide was applied to soil from a cotton field with similar characteristics as the soil used for the nematode experiment. The soil was apportioned in 1 Kg amounts and was planted with yellow nutsedge [*Cyperus esculentum*] by planting 5 tubercles/Kg soil contained in a pot. The compound was delivered at rates of 100, 200, 300, 400, 500, 600, 800, and 1000 mgs/Kg soil. There were in the experiment a control and 8 treatments each with 7 replications [pots]. Experimental design and methods for this experiment were as described for the experiment on nematicidal activity except that soybean was not planted.

Statistical Analyses. Variables studied in the experiment with nematodes were: nematode numbers in soil and roots, soybean shoot height, and fresh weights of shoots and roots. In the weed experiment the number nutsedge plants in each pot was recorded 8 weeks after removal of the polyethylene covers. Data from the experiments were analyzed by standard procedures for analyses of variance. When F values were significant [$p \leq 0.01$], differences among means were evaluated for significance according to Duncan's multiple range test.. Unless otherwise indicated differences referred to in the text were significant at $p \leq 0.01$.

RESULTS

Nematicidal Activity. Methyl disulfide effectively reduced pre-plant nematode populations when applied at rates $\geq$ 75 mgs/Kg soil [Fig.1A]. The compound did not affect plant growth but reduced final nematode soil populations when applied at rates ≥ 50 mgs/Kg soil [Fig. 1B]; root populations were suppressed only by the two highest rates [Fig.2].

Applications of methyl disulfide failed to control nutsedge. The data indicated that the compound either did not affect numbers of nutsedge or increased populations of the weed [Fig. 3].

CONCLUSIONS

Results suggest that methyl disulfide, a compound with significant fungicidal activity, is a poor nematicide considering that it must be applied at rates above 300 Kgs/Ha [1 mg/Kg = 2 Kgs/Ha.] to obtain satisfactory nematode control. The data also indicate that the compound is not acceptable as a herbicide since it did not control yellow nutsedge, a major problem weed controlled by methyl bromide.

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Fig. 1A. Relation between preplant nematode populations and dosage of methyl disulfide applied to soil and covered with polyethylene mulch for one week.

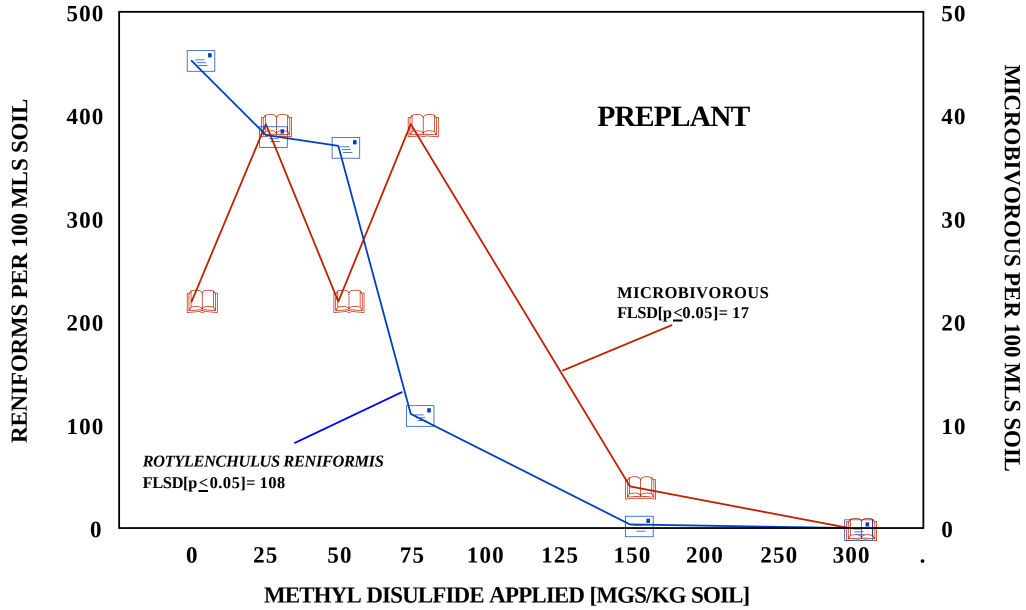

Fig. 1B. Relation between final nematode soil populations and dosage of methyl disulfide two months after application.
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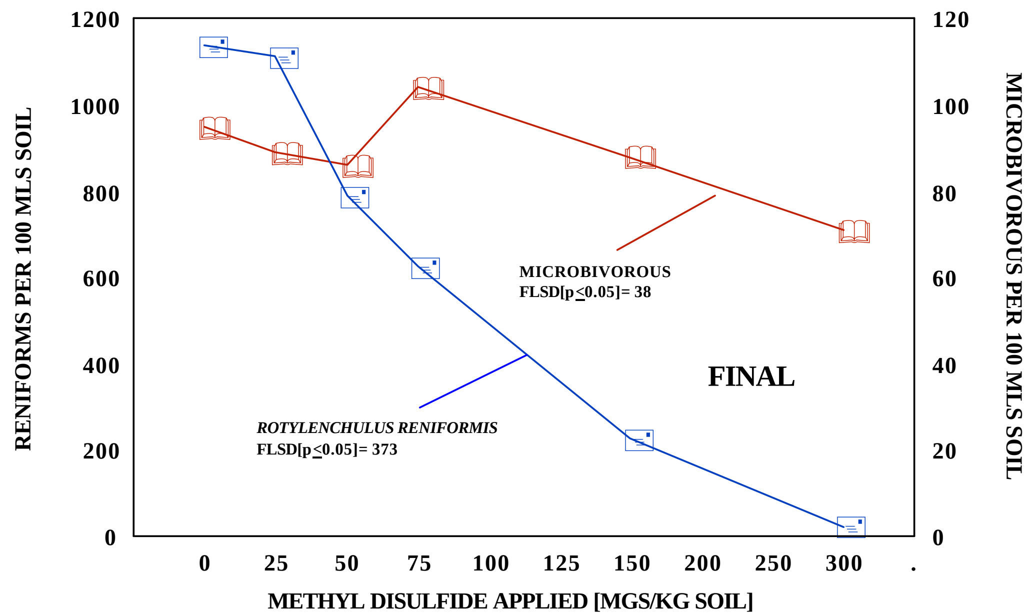

Fig. 2. Nematode populations in soybean roots after 8 weeks of growth in a greenhouse experiment with methyl disulfide.

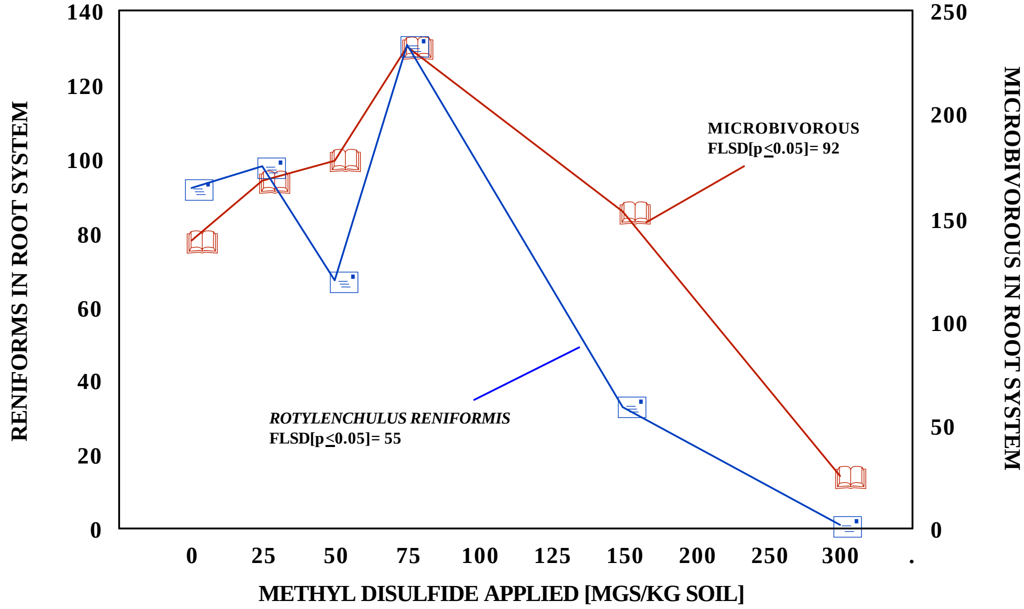

Fig. 3. Relation between dosage of methyl disulfide and populations of yellow nutsedge determined 8 weeks after application of the chemical