EVALUATION OF TIF TO REDUCE FUMIGANT EMISSIONS AND THE POTENTIAL TO USE REDUCED RATES

Suduan Gao[1], Ruijun Qin[1,2], Husein Ajwa[2], Dave Sullivan[3], and Dong Wang[1]
[1] USDA-ARS, Parlier, CA. [2] UC Davis, Salinas, CA. [3] Sullivan Environmental,

Alexandria, VA.

Soil fumigation is critical to strawberry growers for assuring profitable berries and high yields. However, fumigant use is stringently regulated to control emissions and minimize environmental impact. Technology using low permeability tarps (e.g., virtually impermeable film or VIF) has shown the potential to achieve low emissions, to improve efficacy, and to use potentially lower fumigation rates. The VIF tarp is susceptible to damage from tearing or stretching which affects its efficiency in field applications. A new low-permeability film, the so-called totally impermeable film (TIF), claims to have a lower permeability to fumigants and more advantages in preserving its integrity, while being less prone to damage than VIF in field installations (Ajwa et al., 2008; Chow, 2008). This study was to evaluate TIF performance for emission control and fate in soil from large field broadcast applications in the coastal strawberry-growing region.

<u>OBJECTIVES</u>: 1) Determine the effectiveness of the TIF tarp on emission reduction from soil fumigation; and 2) Evaluate the ability of TIF to improve fumigant distribution in soil and its potential in reducing fumigation rates.

<u>STUDY METHODS:</u> A large field trial was conducted September 10-18, 2009 on growers' fields in Ventura County, CA. Two large fields were selected. The soil type in Field #1 was Hueneme Sandy Loam (Coarse-loamy, mixed, superactive, calcareous, thermic Oxyaquic Xerofluvents) and the soil in Field #2 was Metz Loamy Sand (Sandy, mixed, thermic Typic Xerofluvents). A one-acre (0.40 ha) area in each field was selected for the same fumigation treatment, but was tarped with different films. An experimental 50/50 mixture of 1,3-D and CP was applied to both fields by shank injection to a 12-in (~30 cm) depth at a 12-in spacing between emitters. Following fumigant injection, Field 1 was tarped with standard polyethylene (PE) film and Field 2 was tarped with TIF. Fumigant application rates were 280 lbs/ac (314 kg/ha) in both fields. The fumigation service and tarp installation were done by TriCal Inc. (Hollister, CA). The fumigant mixture and the standard PE film (10.5-foot wide, 1-mil thickness, clear) were also provided by TriCal Inc. The TIF tarp (VaporSafe™, 10.5-foot wide, 1-mil, EVAL-resin barrier film) was provided by Raven Industries (Sioux Falls, South Dakota, USA).

Emission sampling. Dynamic flux chambers (DFCs) were installed in both fields to measure fumigant emissions. The DFCs used were upgraded with a heating unit installed in the air flow path to prevent water condensation for proper functioning of the flow meters (Figure 1.) The DFCs allow continuous emission sampling. Details of the DFCs can be found in Gao et al. (2008). Three chambers were installed in each field on the continuous sheet. To test whether the new film was successfully glued together between sheets, an additional three chambers were installed over TIF glue joints to measure emissions. Large XAD resin-filled sampling tubes (226-175, XAD-4, 8 x 150 mm, 400/200 mg, SKC, Eighty Four, PA) were used to trap both 1,3-D and CP by sampling the flowing air. The tubes were exchanged with new ones every 3 hours for the first 3 days, every 4 h for the following 3 days, and every 6 hours for the remaining days. The background (inlet) air to each chamber was also sampled, which turned out to be negligible. The tarps were cut on day 7 and the sampling continued for another 24 hours by repositioning the chambers on the tarp-removed areas. The XAD sampling tubes were stored in a cooler with dry-ice in the field and in a freezer (-80^{o}C) in the laboratory until they were processed for analysis. Fumigant emission flux and cumulative emission losses were calculated based on the fumigant amount captured through the chambers, sampling time and sampling area.

Gas sampling in soil. Distribution of gaseous fumigants in soil profile was monitored over time. Sampling probes were installed in each field at two locations: fumigant injection lines and the center between injection lines. At each location, the sampling probes included sampling depths at 0, 5, 15, 25, 35, 45, 55, and 70 cm. Target sampling times were 9, 24, 48, 72, 120, 168 and 192 h after application. The last two sampling times were 24 and 48 h following tarp-cutting, respectively. Small XAD sampling tubes (226-93 XAD-4, 7 X 70 mm, 80/40 mg, SKC, Eighty Four, PA) were used to trap the fumigants by drawing samples through with gas-tight syringes.

Air under tarp and residual fumigant. Air samples below the tarp (above soil surface) under each chamber were collected for monitoring fumigant concentration changes during the trial. The sampling was done more frequently during the first few days than at later times. One hundred ml of air sample was withdrawn at each sampling time. Similar to the soil-gas sampling, fumigants were trapped on small XAD sampling tubes that were processed using similar procedures. At the end of the field trial, soil samples were collected at depths of 0-10, 10-20, 20-30, 30-50, 50-70, and 70-100 cm to determine the amount of fumigant remaining in the soil (liquid and solid phase). The soil sampling positions were close to the soil gas sampling.

RESULTS AND DISCUSSIONS**:** Emissions of both 1,3-D and CP were significantly reduced in the TIF tarped field compared to the PE field. The peak emission flux of 1,3-D and CP from the TIF tarped field was 1.3 and 0.9 μg m^{-2} s^{-1}, respectively, compared to the 29.9 and 14.3 for 1,3-D, and CP, respectively, from the PE field. These measurements were taken from the continuous sheet and indicate a 94-96% reduction that can help improve buffer zones. The cumulative emission loss during the tarping period was 2% of total applied for 1,3-D and <1% for CP compared to the 43% for 1,3-D and 12% for CP from the PE field. Measurements of emission flux from the glue joints showed a 6-8 times increase from the continuous sheet; but were still substantially lower (27-52%) than the PE tarp. Because glue joints only accounted for <10% of the total field area, the contribution to total emission loss was very small. Tarp permeability of TIF after field installation increased several-fold; but because of its extremely low permeability, the increased values were still much lower than that of the PE film. The data indicate that TIF can be installed successfully for effective emission control without much impact on its integrity.

A great concern raised from this trial was that upon tarp-cutting, surges of emissions were observed with much higher fluxes from the TIF field than the PE field because the TIF tarp retained higher concentrations of fumigants. Chloropicrin emissions after tarp-cutting were very low, so this may not be a concern. A longer waiting period will be required for 1,3-D when using TIF tarping. A more uniform and higher concentration profile in the soil gas-phase was also observed under the TIF as compared to the PE tarp, indicating the great potential of using reduced rates under the TIF tarp that can still provide satisfactory pest control. Addressing these issues in further field research will help develop practices for the safe use of TIF in soil fumigation.

ACKNOWLEDGEMENTS

Funding support for this research was provided by California Strawberry Commission. Fumigant and fumigation service were provided by TriCal. Inc. Research supporting staff to this project: Robert Shenk, Allison Kenyon, Tom Pflaum, Jim Gartung, and Stella Zambrzuski in the WMR, USDA-ARS, Parlier, CA.

REFERENCES

Ajwa H. 2008. Testing film permeability to fumigants under laboratory and field conditions. p. 35(1–2) *In* Proc. Ann. Int. Res. Conf. on MeBr Alternatives and Emission Reductions, Nov. 11–14, 2008. Orlando, FL. Available online at http://www.mbao.org/2008/Proceedings/035AjwaHPermeabilityAbstractMBAO2008.pdf.

Chow, E. 2008. Properties of EVOH and TIF films for the reduction of fumigant dosage and VOC emission. *In* Program for 2008 Conference & PowerPoint Presentations at Ann. Int. Res. Conf. on MeBr Alternatives and Emission Reductions, Nov. 11-14, 2008, Orlando, FL. Available online at: http://www.mbao.org/2008/038Chow.pdf.

Gao, S.; Wang, D.; Pflaum, T.; Qin, R.; Hanson, B.; Browne, G.; Ajwa, H.; Yates, S. 2008. Dynamic flux chamber systems for fumigant emission measurements. 22(1-4) *In* Proc. Ann. Int. Res. Conf. on MeBr Alternatives and Emission Reductions, 11-14 November, San Diego, CA, USA, Available at: http://www.mbao.org/2008/Proceedings/022GaoSMBAO2ChambersAWProject.pdf.

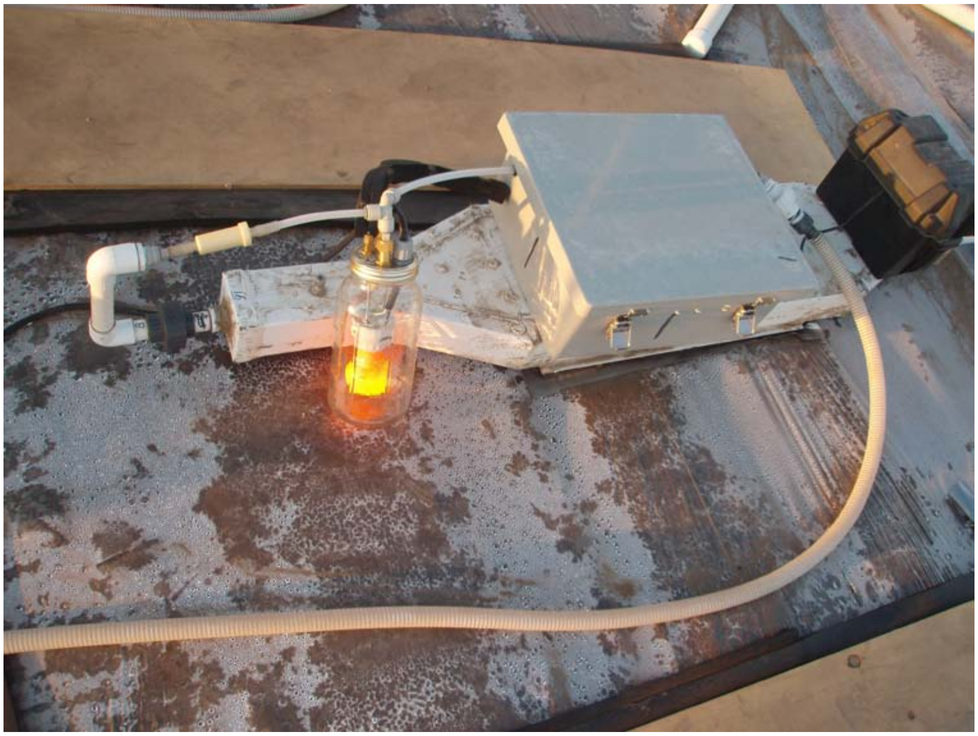

Figure 1. A dynamic flux chamber used for emission measurement with a heating unit to prevent water condensation in the air flow path.