Field Tests on Biochar to Reduce Emissions from Soil Fumigation

Suduan Gao[1]*, David A. Doll[2], Bradley D. Hanson[3], Michael S. Stanghellini[4], Becky B. Westerdahl[3], Dong Wang[1]

[1]USDA-ARS, Parlier, CA; [2]UCCE, Merced, CA; [3]UC Davis, CA, [4]TriCal, Inc., Hollister, CA.

Issues

- Soil fumigation continues to be an important practice to control soil-borne pests and diseases.
- Fumigant emissions must be minimized to reduce exposure risks and environmental impact.
- Low permeability tarp, such as total impermeable film (TIF), is one of the most effective strategies to control emissions but has high initial purchase, installation, and disposal costs.

Objective

- To evaluate if deep fumigant injection and biochar soil amendments can reduce emissions, improve fumigant distribution in soil, and provide acceptable control of plant parasitic nematodes.

Fumigation Trial in Pre-planting Almond Orchard

- A fumigation trial was conducted on Nov. 14, 2016; Location: Hicks Farm, Hughson, CA; Soil: Hanford Sandy Loam (Mixed, superactive, nonacid, thermic Typic Xerorthents).
- Fumigant: Telone® C-35 (35% chloropicrin, 63% 1,3-dichloropropene, and 2% other ingredients).
- Treatments: Two injection depths: regular (45 cm) and deeper (65 cm) with two application rates: 100% (610 kg/ha) and 66% rate: (407 kg/ha); four surface sealing methods: bare (no tarp) and TIF (VaporSafe®,1-mil thickness, clear, Raven Industries, Sioux Falls, SD, USA) for both rates; Biochar low (20 ton/ha) and biochar high (40 ton/ha) for 66% rate at 65 cm injection depth.
- Biochar: CoolTerra® (Cool Planet, Camarillo, CA, USA) derived from 100% coconut shell feedstock and pyrolyzed at 550°C.
- Field sampling and measurements: emissions, movement in soil profile, and residual fumigant at end of the trial; plant-parasitic nematode survival at four months after fumigation.

Fumigant and biochar applications, soil preparation, and sampling for emissions.

Aerial view of fumigation trial conducted on a pre-planting almond orchard, Nov. 2016. Photo by Donald Hicks.

Soil temperature and rain events

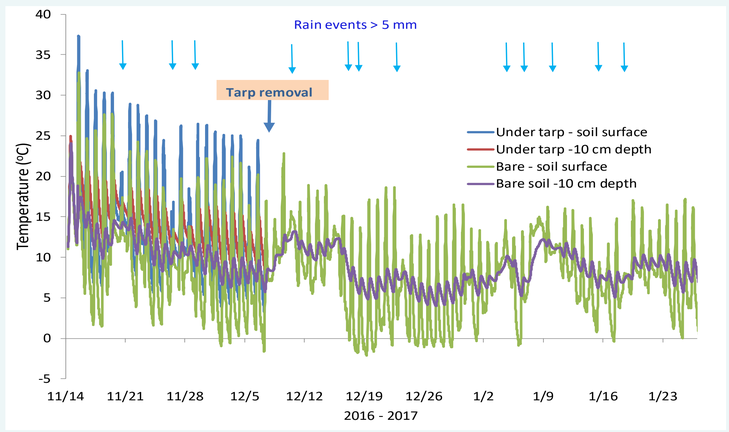


Fig. 1. Temperature at soil surface and at 10 cm depth from a bare plot, and under TIF tarped plot during fumigation trial from conducted in fall 2016, Hughson, CA. Arrows show rain events. About 500 mm rain was received during the two month field monitoring period.

Results

Emissions

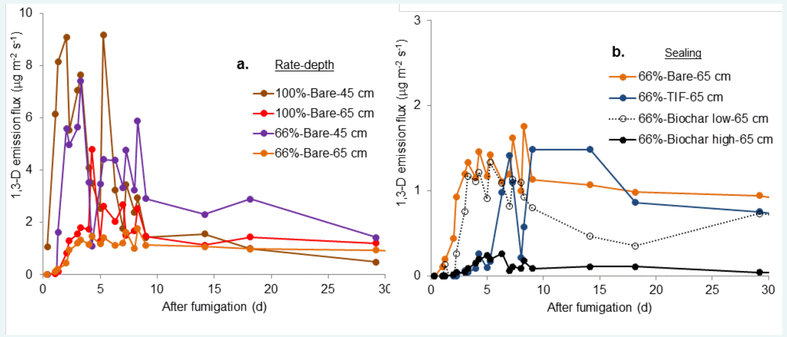


Fig. 2 Emission flux of 1,3-dichloropropene (1,3-D) from (a) regular (45 cm) or deep injection (65 cm) depths and (b) different surface sealing methods. Biochar low: 20 ton/ha, Biochar high: 40 ton/ha.

- The deeper injection (65 cm depth) resulted in significantly lower flux values than that from the regular injection (45 cm depth) especially during the first 4-5 days (Fig. 2a).
- TIF resulted in much lower emission rates compared to no tarped soil and the low biochar rate during the first five days, but emission rates increased significantly thereafter (Fig. 2b).
- The high biochar rate (40 ton ha^{-1}) resulted in the lowest emissions throughout the monitoring period.
- In general, all emission fluxes from this trial were about an order of magnitude lower than in other trials due to the lower temperature and rain events encountered.

Fumigant distribution profile in soil-gas phase

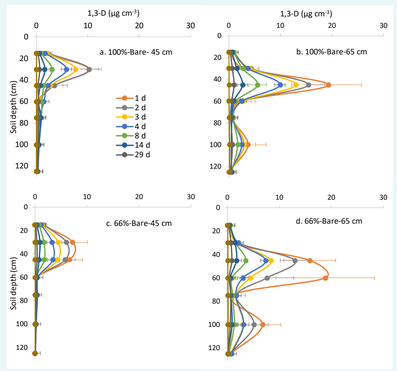


Fig. 3. 1,3-Dichloropropene (1,3-D) concentrations in soil-gas phase affected by application rate and injection depth following Telone® C-35 application. Plotted are averages of three replicates. Error bars are standard error of the mean (n=3).

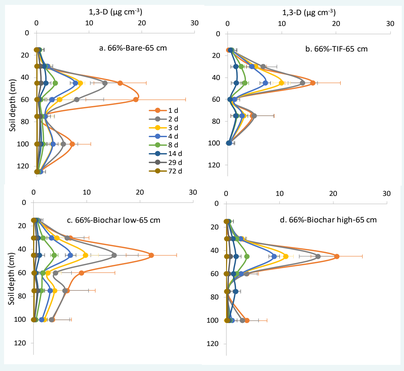
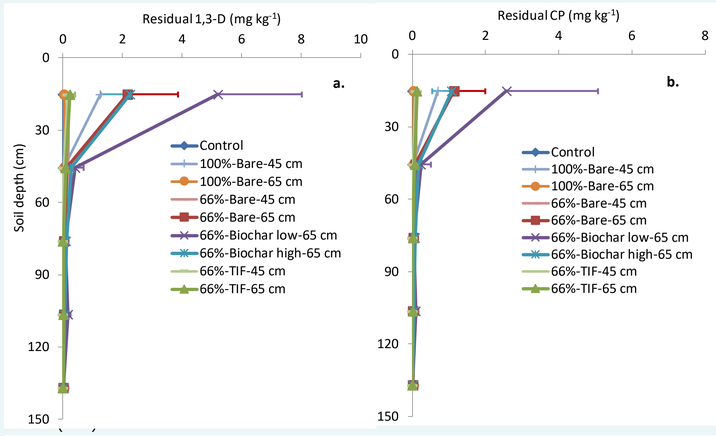


Fig. 4. 1,3-Dichloropropene (1,3-D) concentrations in soil-gas phase affected by surface sealing method following application of Telone® C-35. Error bars are standard error of the mean (n=3).

- Deeper injection resulted in the highest concentration near 45 or 60 cm depth compared to the 30 or 45 cm soil depth from regular injection (Fig. 3).
- The deeper injection resulted in much higher concentrations at 100 or 125 cm depths in bare soil (Fig. 3).
- The low concentration observed at 75 cm depth was due to the presence of a hard pan layer in the orchard (Figs. 3 and 4).
- Chloropicrin (not shown) showed similar distribution pattern as 1,3-D except at lower concentration levels.
- The data indicate that the deep injection did enhance fumigant diffusion into the deeper depths.
- Although fumigant concentrations at 120 cm were generally low, the values were much higher from the deep injection than the regular injection (Figs. 3 and 4).

Residual fumigants four months after fumigation



- Soil samples below 60 cm depth had extremely low or non-detectable fumigants indicating that most of the fumigants had dissipated.
- The surface soils had the highest fumigant concentrations but with large variability.
- Biochar amendments tended to raise fumigant concentration (1.1 to 2.5 mg kg^{-1}) and TIF covered plots showed the lowest concentration (0.1 mg kg^{-1}) with no clear indication how injection depth affected the fate of the fumigants.

Nematode survival

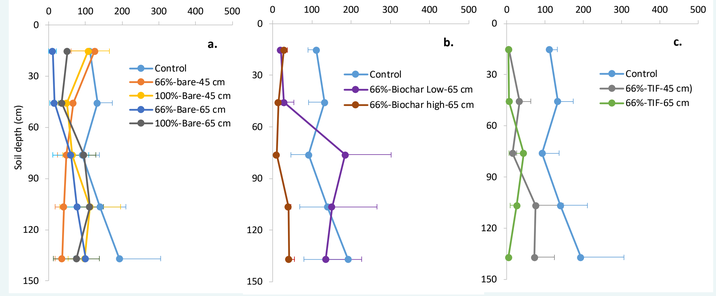


Fig. 6. Total population of plant-parasitic nematodes in soil approximately four months after application of Telone® C-35. Error bars are standard error of the mean (n=3).

- Plant parasitic nematodes observed in this trial included pin nematode (*Paratylenchus*), which accounted for 70% of the total population, and other minor species: lesion (*Pratylenchus*), root knot (*Meloidogyne*), stunt (*Tylenchorhynchus*), *Tylenchidae*, stubby-root (*Trichodorus*), and ring (*Mesocriconema*) nematodes.
- The non-fumigated control had the highest nematode population throughout the soil profile, but nematode populations in bare soil fumigated plots were not statistically lower (Fig. 6a).
- Biochar and TIF tarp, however, resulted in much lower nematode populations than the non-fumigated control especially in surface soil. (Figs. 6b and 6c).

Conclusions

- Deeper injection delivered fumigants to deeper depth while reducing emissions.
- Biochar at high rate (40 ton/ha) showed good potential to effectively reduce emissions with better performance than TIF in this trial.
- Due to rain, emission rates and nematode control were generally low or poor in this trial. Confirmation of the results is needed before biochar amendment is recommended as an effective strategy for emission control.

Acknowledgements

This research was supported by Almond Board of California and California Department of Food and Agriculture (CDFA) Specialty Crop Block Grant Program. Fumigant and fumigation service were provided by TriCal, Inc. Donald Hicks prepared the field for fumigation and coordinated with field sampling and measurements. Technical support was received from Robert Shenk, Aileen Hendratna, Julio Perez, Zac Shenk, Jim Gartung, & Stella Zambrzuski at USDA-ARS, Parlier, CA; Andrew Ray from UCCE, Merced; and Amanda Hodson, Department of Entomology and Nematology, UC Davis.

Contact Information: *Suduan Gao, Research Soil Scientist, USDA-ARS, 9611 S. Riverbend Ave., Parlier, CA 93648. Suduan.Gao@ars.usda.gov.*

The Almond Conference, December 5–7, 2017, Sacramento, CA