DEGRADATION AND ADSORPTION OF CARBONATED DIMETHYL DISULFIDE IN SOILS WITH GRAPE PRODUCTION IN CALIFORNIA

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Dimethyl disulfide (DMDS) is a pre-plant soil fumigant that has zero ozone depletion potential. This fumigant can be delivered through shank and drip systems. DMDS can be applied alone or in combination with other fumigants. DMDS is used to control weeds, soil-borne plant pathogens and nematodes and is currently registered in 21 states, with six registrations pending, including CA.

The common method to apply pre-plant soil fumigants, including DMDS, is through pressurizing the pesticides with compressed nitrogen (N_2). N_2 is a non-polar compound whereas DMDS is polar. Thomas et al. (2011a) demonstrated that fumigant diffusion can be enhanced by pressurizing polar fumigants with polar compounds, producing a polar-polar interaction. Polar CO_2 can be used as a gas carrier and propellant. For example, the soil fumigant Telone C35 was better dispersed using CO_2 than N_2 (Thomas et al. 2009). Therefore, it is believed that other fumigants, such as DMDS, can be better dispersed with CO_2 than with N_2. The advantage of increasing the dispersion of a fumigant is that it can potentially be used at lower application rates and provide adequate pest control (Thomas et al. 2011b). The reduced application rates of carbonated fumigant could decrease chemical inputs in the environment. However, independently of dispersion processes, little is known about the effects of CO_2 on DMDS fate in soils. Degradation and adsorption could be affected by the use of CO_2. Faster degradation and/or higher adsorption could potentially compromise DMDS pest control efficacy. To better understand the impacts of CO_2 on DMDS, the objectives of this investigation were;

1) Evaluate the degradation (*half-life*) of carbonated vrs. non-carbonated DMDS.
2) Identify the effect of temperature on DMDS degradation.
3) Determine the adsorption of carbonated and non-carbonated DMDS.
4) Investigate the effect of dose on DMDS adsorption

STUDY METHODS: Two field soils under grape production in CA were collected. The first soil was a Delhi loamy sand (total organic carbon 0.06%) from a raisin grape production in Fowler, central CA. The other soil was a Carsitas gravelly sand (total organic carbon 0.20%) from a table grape production in Mecca, south CA.

Laboratory tests were performed to investigate both degradation and adsorption. DMDS (SigmaAldrich) was carbonated with a CO_2 injector (SodaStream Fountain Jet). Each soil received 60 mg of DMDS a.i. per kg of soil which is ≈ the maximum allowed DMDS rate in the field (455 lbs/acre). The soils were incubated at 10, 24 or 37°C. Triplicate sets of samples from each temperature were evaluated after 0, 1, 7, 21, 28 & 35 days after DMDS application. Extraction of DMDS from soil was accomplished with ethyl acetate and anhydrous sodium sulfate. Quantification of DMDS was performed with a GC-MS (Agilent Technologies). The half-life of carbonated and non-carbonated DMDS was determined using first-order kinetics.

To investigate the adsorption (K_d) of DMDS three treatments were performed in triplicate; vials with 10 g of dried soil, vials with 10 ml of distilled water, or empty glass vials. A total of 10.62 mg of carbonated or not carbonated pure DMDS was applied to each vial and equilibrated for 24 h at 10, 24 or 37°C. To determine the adsorption; $K_d = C_s/C_w$, where C_s was the concentration in soil (mg/kg), and C_w the concentration in aqueous phase (mg/l) (Ajwa et al. 2010). Additionally, K_d was investigated in the Delhi loamy sand soil using increasing DMDS concentrations (0.25, 0.5, 1, and 10 mg/kg of soil) at 24°C.

RESULTS: The preliminary laboratory studies indicated that carbonation did not affect DMDS *half-life* in soil. In the Delhi loamy sand soil the DMDS *half-life* ranged from 14 to 35 days. In Carsitas gravelly sand soil DMDS *half-life* ranged from 13 to 30 days. Temperature affected DMDS *half-life*. In particular, the lowest temperature evaluated (10°C) had the slowest degradation process, thus having the largest amount of *half-life* days. This may be due to the reduction in biological activity due to the cold conditions. Temperatures such as 24 and 37°C are optimal conditions for the growth of microbial organisms that are involved in the degradation of fumigants.

The adsorption of DMDS was not affected by the carbonation process. In the Delhi loamy sand soil the K_d ranged from 0.96 to 1 (g/cm^3). In Carsitas gravelly sand soil the K_d ranged from 0.88 to 2.01 (g/cm^3). The K_d appeared to be higher in Carsitas gravelly sand soil perhaps because its higher total organic carbon content. In addition, the interaction of high temperature (37°C) and carbonation appeared to increase K_d in Carsitas gravelly sand soil. When DMDS was applied at different concentrations to the Delhi loamy sand the K_d remained constant. Thus, carbonation, temperature, and dose, did not affect DMDS adsorption, however, there may be an interaction between high temperature and carbonation that requires further analysis.

CONCLUSIONS: The preliminary results of this laboratory tests indicate that carbonation did not affect DMDS *half-life* in two different grape growing soils of CA. Temperature appeared to be the most important factor affecting DMDS degradation, where higher temperatures favor the degradation process. The adsorption of DMDS was not affected by carbonation, temperature and dose, although the interaction of high temperature and carbonation appeared to affect K_d in Carsitas gravelly sand soil. Further studies of this interaction are required. Carbonated DMDS can be expected to last and be available similarly as non-carbonated. This will be essential for a lasting efficacy when low carbonated rates are applied for pest control. Further research is being conducted with soils from wine grape production in Paso Robles (central west CA) and

Clarksburg (north CA). Efficacy studies with carbonated DMDS against nematodes, pathogens and weeds will also be performed in the future.

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