EMISSION, PEST CONTROL, AND CROP RESPONSE IN ALMOND ORCHARD SOIL FUMIGATION

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Almond growers have been using soil fumigation to control plant parasitic nematodes or diseases for successful replanting. Since the phaseout of methyl bromide (MeBr), the industry has begun using either Telone® (1,3-dichloropropene or 1,3-D) or a combination of 1,3-D and chloropicrin (CP). These fumigants require emission control due to exposure risks and volatile organic compound (VOC) emissions in air quality (ozone) non-attainment areas, which includes the San Joaquin Valley (SJV) where most of the tree fruits, nuts, and grapes are produced. Low permeability tarp such as the totally impermeable film (TIF) has shown effectiveness in reducing emissions. These highly retentive films also allow the potential of reducing fumigation rates, which had been demonstrated for annual crops but has not been tested in deeply rooted perennial crops. The objective of this research was to determine if a commercially available TIF can help achieve good fumigation efficacy, lower emissions, and reduced fumigant rates in orchard replant situations.

Study Methods: A fumigation trial was conducted in an almond orchard replant site 13 miles NE of Merced, CA from November 29, 2012 through January 12, 2013. The soil is Snelling sandy loam (Fine-Loamy, mixed, superactive, thermic Typic Haploxeralfs). An existing almond orchard was removed after harvest in September 2012 and the trial followed a typical orchard renovation schedule with the old trees removed in the fall and new trees replanted early the next year (February 2013 in this trial). Due to a reduction in VOC and ozone regulations before October 31st in the SJV, most orchard fumigation now occurs in the late fall or winter. Very few field trials have been conducted during the cool and wet season, and thus these data are applicable to a number of potential issues related to orchard renovation practices in California.

Treatments included three surface sealing methods [bare, standard polyethylene (PE), and TIF] and four fumigant rates (a full label rate [610 kg/ha, 100% rate]; 66% rate, 33% rate, and 0 rate, non-fumigated controls) of Telone® C-35 (35% CP, 63% 1,3-D, and 2% other ingredients). Measurements included fumigant emissions, changes in fumigant concentration under tarp and distribution in soil, efficacy against pests including soil-borne nematodes, and tree growth response to fumigation treatment after replanting. The 12 treatments with 6 replicates were applied in a randomized complete block design. Three replicates were monitored for fumigant movement and pest efficacy; all six replicates were monitored for tree growth and yield.

Results: The highest emission flux of 1,3-D was from the PE tarp at the 100% rate, followed by the PE tarp at the 66% rate, and lowest from the TIF. This data confirmed that TIF continues yielding the lowest emissions. Monitoring fumigant emissions adjacent to the edge of the TIF tarp (0 and 50 cm distance from tarp edge) indicated that the emission flux was much lower than that measured adjacent to shallow injections in previous trials. The data indicate that off-tarp emissions are less of a concern when fumigation depth was deeper (18 inch vs. 12 inch soil depth). Chloropicrin emission flux (<15 µg m^{-2} s^{-1}) was always much lower than 1,3-D (up to 120 µg m^{-2} s^{-1}) when Telone® C-35 was applied indicating less concerns compared to 1,3-D. 1,3-D concentrations under TIF were much higher than that under PE at the same rate. Furthermore, the peak concentrations under TIF were measured about one week after fumigant application; while the peak concentrations under PE were observed 2-3 days after application before declining. Similar fumigant distribution patterns were followed for all monitored treatments except that higher application rates resulted in higher concentrations in soil profile. Large variations were measured from three replicated plots for the same treatment resulting in no apparent differences in the soil fumigant concentrations at the same rate among the bare soil, PE tarp, and TIF. The field had an undulant soil surface (see **Fig. 1**). Rain events occurred during the trial that led to very different soil moisture profiles plus the soil in tarped plots received less precipitation than the soil in bare plots. At the end of the trial when retrieving pest bags after tarp was removed, plots at lower elevations were found to be flooded while those in the upslope were dry. These conditions are expected to have significant impacts on fumigant distribution and efficacy.

The field was infested with plant parasitic nematode species including high populations of pin nematode and low populations of ring nematode throughout the soil profile. After fumigation, Telone® C-35 at the 100% and 66% rates under both PE and TIF provided 100% nematode control at all soil depths above 1 m. Nematode survival was detected in surface soils in the untarped plots at full rate. Similar results were obtained for the 66% rate except nematode survival was detected in bare soil at all soil depths. Below 1 m soil depth, however, nematode survival was detected from all treatments including the TIF at 100% rate although population was low. At the 33% rate, nematode survival was observed throughout the soil profile.

At 10 months after fumigation, significant differences in almond tree growth were found among fumigated treatments at 100% and 66% rates (regardless of rate and tarp) and the non-fumigated controls. There were no significant difference among fumigated plots or between two 33% rate treatments and the tarped controls. After about two years, these differences in tree growth were still evident. The first yield data were collected in August 2015 with significantly higher almond yield from all 100% and 66% rates compared to all non-fumigated controls. These data indicate the potential to reduce the current fumigant maximum rate.

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Figure 1. A view from northwest corner of the fumigation field near Merced in November 2012 trial.