REDUCING FUMIGANT VOLATILIZATION THROUGH OPTIMIZED APPLICATION AND SOIL MANAGEMENT

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Soil fumigants represent a category of highly volatile pesticides. The potential volatilization of these compounds is related to their vapor pressures, but the actual emission may be modified by many application and environmental factors. The two most important factors related to application methods are application depth and use of surface cover. The primary environmental factors include soil moisture, bulk density, organic matter content, air and soil temperature, and air movement across the soil surface. In our studies on methyl bromide (MeBr) and 1,3-D, we demonstrated that by controlling some of these factors, the volatilization of these two fumigants was substantially reduced. We developed a closed, packed soil column system and assumed that under experimental conditions, transport of these compounds in soil was caused only by gas-phase diffusion. Simulation models were used to correct for the bottom boundary effect and to extrapolate the results to field conditions. Emission rates of MeBr generated from these experiments compared well to the field measurements.

For shallow applications, covering the soil surface with 1-mil high-density-polyethylene (HDPE) film was somewhat effective in preventing MeBr emission. The reduction caused by tarping alone was 47% (Table 1). Increasing application depth reduced MeBr emission. When the surface was not tarped, 82 and 71% of the applied MeBr was emitted following 20- and 30-cm application, respectively. The emission decreased to 38% when the depth was increased to 60 cm. The minimum emission was found with a tarped 60-cm injection, following which only 25.5% was emitted.

Table 1. Methyl Bromide and 1,3-D Emission Rates (%)

Injection depth (cm)	MeBr		1,3-D	
	Bare	Tarped	Bare	Tarped
20	82.3	43.3	65.0	55.0
30	71.2	37.3	48.5	-
40	-	-	36.3	-
60	38.1	25.5	-	-

Volatilization of (EZ) 1,3-D applied in Telone-II was found to be surprisingly high: 65% was emitted for a 20-cm untarped application during a 3-week period. Since 1,3-D is defined as a hazardous air toxic compound, emission at this level should draw attention. Compared to MeBr, gas-phase diffusion of 1,3-D in soil was slower, and the volatilization continued for a much longer time. Application methods showed different effect on 1,3-D than that on MeBr. Tarping did not significantly reduce 1,3-D emission for the same injection depth (Table 1). This could be attributed to the fact that the 1-mil HDPE film is highly permeable to 1,3-D. The measured diffusion coefficient for 1,3-D across the film is 7-8 times that for MeBr. However, increasing injection depth was found to be more effective in reducing 1,3-D volatilization than that for MeBr. Increasing the injection depth from 20 to 40 cm, the emission rate decreased from 65 to 36% under untarped conditions.

Volatilization of MeBr was found to be affected by a few selected soil factors. In a soil rich in organic matter, MeBr emission was only a half of that from a sandy loam. Transformation of MeBr catalyzed by organic matter was assumed to be responsible for this effect. Therefore, MeBr emission rates from different soils could be very different. Increasing soil water content resulted in reduced MeBr volatilization, and this effect could be attributed to the reduced gas-phase diffusion. In practice, irrigating the soil surface right before fumigation should lead to reduced MeBr emission. Modifying soil bulk density also influenced MeBr emission. In a sandy loam packed at 1.7 g/cm^3, MeBr emission rate was 53%, significantly smaller than the 77% from the same soil with a smaller bulk density of 1.4 g/cm^3. This implies that in practice, packing the field immediately after fumigation to close trench openings and increase bulk density might also help to reduce the emission.

From these studies, it can be concluded that when proper application and soil management strategies are used, MeBr emission can be substantially minimized from the current level. In the process of developing MeBr alternative fumigants or their combinations, it is important to realize that application methods and soil conditions all can have significant effect on their emission behavior. It is also important to realize that by modifying some of these factors, it is possible to minimize the volatilization loss of these fumigants into the air, and hence reduce the risk of air pollution. Alternative fumigants should be developed along with the optimized application and soil management techniques under which the efficacy and environmental impact are balanced, so they will not have a future like MeBr.