DEEP INJECTION AND BIOCHAR AMENDMENT ON FUMIGANT EMISSIONS AND NEMATODE CONTROL

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Purpose: Soil fumigation continues to play a critical role in orchard replanting, primarily for management of plant-parasitic nematodes and replanting disease. The phase-out of methyl bromide (MeBr), due to its contribution to the depletion of the stratosphere ozone, has resulted in the wide use of other soil fumigants in California, such as 1,3-dichloropropene (1,3-D) and chloropicrin (CP). These alternatives, however, are highly regulated due to their emissions that degrade air quality. Federal and state regulatory agencies in the USA continue to develop and amend fumigant regulations to protect people and the environment. Techniques that reduce fumigant emissions from soil could determine the availability of these pest management options for growers. Earlier studies have shown that low permeability films such as virtually impermeable film (VIF) or totally impermeable film (TIF) can significantly reduce emission loss, increase fumigant concentrations in soil, and improve fumigant distribution for good efficacy, but these films are more expensive than standard polyethylene (PE) film that is commonly used for controlling MeBr emissions but is not effective for the alternatives. Soil amendment with biochar and deep injection have recently been shown to reduce fumigant emissions in either laboratory or field tests while also potentially eliminating the initial cost and disposal cost of plastic films. The objective of this research was to determine if deep fumigant injection and biochar soil amendments can reduce emissions, improve fumigant distribution in soil, and provide acceptable control of plant parasitic nematodes.

Study Methods: A pre-plant fumigation trial was conducted in a commercial field near Hughson in the San Joaquin Valley, CA, USA. Treatments included two rates of Telone® C-35 (a mixture of 1,3-dichloropropene and chloropicrin) under totally impermeable film (TIF) or with no surface seal, two injection depths (45 or 65 cm), and two biochar rates (20 or 40 ton ha^{-1}). These treatments were tested in two different settings. The injection depths and rate treatments were investigated in large plots with each plot 34 m long and 6.4 m wide for planting 8 trees. Testing the biochar treatment effects were carried out in small plots within the large field with each plot occupying one tree area. The TIF was VaporSafe® (1-mil thickness, clear, Raven Industries, Sioux Falls, SD, USA). CoolTerra® biochar (Cool Planet, Camarillo, CA, USA), was derived 100% from coconut shell feedstock, pyrolyzed at 550^{o}C, and subjected to a proprietary post-production treatment to neutralize the pH and remove some residual elements. All treatment combinations were tested in a randomized complete block design with three replicates.

Telone® C-35 was shank-applied on November 14, 2016 using a fumigation rig, which had a spacing of 50 cm between shanks. The same rig was used to inject fumigants at both 45 cm and 65 cm depths. Fumigated areas were only 2.52 m wide along tree row center, which accounted for approximately 40% of the orchard floor fumigated. Biochar was applied on the day before fumigant application by spreading the materials uniformly to a 3.05 m ×3.05 m area and then incorporated into surface 0-15 cm soil. The plastic tarp was installed following fumigant injection using another rig. Following fumigant injection and tarping, fumigant emissions and fumigant concentration changes in soil profile were measured for up to two months. Nematodes survival and residual fumigants in soil were determined approximately four months after fumigant injection. All sampling, processing, and analysis were carried out following procedure described previously (Gao and Trout, 2006; Gao et al., 2009).

Results: During the fumigation trial, several heavy rain events were encountered. These resulted in generally much lower emission rates compared to measurements in previous trials, but all data clearly showed that the deep injection enhanced fumigant delivery to depths below 60 cm and resulted in significantly lower peak emission compared to the standard injection depth. Biochar applied at 40 ton ha^{-1} had the lowest emission rates within the first month monitoring suggesting that this approach has the potential to mitigate fumigant emissions. Significant increases in fumigant persistence, especially chloropicrin, was observed in this study, likely due to the high soil moisture and low temperature during the trial. Although variability in nematode survival was high, tarped, deep injection, and biochar treatment showed lower survival of nematodes at different depths. These results indicate that biochar amendments could reduce fumigant emissions without reducing nematode control; however, additional research is needed to optimize treatments, determine the affordability of various biochar materials, and validate the findings under a range of field conditions.

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Figure 1. Aerial photo over the field in Hughson fumigation trial conducted in November 2016 (photo by Donald Hicks).