CHLOROPICRIN AND DIMETHYL DISULFIDE GAS EMISSIONS RELATED TO SOIL MOISTURE CONTENT

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Introduction

Liquid fumigants have been used for many years in the production of vegetables in the Southeast. The fumigant of choice has traditionally been methyl bromide. Price and availability is limiting methyl bromide use in Georgia. Alternative fumigants have been tested to give similar effects as methyl bromide. Dimethyl disulfide mixed with chloropicrin (79:21) is one alternative.

Minimizing buffer zones is a major concern for vegetable producers in Georgia. Current buffer zones for application of fumigants such as chloropicrin have endangered vegetable production in Georgia as it is known today. The effect of moisture on reducing emissions from mulched beds as a means of further reducing buffer zones has been questioned. This experiment will determine the effects of moisture on gas emission from low density polyethylene (LDPE) mulch film.

Materials and Methods

Plot land was chosen in the fall of 2008 for two soil types (loamy sand and sand) which is comparable to soils used for commercial vegetable production in South Georgia. Four moisture content strategies were super imposed on to each soil type. The moisture content of the soil was altered by placing 0, 1, 2, or 3 drip irrigation tubes on the surface of the bed area. Beginning one week prior to fumigation, the plots were irrigated once a day for 1 hour. Irrigation tubing was removed the day of fumigation. Plots were tilled with a field cultivator and bedder prior to operation of the fumigation equipment.

Fumigants were applied on July 17 at 9:00 AM to both soil types in 1.8 m by 15 m plots with 81 cm bed tops. Dimethyl disulfide mixed with chloropicrin (79:21) was applied with a prebedder injecting fumigants 20 cm deep with three knives 28 cm apart. Application rates were chloropicrin 16.14 g/m^2 and dimethyl disulfide 38.93 g/m^2. Next, the final bed was pressed and covered with a white on black LDPE (1.25 mil) mulch film.

Soil samples of 365 cm^3 were obtained from each plot with a soil probe (4.8 cm diameter by 20 cm deep). Gravimetric moisture content basis was determined for each sample by weighing the soil and placing the soil in a 105°C oven for 24 hours and then reweighing. Next, the samples were evaluated for soil field capacity. Soil samples (7.6 cm diameter by 15 cm deep) were collected before any tillage operation for field capacity analysis. Soil samples were placed on a ceramic plate. Each sample was saturated with water for 24 hours to equilibrate. The porous ceramic plate with saturated soil was pressurized to 1/3 bar of pressure. After 24 hours in this chamber, the moisture content in the soil was determined with the above method. Soil samples were finally sent to the University of Georgia Soils Lab for classification.

Chloropicrin was measured with a gas detector pump (GASTEC GV100S) and a detector tube (Sensidyne #172S). An inverted HDPE funnel (1.9 L) with a rubber stopper measuring 16.5 cm in diameter fill opening by 22 cm high with a 2 cm drain was glued (silicon) to plastic mulch beds (Figure 1). Chloropicrin gas collected inside the funnels for a known period of time (1-10 minutes). After the known period, a 100 ml sample was drawn through the detector tube from the inside of the funnel by the gas detector pump. The chloropicrin detector tubes had a range of 0.05 – 16 ppm.

Dimethyl disulfide was measured with a handheld volatile organic compound (VOC) monitor (MiniRae 2000) with a range of range of 0-10,000 ppm. DMDS measurements were taken immediately after the chloropicrin inside the inverted funnel.

Samples of the accumulated gas inside the funnels were taken from 3 to 55 hours after application. Fumigants were measured in the funnels until no gases were detected.

Results and Discussion

Soil moisture content was determined for each plot per soil type. Plots were categorized into 5, 6, 7, 8, 9 and 10% moisture content. Field capacity of the soil was determined to be 9.6% for loamy sand and 7.6% for sand on a dry basis.

The amount of chloropicrin passing through LDPE was reduced by 84% for loamy sand and 72 % for sand when moisture was increased 6 to 10% MC (Figures 2 and 3, Tables 1 and 2). The gas emission increased to 79 % when comparing soil moisture 5% to 10%. The gas emission rate typically follows the daily rise and fall of temperature as noted in figures 2 and 3. The gas emission rate was the highest during the afternoon once the sunlight has warmed the soil. Fumigant emissions peaked on the first day. The daily soil temperature at 20 cm ranged from 22°C to 40°C during the data collection period.

Dimethyl disulfide was evaluated for gas being emitted from the surface of the LDPE plastic mulch based on moisture content of the soil in the raised bed. Figures 4 and 5, Tables 3 and 4 show the results of the data collected. When moisture content of soil increased the amount of DMDS fumigant being released decreased similar to chloropicrin. The gas emission was reduced by 42.6 % when soil moisture increased to 10% for both soil types.

This study showed that increasing moisture levels in the soil will significantly reduce the amount of chloropicrin or dimethyl disulfide being released to the environment.

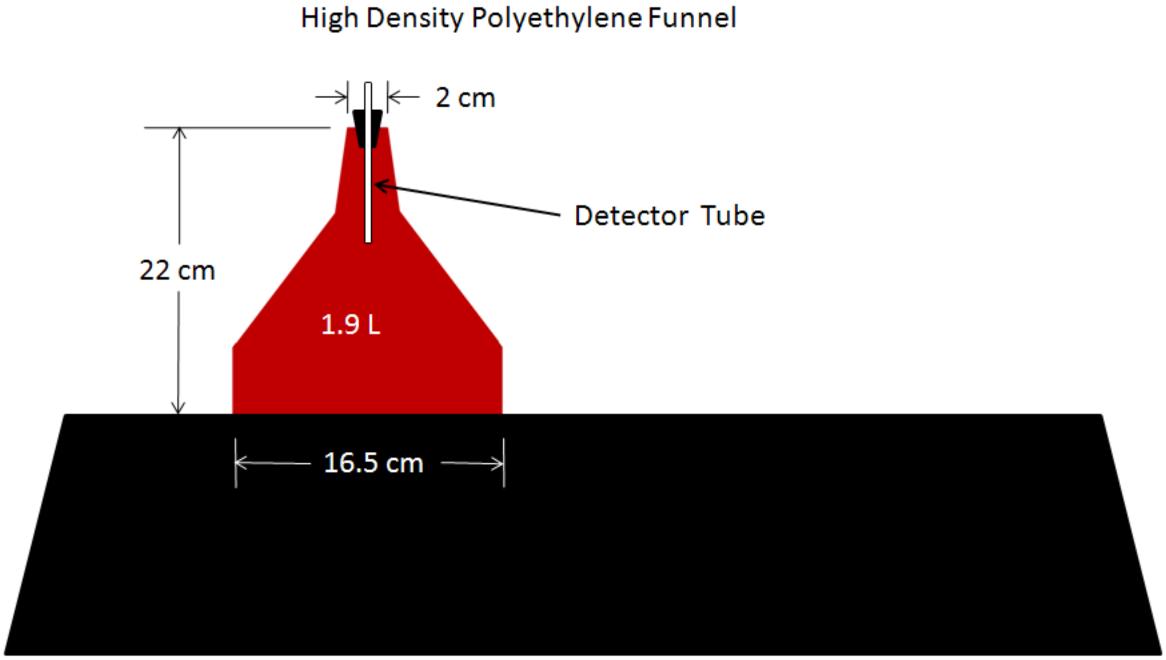

Figure 1. Schematic of fumigant sampling system.

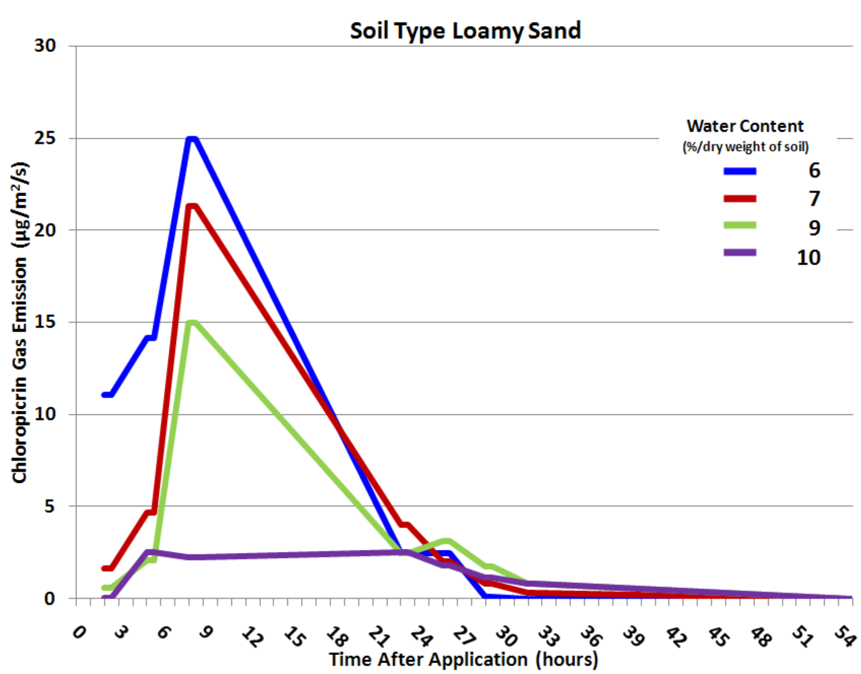

Figure 2. Comparison of chloropicrin gas emission with soil moisture content through LDPE plastic mulch loamy sand. Fall 2008.

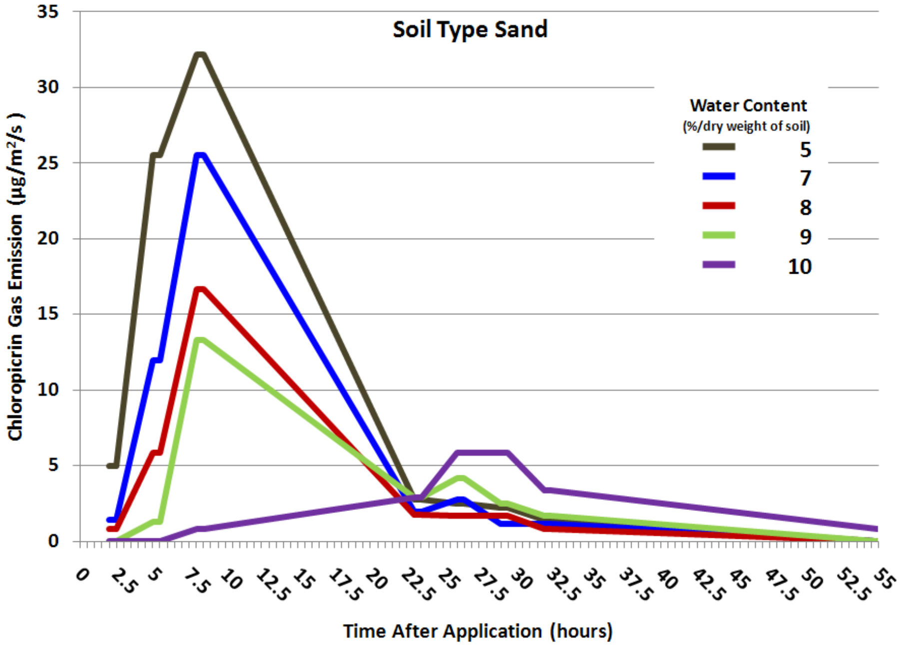

Figure 3. Comparison of chloropicrin gas emission with soil moisture content through LDPE plastic mulch sand. Fall 2008.

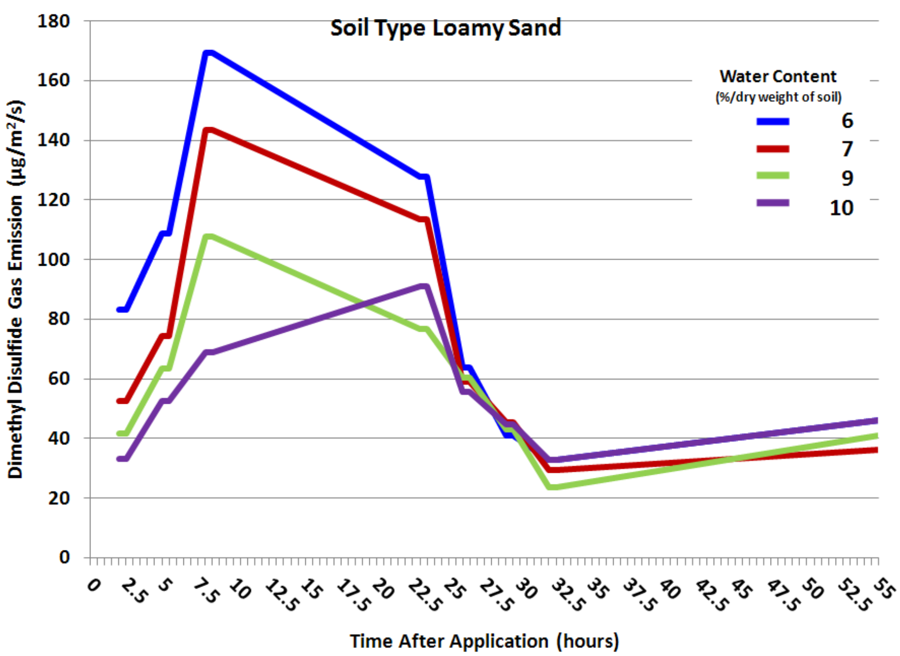

Figure 4. Comparison of dimethyl disulfide gas emission with soil moisture content through LDPE plastic mulch loamy sand. Fall 2008.

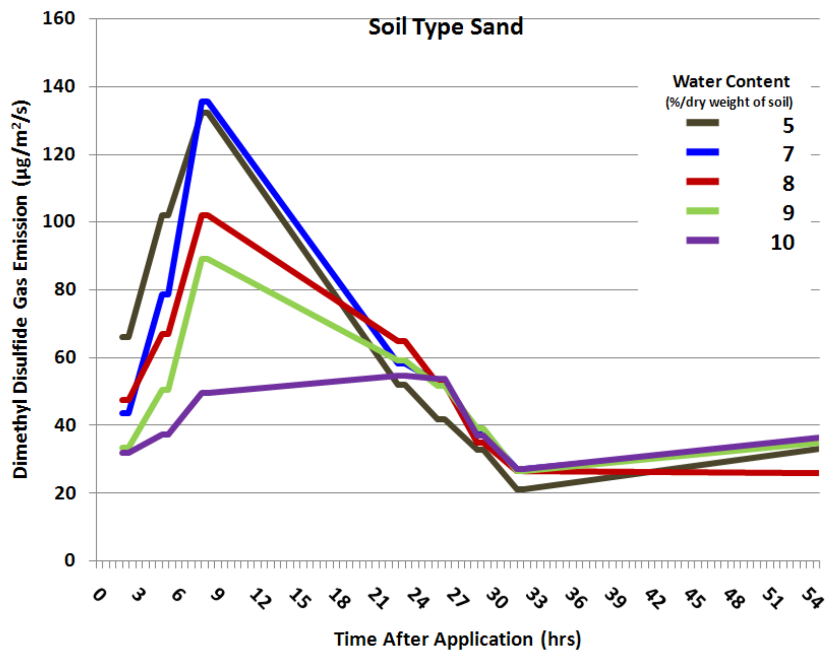

Figure 5. Comparison of dimethyl disulfide gas emission with soil moisture content through LDPE plastic mulch sand. Fall 2008.

Table 1. Reduction in total chloropicrin gas emission for loamy sand soil type. Ponder Fall 2008.

Soil Moist (%)	Field Capacity (%)	Total Emission (mg/m^2)	Reduction - 6% Base (%)	Reduction - 7% Base (%)	Reduction - 9% Base (%)
6	65	1868			
7	77	1489	20.3		
9	88	1115	40.3	25.1	
10	105	293	84.3	80.3	73.7

Table 2. Reduction in total chloropicrin gas emission for sand soil type. Ponder Fall 2008.

Soil Moist (%)	Actual Field Capacity (%)	Total Emission (mg/m^2)	Reduction - 5% Base (%)	Reduction - 7% Base (%)	Reduction - 8% Base (%)	Reduction - 9% Base (%)
5	67	2542				
7	86	1907	25.0			
8	104	1240	51.2	34.9		
9	114	1096	56.9	42.5	11.6	

10	136	531	79.1	72.1	57.2	51.5

Table 3. Reduction in total dimethyl disulfide gas emission for loamy sand soil type. Ponder Fall 2008.

Soil Moist (%)	Field Capacity (%)	Total Emission (mg/m^2)	Reduction - 6% Base (%)	Reduction - 7% Base (%)	Reduction - 9% Base (%)
6	65	17207			
7	77	14494	15.8		
9	88	11470	33.3	20.9	
10	105	9874	42.6	31.9	13.9

Table 4. Reduction in total dimethyl disulfide gas emission for sand soil type. Ponder Fall 2008.

Soil Moist (%)	Field Capacity (%)	Total Emission (mg/m^2)	Reduction - 5% Base (%)	Reduction - 7% Base (%)	Reduction - 8% Base (%)	Reduction - 9% Base (%)
5	67	12980				
7	86	13363	-3.0			
8	104	10999	15.3	17.7		
9	114	9976	23.1	25.3	9.3	
10	136	7444	42.6	44.3	32.3	25.4