An Improved Delivery System for Telone C35 in Florida Tomato Production

J. E. Thomas*[1], L.-T. Ou[1], L.H. Allen, Jr. [2], J.C. Vu[2], and D.W. Dickson[3]
[1]Soil and Water Science Department, University of Florida, Gainesville, FL 32611, USA
[2]USDA-ARS and Agronomy Department, University of Florida, Gainesville, FL 32611, USA
[3]Entomology and Nematology Department, University of Florida, Gainesville, Florida 32611, USA

Methyl bromide (MeBr) was suspended in 2005 for agricultural use in the U.S. with the exception of yearly critical exemptions. Although the 2008 approved critical use exemptions allow 4813.5 metric tonnes of MeBr to be used in the U.S. (Perez-Sullivan, 2007), the need for an efficient, low-cost alternative still exists. The main aim of this study was to compare the efficacy of three colored films (black virtually impermeable film (VIF), metallized polyethylene (PE), and blue PE) with better distribution of the three biologically active compounds (Z)- and (E)-1,3-D and CP in field beds after chisel injection of Telone C35. It is recognized that VIF is a better barrier than metallized PE film which is better than blue PE for reducing volatilization of Telone C35, an alternative fumigant to MeBr, into the atmosphere. Maintaining appropriate concentration of the three biologically active compounds in the root zone for an adequate period of time after fumigation is essential for effective pest-pathogen management. It was demonstrated that carbonating Telone C35 provided better distribution; hence, it should enable a lower application rate to be as effective as high rate application by N_2. Our results also indicated that carbonated Telone C35 initially penetrated deeper than non-carbonated Telone C35. Although this was beneficial by inhibiting re-infestation by deep dwelling nematodes, it may be problematic for areas with shallow water tables. The eventual goal is to link the three plastic covers and carbonation versus non-carbonation with fumigation efficacy. It is anticipated that those plastic films having higher capacity to retain a fumigant in the root zone such as black VIF and metallized PE combined with better distribution of the fumigant should provide greater efficacy for the fumigant even at reduced rate of application.

METHODS

Field site, fumigant, and plastic mulches. The field site was located at the Plant Science Research and Education Unit of the University of Florida in Citra about 35 km south of Gainesville, Florida. Soil at the site was classified as Arredondo fine sand. Analytical grade (Z) - and (E)-1,3-dichloropropene (1,3-D) and chloropicrin (CP) with greater than 99% purity plus Telone C35 [about 65% 1,3-D and 35% CP] were provided by Dow AgroSciences (Indianapolis, IN). Methyl Bromide (53%) mixed with chloropicrin (47%) was obtained from Great Lakes Chemical Corp. (West Lafayette, IN). Two colored high density PE (blue and metallized) with 0.033mm thickness and black VIF with 0.035mm thickness were used.

Plots and fumigant treatment. Prior to fumigation, raised beds (0.90 m wide and 11 m long) were formed. These beds were injected with Telone C35 by three conventional sweptback chisels at 30 cm apart to 30 cm depth at rates of 327 or 245 liters/ha and immediately covered with one of the three plastic mulches. The 327 liters/ha as full rate and 245 liters/ha as three-quarter rate were applied using N_2. Other beds received 245 liters/ha using CO_2 as propellant/dispersant. Prior to application, the Telone C35 dispersed by CO_2 was carbonated for

18 hours at ambient temperature through the fumigant's siphon tube. Control beds with no fumigant with mulch as well as beds with no fumigant and no mulch were established concurrently. All beds were replicated four times in a random block design.

Soil-pore air sampling. After fumigation, a set of seven different lengths of stainless steel soil gas probes (1, 5, 10, 20, 30, 40 and 60 cm) were installed in the center trace of each metallized PE bed. Additionally, six more 20 cm length probes were installed every 10 cm perpendicular from the center 20 cm probe across the width of each bed covered with metallized mulch. Thirty-five milliliters of soil-pore air were withdrawn daily from the probes. Plastic syringes were used to withdraw soil-pore air from the probes through a XAD-4 resin sampling tube, which absorbed (Z)- and (E)-1,3-D and CP (Ou *et al.*, 2005).

Surface air sampling. A stainless steel collection pan (4.7 liters volume and 471 cm^2 cover area) was placed daily on the surface of each metallized mulch bed over the center trace of the chisel injection. A second collection pan was placed on the bare soil next to the edge of metallized mulch beds that had been treated with full rate Telone C35 by N_2 and with three-quarter rate of carbonated Telone C35. A volume of 50 mL air was withdrawn from the collection pans at 15 minutes intervals for 60 minutes using a plastic syringe to trap (Z)- and (E)-1,3-D and CP on XAD-4 resin (Thomas *et al.*, 2004).

Analysis. After XAD-4 resin samples were extracted with n-hexane, a 1-mL aliquot was transferred to an amber GC vial for analysis of (Z)- and (E)-1,3-D and CP on a Perkin-Elmer Autosystem gas chromatograph (GC) equipped with an electron-capture detector (Thomas *et al.*, 2004).

RESULTS

Subsurface distribution of (Z)- and (E)-1,3-D and CP. Three hours after Telone C35 was chisel injected, the (Z)- and (E)-1,3-D and CP had diffused downward from 30 cm depth to 40 cm depth for CO_2 application, but not for N_2 application of full or three-quarter rate. Average concentrations of the three compounds were fairly variable. Based on the 20-cm long probes that span the width of the bed, samples taken three hours after injection showed distributions of the three compounds at 20 cm depth in each bed were variable as well. Since (Z)-1,3-D is more volatile than (E)-1,3-D and CP (Hornsby *et al.*, 1995), greater concentrations of (Z)-1,3-D were found at 20 cm depth for all application methods. Twenty-four hours after injection, concentrations of the three compounds at 20 cm depth became less variable for all treatments. Peak concentration likely occurred shortly before 24 hours from the time of injection, although the 24 hour samples exhibited the maximum measured concentration.

Volatilization of (Z)- and (E)-1,3-D and CP. Three hours after chisel injection of Telone C35, (Z)- and (E)-1,3-D and CP had volatilized from the bed surfaces of all metallized PE covered beds. A greater amount of (Z)-1,3-D was emitted initially than (E)-1,3-D and CP. The maximum amount of volatilization flux measured for the three compounds occurred at 24 hours with declining concentrations thereafter. (E)-1,3-D declined more slowly than (Z)-1,3-D that, in turn, was slower than CP loss. This may have been due to the fact that CP is more rapidly degraded in soil than (Z)- or (E)-1,3-D (Zheng *et al.*, 2003). Due to shortage of equipment and manpower, only the full application rate by N_2 and the three-quarter rate by CO_2 were measured for emissions from the bare soil next to the metallized PE covered bed. Starting at 24 hours after injection, flux rates of the (Z)-1,3-D from the application by carbonated Telone C35 at three-quarter rate were greater than from the soil at the edge of the beds that received the full rate of

Telone C35 applied by N_2. Although volatilization of (E)-1,3-D from the furrow was statistically equal at 48 hours for carbonated three-quarter rate vs. non-carbonated full rate, it was almost 2 times less by 120 hours. CP was sporadically emitted from soil next to the three-quarter rate by CO_2 beds and not at all for 120 hours after full rate application by N_2. Although the flux rates from the bare soil next to the beds were generally greater from the CO_2 application than from the N_2 application, the total amount from center and side volatilized from the full-rate N_2 application was greater than from the total amount emitted by the three-quarter rate CO_2 application. Additionally, the quicker emission of the Telone C35 components from the bare soil next to the carbonated fumigant plots compared to the non-carbonated beds implies that not only was the vertical subsurface dispersion influenced, but that the horizontal dispersion was also affected by the use of CO_2 versus N_2.

KEY CONCLUSIONS

1) Carbonated Telone C35 dispersed faster, deeper, and wider than non-carbonated Telone C35.
2) Carbonated Telone C35 was as effective in nematode control as non-carbonated Telone C35 while using 25% less fumigant.

LITERATURE CITED

Hornsby, A.G., R.D. Wauchope, and A.E. Herner. 1995. Pesticide properties in the environment. Springer-Verlag, New York.

Ou, L.-T., J.E. Thomas, L.H. Allen, Jr., L.A. McCormack, J.C. Vu, and D.W. Dickson. 2005. Effects of application methods and plastic covers on distribution of cis- and trans-1,3-dichloropropene and chloropicrin in root zone. J. Nematol., 37:483-488.

Perez-Sullivan, M., Dec. 2007, “EPA authorizes critical uses of methyl bromide for 2008”, U.S. E.P.A. News Release, http://yosemite.epa.gov/opa/admpress.nsf/6424ac1caa800aab85257359003f5337/2ea8e3e38d659cd4852573b7005916f9!OpenDocument (Last checked 8/26/09)

Thomas, J.E., L.-T. Ou, L.H. Allen, Jr., L.A. McCormack, J.C. Vu, and D.W. Dickson. 2004. Persistence, distribution, and emission of Telone C35 injected into a Florida sandy soil affected by moisture, organic matter, and plastic film cover. J. Environ. Sci. Health, B39:505-516.

Zheng, W., S.K. Papiernik, M. Guo, and S.R. Yates. 2003. Competitive degradation between the fumigants chloropicrin and 1,3-dichloropropene in unamended and amended soils. J. Environ. Qual., 32:1735-1742.