Dissipation of Fumigants from Soil Following Repeated Applications

Husein Ajwa and Shachaf Triky-Dotan

Department of Plant Sciences, University of California, Davis, CA 93905, (831) 755-2823, haajwa@ucdavis.edu

Introduction

Pre-plant soil fumigants are commonly used to control soilborne fungal pathogens, nematodes, and weeds in high-value crops. Following methyl bromide (MBr) phase out, the use of alternative soil fumigants and combinations thereof became a widespread approach to improve the effectiveness of soil disinfestations.

To achieve effective control of soilborne pathogens, a soil fumigant must move rapidly from the application site and distribute uniformly within the cultivated soil. Soil diffusion is affected by such chemical characteristics of the fumigant as water solubility, vapor pressure, boiling point and Henry's constant. Dissipation of a fumigant in soil is also affected by the microbial activities and/or by the physical-chemical properties of the soil, such as pH, organic matter content, moisture content, and texture. As a result, the fumigant's fate in soil varies among different soils, cropping and application conditions.

Repeated pesticide application may accelerate fumigant degradation in soil and result in reduced disease control. For soils with a prior history of rapid fumigant degradation, reduction in fumigant dissipation following soil sterilization may indicate dependence on biological factors.

The objectives of this study were to:

❖ Determine dissipation rates of various fumigants after repeated applications, and

❖ Assess the development of accelerated degradation of soil fumigants in various soils.

Materials and Methods

Fumigants: Chloropicrin (99%), methyl bromide (MBr, 98%), methyl iodide (MI, 98%), methyl isothiocyanate (MITC, the active ingredient of metam sodium, 42%), and Telone II, (1,3-D, 1,3-dichloropropene, 98%)

Soils: From fumigated strawberry plots in California (Oxnard, Salinas, Watsonville). Soil properties are in Table 1. Soils with no history of fumigation (nontreated) served as a control.

Table 1. Selected properties of soils.

Soil	Previous treatment	No. previous chloropicrin applications	Soil property			
			pH	Organic matter (%)	Sand (%)	Clay (%)
Oxnard	Nontreated	0	7.1	1.83	33	25
	Chloropicrin	1	6.2	2.41	23	35
Salinas	Nontreated	0	7.01	0.9	75	10
	Chloropicrin	1	7.74	1.02	75	11
Watsonville	Nontreated	0	6.78	1.9	70	15
	Chloropicrin	1	6.51	1.65	71	15

Assessment of fumigant dissipation in soils: Fumigant concentration in gaseous phase was assessed on a micro gas chromatograph. A known volume of soil headspace inside the closed container was withdrawn via a needle attached to the micro-GC internal sampling pump. Each measurement was repeated three times.

Fumigant concentration was measured under controlled conditions in the laboratory. A gas generation and dissipation concentration curve was drawn for each soil (Fig. 1). ∑concentration x time (∑ C×T) values (µg h cm^{-3}) were calculated by integrating the area under the generation-dissipation curve for each fumigant application for 24 h of incubation (Table 2).

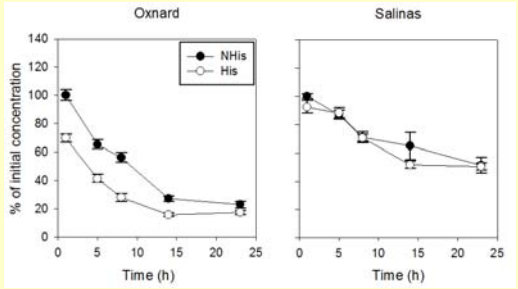

Figure 1. Dissipation of chloropicrin (% of initial concentration) in Oxnard and Salinas soils during 24 hours after application.

Results

❖Fumigant dissipation reflected by ∑CxT and half-life values varied widely among tested soils. Methyl iodide (MI) had the slowest dissipation rate in all tested soils.

❖Eliminating biotic agents by soil sterilization prior to MI application did not affect MI concentration in Oxnard soil.

❖This study suggests that biotic factors are more essential in the dissipation of metam sodium and MBr than abiotic factors. By contrast, MI dissipation from the tested soils is affected more by abiotic factors than biotic activities.

Table 2. Effect of previous chloropicrin (CP) applications on fumigant dissipation.

Soil	Previous treatment	No. previous chloropicrin applications	Area under dissipation curve ∑C×T ($t_{1/2}$, hour)				
			CP	1,3-D	MI	MITC	MBr
Oxnard	Nontreated	0	893 (8.2)	1102 (10.0)	1369 (17.5)	1244 (5.5)	1602 (14.5)
	CP	1	597 (6.6)	709 (7.1)	1166 (16.1)	1034 (4.1)	1275 (11.6)
Salinas	Nontreated	0	1540 (21.9)	1361 (16.3)	2040 (57.3)	1065 (1.0)	342 (2.2)
	CP	1	1426 (20.6)	1228 (14.3)	2039 (45.9)	1128 (1.3)	1550 (11.9)
Watson-ville	Nontreated	0	1349 (15.0)	1335 (13.3)	2038 (49.5)	1097 (1.2)	200 (0.1)
	CP	1	1783 (18.7)	1515 (14.4)	2108 (41.3)	1230 (1.1)	2639 (14.8)

Table 3. Effect of previous applications on fumigant dissipation in Oxnard soil.

Previous treatment	Fumigation dosage (kg ha^{-1})	No. of previous applications	Area under dissipation curve ∑C×T ($t_{1/2}$, hour)				
			CP	1,3-D	MI	MITC	MBr
Nontreated	Nontreated	0	1485 (17.9)	1694 (28.3)	1369 (17.5)	1244 (5.5)	1602 (14.5)
CP	224	1	1215 (17.2)	1373 (31.9)	1241 (19.1)	1088 (8.2)	1184 (10.5)
CP	336	1	1121 (16.5)	1317 (31.5)	1166 (16.1)	1034 (4.1)	1275 (11.6)
Pic-Clor 60	392	1	1114 (15.1)	1368 (33.5)	1228 (19.2)	1110 (3.2)	1340 (13.1)
InLine	448	3	1201 (17.0)	1520 (34.3)	1326 (15.5)	1180 (2.5)	940 (8.8)

Table 4. Effect of soil sterilization and repeated chloropicrin applications on chloropicrin and methyl iodide (MI) dissipation in three soils.

Soil sterilization	Previous treatment	No. of previous chloropicrin applications	Area under dissipation curve ∑C×T ($t_{1/2}$, hour)			
			Chloropicrin			MI
			Oxnard	Salinas	Watsonville	Oxnard
Nonsterilized	Nontreated	0	1601 (29.9)	1803 (35.9)	1460 (31.8)	2261 (173.3)
Sterilized	Nontreated	0	1562 (29.2)	2019 (79.7)	1777 (55.9)	2330 (150.7)
Nonsterilized	Chloropicrin	1	1299 (35.0)	2074 (72.9)	3141 (47.1)	2124 (203.8)
Sterilized	Chloropicrin	1	1246 (27.1)	2054 (55.9)	2937 (51.3)	2171 (198.0)