Dispersion and Emissions of 1,3-D in Florida Field Soil

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With the anticipated phase out of methyl bromide in agriculture in near future, 1,3-dichloropropene (1,3-D) is considered to be a potential alternative to methyl bromide. 1,3-D in combination with chloropicrin and a herbicide has similar pesticidal activity to methyl bromide. Unlike methyl bromide which is a gas, 1,3-D is a liquid and fairly water soluble (~2200 µg/ml), and has a vapor pressure slightly greater than water. This chemical consists of two isomers, cis and trans, with cis-1,3-D being slightly more volatile than trans-1,3-D, but somewhat less water soluble.

The field site used for this study is located at the Plant Science Research Center of the University of Florida in Citra, Florida about 20 miles south of Gainesville. This site was recently developed for plant science research by the university and at the time of this study it had not been infested with phytopathogenic root-knot nematodes. Soil at this site is classified as Arredondo fine sand. Field plots, 2 m x 20 m, were set up as 1-m wide raised beds and covered with polyethylene film (PE), virtually impermeable film (VIF), or not covered (bare). 1,3-D was injected into the soil at a 30-cm depth at a rate equivalent to 18 gallons per acre by conventional chisels or by Yetter “Avenger” coulters. Broadcast application was performed by Yetter coulters. After Yetter coulter applications, with the exception of the broadcast application, beds were formed which raised the soil surface 10 cm higher.

To determine 1,3-D dispersion in soil pore air space in soil profiles, depending on the specific substudy, either three or four sets of stainless steel probes for soil gas sampling were installed in each plot. Each set consists of 7 probes ranging 5 to 90 cm in length. Either one or two sets were installed on injection lines, one was between two adjacent injection lines, and one set was adjacent to the edge of a bedded plot. In addition, eight 30 cm or 20 cm probes were installed randomly in each plot. Thirty ml of soil air were withdrawn and the air passed through an ORBO-32 activated charcoal tube. To determine 1,3-D volatilization rates from the surface of the plots, either three or four stainless steel pans (4.7 liters) were placed on the surface of each plot and one was placed adjacent to the edge of each plot. At 20 minutes intervals for 80 minutes, 50 ml of air were withdrawn and passed through an ORBO-32 charcoal tube. Soil pore air samples and pan air samples were taken daily for 5 days. Cis- and trans-1,3-D in ORBO-32 tubes obtained from soil air probes were analyzed by headspace-GC. Cis- and trans-1,3-D in ORBO-32 tubes obtained from air in pans were extracted with acetone and quantified by GC.

Cis- and trans-1,3-D injected by conventional chisels rapidly dispersed in soil profiles whether or not covering with plastic films (VIF and PE) or bare. After 20 hours, concentrations of cis- and trans-1,3-D started to decline. Concentrations of cis-1,3-D in soil pores of the three plots were greater than trans-1,3-D. The cis isomer is more volatile than the trans isomer. 1,3-D concentration values of soil pore-space air from the 8 randomly installed 30 cm gas probes during the first 2 days after injection were quite variable, especially for PE and bare plots, ranging from zero to 5.6 µg/ml. The VIF plot retained 1,3-D much better than PE and bare plots, while bare plot was better than PE plot. It is likely that 1,3-D fumes in soil pores of 5 to 30 cm depth of the VIF plot would kill nematodes in a matter of a few hours. Whereas for the bare and PE plots, especially the PE plot, longer exposure may be required. In comparison with 1,3-D emissions from the bare plot, PE did not retard 1,3-D emissions into the atmosphere, whereas VIF retarded 1,3-D emissions significantly. 1,3-D emissions for all plots peaked one day after the injection and declined afterward.

1,3-D, which was injected by Yetter coulters, in PE, VIF, and bare raised-bed plots, dispersed slowly and unevenly. 1,3-D concentrations in soil profiles of the plastic film covered plots were generally lower and diffused more unevenly than the bare plot. Much larger 1,3-D concentrations were found in the soil pores of broadcast plot than the other three raised-bed plots. The soil surfaces of the bedded PE, VIF, and bare plots were 10 cm higher than the broadcast plot. Five hours after injection, 1,3-D in the broadcast plot had already diffused upward to 5 cm below soil surface. 1,3-D at this depth in other plots was not detected until next sampling, 19 hours after injection. However, 1,3-D was not present in all 5-cm depth probes. After 19 hours, 1,3-D concentrations in soil pores for all the plots started to declined. After injection, 1,3-D appeared to diffuse unevenly. 1,3-D concentrations in eight 20 cm probes were highly variable for all four plots. 1,3-D in the broadcast plot diffused faster and had larger concentrations than the other plots. Five hours after injection, 1,3-D in the broadcast plot had diffused upward to most of the majority of 20-cm depth probes. 1,3-D in the broadcast plot rapidly diffused upward to soil surface as 1,3-D fumes were found in air samples of pans five hours after injection. 1,3-D emissions in this plot peaked between 5 and 19 hours after injection. 1,3-D in the three raised-bed plots slowly dispersed upward to soil surfaces. None or small amounts of 1,3-D vapor were detected in air samples of pans placed on the surfaces of the three raised-bed plots, especially the VIF plot. VIF appeared to retard 1,3-D volatilization from soil surface into the atmosphere. More cis-1,3-D was found in the air samples than trans-1,3-D. Broadcast application by Yetter coulter machine may provide good 1,3-D dispersion and hence, better pest control. However, there may have higher potential for 1,3-D to volatilize into the atmosphere.

In conclusion, dispersion and emissions of cis- and trans-1,3-D in soil at a field site in Florida were evaluated using two application techniques, conventional chisels and Yetter coulters. 1,3-D applied by conventional chisels was rapidly dispersed, but unevenly, in PE, VIF and bare bedded plots. VIF retained 1,3-D in soil profiles better than PE and bare. PE was not effective in reducing emissions of 1,3-D into the atmosphere. 1,3-D applied by Yetter coulters dispersed slowly and unevenly in soil profiles of PE, VIF, and bare bedded plots. 1,3-D in the broadcast plot dispersed more rapidly and evenly, and concentrations of 1,3-D were larger than the other three plots. Thus broadcast application by Yetter coulters should provide good pest control. Cis-1,3-D concentrations in soil pores were generally larger than trans-1,3-D. 1,3-D concentrations in root zone (20 to 30 cm from soil surface) were highly variable. Therefore, nematode control by 1,3-D may not be consistent along the rows.