A MICRO SPOT INJECTION SYSTEM FOR STUDYING THE EFFECTS OF CARBONATION ON FUMIGANT DISPERSION IN SOIL

Ruijun Qin[1, 2,*], Tom Pflaum[2], Suduan Gao[1], and Brad Hanson[2]
[1] USDA-ARS, Parlier, CA. [2] Univ. Calif. Davis, CA.

Background: Pest control efficacy with some fumigant alternatives to methyl bromide is limited, in some cases, by relatively slower diffusion through soil from the point of injection. This is particularly a problem for deep rooted perennial crops for which fumigant transport to deep soils is needed to control plant parasitic nematodes and soil borne pathogens. Conventional fumigation systems usually are pressurized with nitrogen because of its relatively low reactivity and solubility. Recently, research suggested that fumigant dispersion in soil and pest control efficacy can be increased by using carbonated fumigants and CO_2-pressurized fumigant injection systems (Thomas et al., 2011). However, commercial applicator safety concerns related to transporting pressurized fumigant cylinders have, thus far, limited field evaluations of fumigant dispersion and subsequent pest control in California. To evaluate this technology under local conditions and determine specific carbonation conditions that enhance fumigant movement in soil and improve efficacy, a micro spot fumigant injection system (MSFIS) was constructed. The goal of this apparatus is to allow highly accurate soil injections of CO_2 or N_2 pressurized fumigants to facilitate research on carbonation of methyl bromide alternative fumigants. The information developed using this system will ultimately assist the adoption of this technology by the industry for the efficient use of fumigants.

Micro Spot Injection System (MSFIS): The MSFIS is constructed with the design shown in Figure 1. This is a modified version of an existing micro fumigant injector from Dr. Greg Browne (Brown, personal communication, 2012). The MSFIS (Figure 1) includes two Swagelock stainless steel cylinders (200 mL): one contains the pressurized or carbonated liquid fumigant and the other contains either CO_2 or N_2 pressurized gas. The liquid cylinder has a dip tube installed, through which the carbonation or pressurization gas is injected and bubbles up through the liquid. The gas cylinder serves as a gas reservoir for maintaining a stable headspace pressure for the fumigant cylinder. The bottom of the fumigant cylinder is connected to the main valve which allows, by changing the valve positions, filling the bottom liquid syringe with fumigant, injecting fumigants to soil, and purging the injection lines. A check valve is used between the two cylinders to prevent fumigant contamination of the gas cylinder and needle valves are used for isolation. Carbonated fumigants are tested at a maximum pressure of 50 psi, which improved fumigant dispersion and efficacy in previous studies (Thomas et al., 2011).

Carbonation of Fumigant and Water: The liquid cylinder was filled with Telone C35 to about 2/3 full (TriCal Inc., Hollister, CA). CO_2 or N_2 gas was added to fumigant cylinder under various pressures at a temperature of 22±3 °C in laboratory investigations. The carbonation or pressurization was monitored for 24 h or longer until equilibrium was reached. Initial testing of the MSFIS was done with water. CO_2 concentration in water at equilibration was 0.17, 0.53, and 0.88% (w/w) at a target pressure of 10, 30, and 50 psi respectively (Fig. 2). Under higher pressure, a longer time is needed to achieve equilibration (Fig. 2). Similar to water, the carbonation of Telone C35 resulted in a linear correlation between the amounts of CO_2 dissolved and the headspace pressure (Fig. 3); however, relatively more CO_2 dissolved in Telone C35 than in water. Under same pressure, the amount of dissolved CO_2 in Telone C35 was almost twice that in water (data not shown). Compared with N_2 gas, more CO_2 dissolved into the fumigants at the same pressure. For example, at 50 psi, the dissolved N_2 in Telone C35 was ~0.24% (w/w) compared to 1.72% (w/w) CO_2 (data not shown).

Application Accuracy of the MSFIS: The injection accuracy of the MSFIS was determined with water. The liquid cylinder was pressurized overnight at 50 psi. Injections with carbonated water or N_2-pressurized water showed that the MSFIS delivered water with high precision and accuracy (99.5-100% of the target value). With the ability to vary pressure and volume of purge gas to injection line, the system can be used for determining carbonation and fumigant injection conditions for enhancing fumigant dispersion in soil and efficient use of fumigants for better pest control. Based on these successful tests, the MSFIS will be used in field testing and confined soil volume treatments in future studies.

Acknowledgement: Funding for this research was provided by NIFA Methyl Bromide Transition Grants Program. We thank Dr. Greg Browne for showing us his micro fumigant injector. Mr. Robert Shenk provided valuable service in designing, constructing, and testing the MSFIS.

Reference:

Gao, S., R. Qin, A. Cabrera, J. Gerik, B. Hanson, L. Sosnoskie, D. Wang, and G. Browne. 2012. Minimize emission and improve efficacy with low permeability tarp and carbonation in soil fumigation for perennials. Proc. Ann. Int. Res. Conf. on MeBr Alternatives and Emission Reductions, Orlando, FL.

Thomas, J.E., Ou, L.T., Allen, L.H., Vu, J.C., and Dickson, D.W. 2011. Improved soil fumigation by Telone C35 using carbonation. Journal of Environmental Science and Health, Part B, 46:655-661.

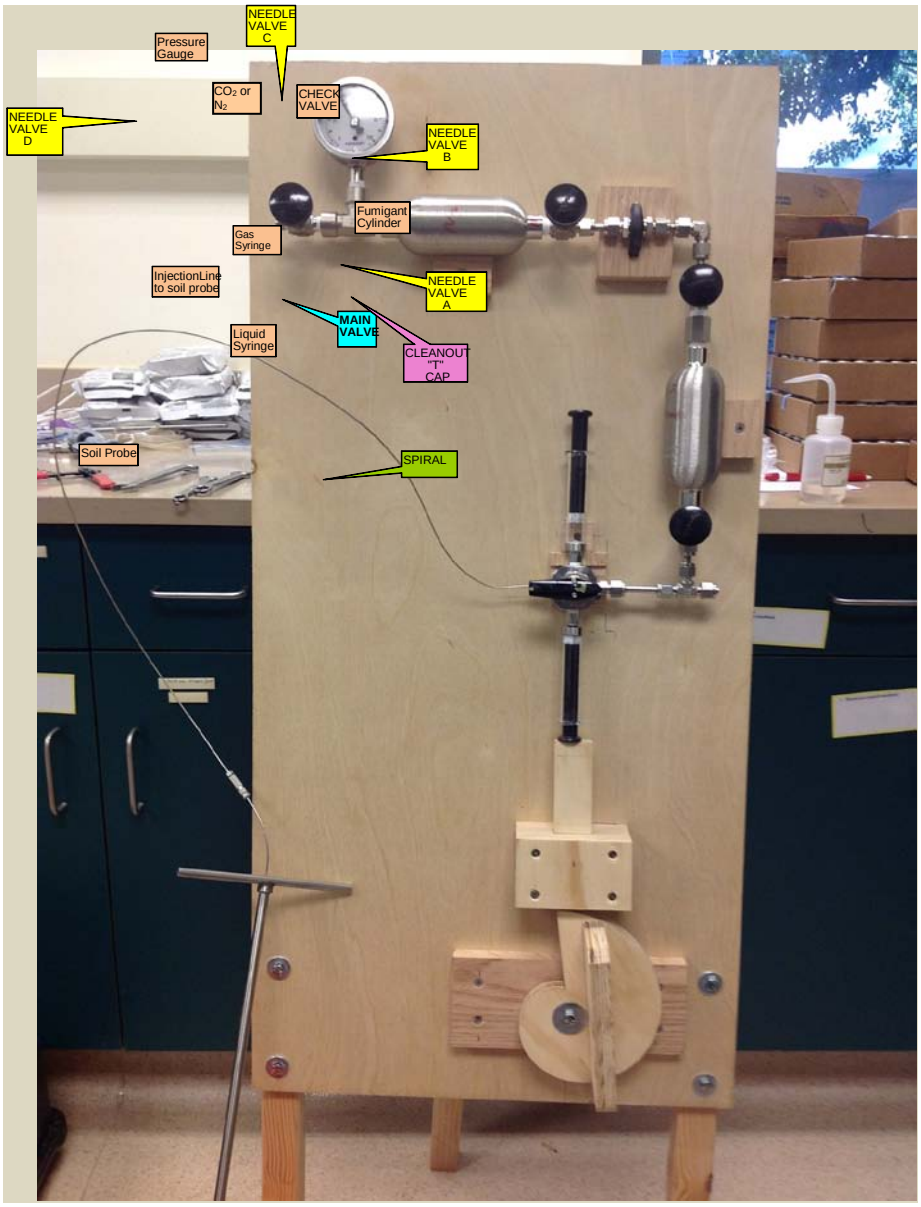

Fig. 1. Micro Spot Fumigant Injection System (MSFIS)

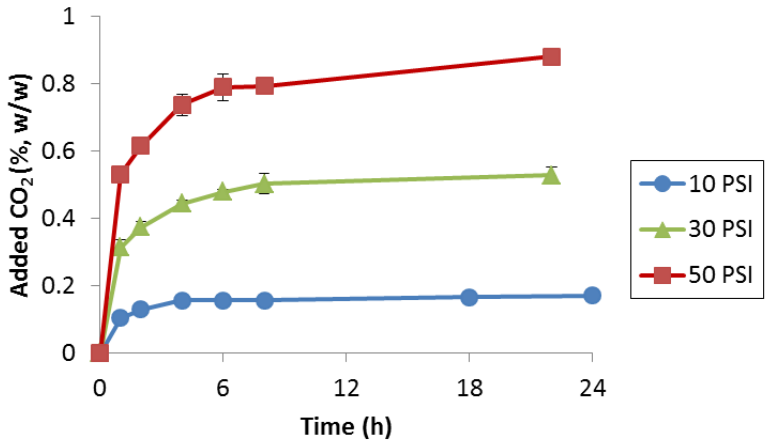

Fig. 2. Carbonation of water under different pressures at a temperature of 22±3 °C.

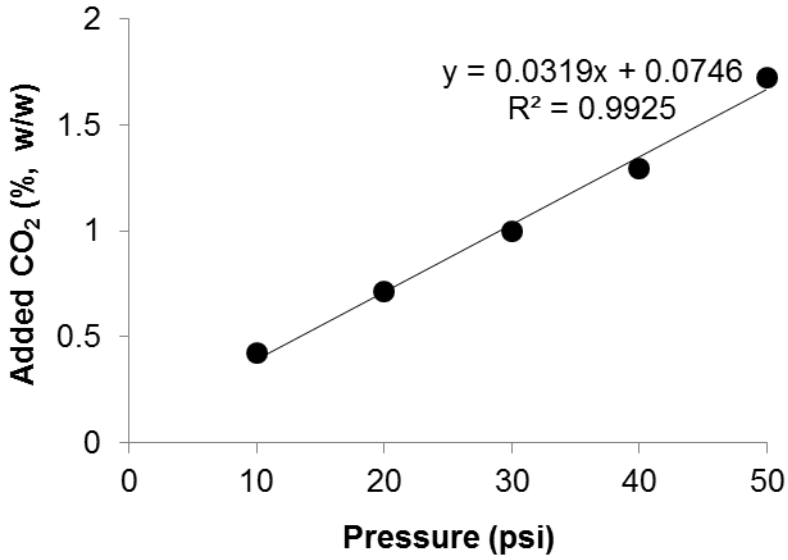

Fig. 3. Carbonation of Telone C35 under the pressure from 10 to 50 psi at a temperature of 22±3 °C.