Reducing Emission of Methyl Bromide from Soil Fumigation: Effect of Shielding Solar Radiation with Non-Woven High-density Polyethylene Fiber Sheet

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Methyl bromide (CH_3Br) is a major fumigant used in Japan to control soil-borne diseases in many crops. Following the Montreal Protocol, in which CH_3Br was included as one of the stratospheric ozone depleting substances, environmental concerns and regulations for restricting its use have increased. The use of CH_3Br as a soil fumigant is to be phased out by 2010, and only some critical uses are permitted at present. Such restrictions have led to an intensive search for improved technologies in CH_3Br fumigation to reduce dosage and emission from fumigated plots into the atmosphere, while maintaining its effectiveness for disease and weed control.

Several techniques such as use of gas-tight films, shallow injection (ca. 25cm depth) in combination with irrigation, deep injection (ca. 68cm depth), etc. have been attempted. These methods can reduce the amount of CH_3Br application and its emission during exposure period, and increase the time of its retention in the soil. Very Impermeable Films (VIFs.) for CH_3Br include multilayer with polyamide (nylon, NY), ethylene vinyl alcohol (EVOH) or polyvinylidene chloride (PVDC). The use of VIFs, however, has problems such as waste disposal, because materials containing chlorine such as PVDC are especially difficult to be destroyed by fire. Moreover, VIFs are generally more expensive than conventional films, such as high density polyethylene (]HDPE) and polyvinyl chloride (PVC). Because field plots are relatively small in Japan, mechanized injection of CH_3Br is difficult and is not practiced widely Only cold or hot gas methods are currently in use. The usual dose of CH_3Br applied under HDPC and PVC films is 15-30 gm^{-2}, which is about half of the amount used in other countries (ca. 60 gm^{-2}).

Direct measurements under field conditions showed that the rate of CH_3Br emission flux was strongly dependent on solar radiation, temperature and CH_3Br concentration below the film. The results indicated that fumigation on cloudy days or around sunset is a simple but effective method in minimizing CH_3Br emission into the atmosphere. Further shielding of solar radiation can be more effective. To reduce emission flux into the atmosphere further by restraining the increase in temperature during application, we improved the method of application by using conventional PE and PVC films in combination with a non-woven high density polyethylene fiber sheet (Tyvek, DuPont). Tyvek, when used a cover sheet is considered to shield solar

radiation by diffuse reflection.

The shielding technique was evaluated in a field experiment from 2 to 12 September in 1996 (Trial 1) and from 10 March to 2 April in 1997 (Trial 2) on Hydric Hapludand soils at the National Institute of Agro-Environmental Sciences, Tsukuba, Japan. "Cold gas method" was used for fumigation by releasing CH_3Br (32.8 g m^{-2}) from cans onto the soil surface (15 m^2) under a film, which was removed after 7 d. An automated gas chromatography system, equipped with flame ionization detectors (GC-FID) and four 7.5 L chambers (diam. 24.5 cm) was used to determine emission flux. The chambers were placed directly on the film, Tyvek sheet or soil surface. Concentrations of CH_3Br in the air below the film and at soil depths of 30, 60, 90, 120, 150 cm were measured.

Temperature below the film without Tyvek sheet varied widely in a day reflecting changes in intensity of solar radiation. Temperature was, however, nearly equal to ambient temperature when Tyvek sheet was used. The CH_3Br flux and cumulative emission from the field with and without Tyvek sheet are shown in Fig. 1. The results suggest that the use of Tyvek sheet considerably reduced emission losses by 35 to 40% during application, and by 14 to 23% on the whole as compared with control (without Tyvek). This technique was more effective in cool than in hot season, further, had larger values of CxT product (Concentration x Tune). The Tyvek sheet can easily be obtained as agricultural materials and used repeatedly, and the problem of waste processing is small. Therefore, this technique holds promise for commercial use.

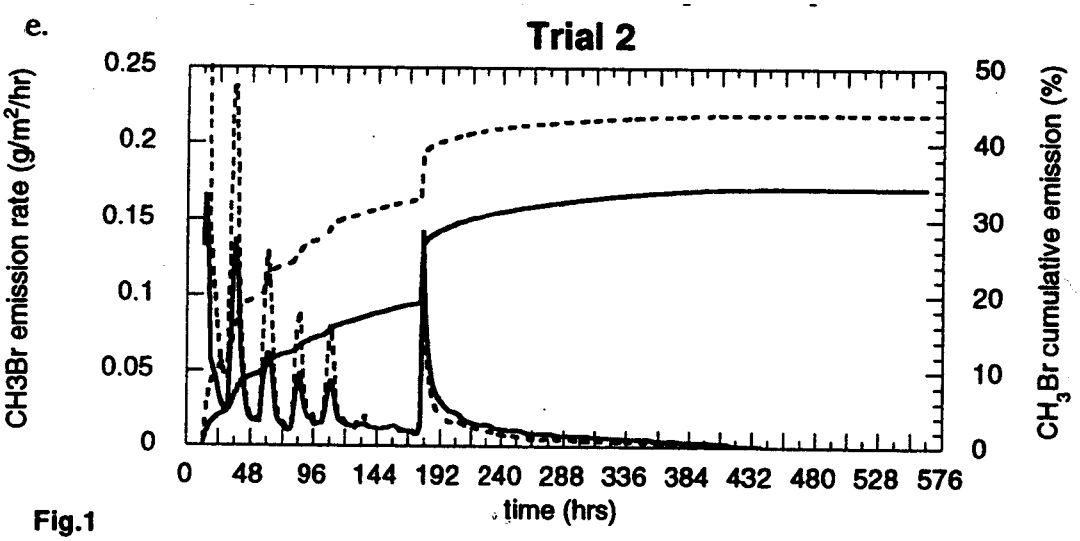

Fig.1

CH_3Br emission rates (g/m^2/hr) and cumulative emission to the atmosphere as fraction of the applied amounts. Data points are means of each two measurements. Soil was covered with a film for 7 d and then removed.

- - - - - - - polyethylene (50urn thickness)

- tyvek+polyethylne (50um thickness)