DEEP FUMIGATION IN TOTALLY IMPERMEABLE FILM COVERED RAISED-BED PRODUCTION SYSTEM

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Coastal California is the primary region for strawberry production in the state and the crop is typically grown in raised-bed systems covered by standard polyethylene (PE) film with two drip lines installed near the bed surface. To control soil borne-pests, soil fumigants are often applied through the drip lines prior to planting. Previous field research has shown that PE does not effectively retain fumigants and results in high emissions. Shallow application and high emission likely reduce the uniformity of fumigant distribution both horizontally and vertically in the bed profile as poor pest control has been observed in bed shoulders or at deeper depths.

Deeper application may improve fumigation efficacy by effectively delivering the fumigant throughout the root zone. Deeper placement also can reduce emissions because the fumigant must pass through and interact with more soil before reaching the surface. Field trials have shown that a totally impermeable film (TIF) can reduce emissions from broadcast application by >90% compared to PE and also improve fumigant distribution uniformity. Combining TIF covering and deep application may further improve fumigation efficacy and reduce fumigant emission losses while potentially leading to reduced fumigant rates. The objective of this research is to optimize drip fumigation by evaluating the combined effects of TIF covering and deeper application on fumigant behavior, pest control, and strawberry production.

Study Method: A field trial was initiated in a sandy loam soil in a commercial strawberry field in Camarillo, CA in August 2013. The fumigant tested was Pic-Clor 60 EC (a mixture of 56.7% chloropicrin, 37.1% 1,3-dichloropropene, and 6.2% other ingredients). Five treatments were tested including a full rate (25 gallon/ac) or half rate (12.5 gallon/ac) applied through either two drip lines or four drip lines under TIF, and an untreated control under TIF. Each treatment was replicated four times in a randomized complete block design.

The raised beds were 120 cm wide and 35 cm high and individual plots were around 30 m long. The plots with two drip lines had the lines installed at a depth of 5 cm and a spacing of 70 cm in apart. In plots with four drip lines, two shallow drip lines were placed in the standard locations and two additional lines were installed 13 cm directly below the shallow lines. For the two drip line treatment at full rate, the fumigant was applied over a four-hour period. For other treatments,

the application period was adjusted to achieve the target application rate. Before and after fumigation, the whole system was flushed with water. After fumigation, a 30-min water seal was applied through sprinklers to reduce fumigant emissions from furrows, following growers' standard practices.

After the fumigant application and water seal, fumigant emissions from beds and adjacent furrows were sampled using static chambers in the TIF covered full rate plots. Fumigant distribution in the soil profile was determined using probes installed near the bed center at depths of 10, 20, and 30 cm, near the bed shoulder at 10, 20, 30, 40, and 50 cm, and in the furrow at 10 and 20 cm. Air between the film and soil surface was sampled at the center and the edge of the bed-top, as well as the mid-point and the base of the bed-side. For comparison purposes, air between film and soil surface was also sampled from an adjacent field with PE covered beds treated with a full rate applied through two drip lines. Fumigant samples were collected for two weeks following the application. At the end, soil samples were collected at locations and depths corresponding to the soil gas sampling to determine residual fumigant concentration and evaluate pest control. Pest control efficacy was also determined by evaluating the survival of pathogen samples placed in the beds prior to fumigation. Plant growth and strawberry yield were monitored throughout the full growing season.

Results: Data showed that TIF improved fumigant retention dramatically. The deep application improved fumigant distribution and concentration, especially at deeper depths compared to the shallow application. Comparing to the PE covered beds in the previous trials, the TIF covered beds had lower emission in this trial, while the deep application further reduced fumigant emissions in comparison with the shallow application. Fumigant emission from uncovered furrows was at trace level regardless of drip line placement. The residual fumigant level was generally lower than 0.5 mg kg^{-1} soil two weeks after fumigation regardless of application rate or the number of drip tapes. It was also found that the fumigant concentration in the air between film and soil surface in the TIF plots with a half-rate was similar or even higher than that in the PE covered beds with full rate in the adjacent field. All treatments provided 100% control of the buried *Fusarium oxysporum* samples and the native *Pythium spp.*, further supporting the potential to use reduced fumigant rates with TIF covering. No significant differences among treatments were observed in strawberry growth and yield which was monitored throughout the crop season (December 2013 to June 2014). The overall results imply that TIF and deep application can improve drip fumigation by reducing emissions, increasing fumigant distribution uniformity, and may lead to reduced fumigant rates in raised bed production systems.

Acknowledgement: This project is funded by a grant from the Walmart Foundation and administered by the University of Arkansas System Division of Agriculture Center for Agricultural and Rural Sustainability. The tested field, field equipment, and field preparation were provided by Steve Imoto and his field crew. Fumigation service and equipment was provided by Crop Production

Service. Technical assistance was provided by staff from the Water Management Research Unit, USDA-ARS, Parlier, CA and the Department of Plant Sciences, University of California, Davis.

Picture Raised beds with two drip lines (left) vs. that with four drip lines (two shallow and two deep; right) in the Camarillo trial.