Improving Fumigation Technology by Doubling the Number of Drip Tapes In Raised-Bed Production Systems

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Introduction

- California Strawberry in 2013*
  - $2.6 billion (88% of the Nation's)
  - 40,000 acres
  - Total production: 2.3 billion lbs.

  *CA strawberry commission website

- Most strawberries are grown in coastal regions.

- Depends on soil disinfestation prior to planting.

- Raised-bed production systems tarped with standard polyethylene film (PE).

- Drip fumigation:
  - Applying fumigants through drip irrigation lines buried near the bed surface.

  - Over 55% of strawberry fields are applied with drip fumigation.

- Major issues on drip fumigation practice:
  - High emissions occur in PE tarped field – Air quality issues.
  - Unsatisfactory pest control.
    - Increasing number of pathogen-infested fields.
    - Difficulty in controlling pests at bed-center or shoulder, especially at deeper depth.
    - Weed problem.

- Low permeability film (LPF) was found to reduce emission and improve fumigant distribution effectively in flat fields with shank injected fumigation.

- Increasing drip line number may provide better fumigant distribution for pest control.

- Information on the performance of LPF covering and applying via multiple drip lines in raised-bed production systems is limited.

Objective

- Develop effective fumigation strategies by LPF covering and applying fumigant via multiple drip-lines in raised-beds of the coastal regions:
  - Increase pest control efficacy
  - Reduce pesticide input
  - Reduce environmental pollution
  - Sustain strawberry production

Materials and Methods

- Field trial (Sept. 2014-June 2015) at Oxnard, CA:
  - Raised-beds production system with sandy loam soil.
- Bed configuration:
  - 45” (bed width), 16” (bed height), 68” (bed center-center).
- Installation tube depths:
  - 2” deep.
- Fumigant:
  - Tri-Clor EC [a mixture of 94% chloropicrin (CP) and 6% inert ingredients]
- Film type:
  - PE vs. Virtually impermeable film (VIF; Filmtech Grozone, black).
- Application rate:
  - 224 lbs/ac (full rate) vs. 112 lbs/ac (half rate).

- 24 tarped beds including 6 treatments with 4 replicates:
  A. 2 drip lines - non-fumigated control under VIF (CK)
  B. 2 drip lines – full rate under PE (2L/full/PE)
  C. 2 drip lines - full rate under VIF (2L/full/VIF)
  D. 2 drip lines - 1/2 rate under VIF (2L/half/VIF)
  E. 4 drip lines - full rate under VIF (4L/full/VIF)
  F. 4 drip lines - 1/2 rate under VIF (4L/half/VIF)

- *Treatments A-D had 2 drip lines (RO-Drip, John Deere Water) spaced 22".*
- *Treatments E-F had 2 outer tapes (Compact thinwall dripline, Eurodrip® USA) spaced 22" and 2 inner tapes spaced 6".*

- Field set-up:

Setting up beds

Installing 2 drip tapes

Covering beds with black film

Installing 4 drip tapes

- Field monitoring during fumigation period (Sept. 8-17. 2014):

  - Fumigant concentration under film above soil surface (AU).
  - Fumigant gas in soil profile.
  - Emission (passive chamber).
  - Residual fumigants at the end of fumigation.
  - Pest control at the end of fumigation.

- Soil gas sampling:
  - In soil profile
    - Bed center: 10-30 cm
    - Bed edge: 10-50 cm
  - Under film
    - Bed center, edge, side, and furrow

- Emission measurement:
  - Passive chamber method:

Emissions from bed

Emissions from furrow

- Pest control measurement:
  - Pre-buried pest bags
    - Nutsedge
    - Pathogens

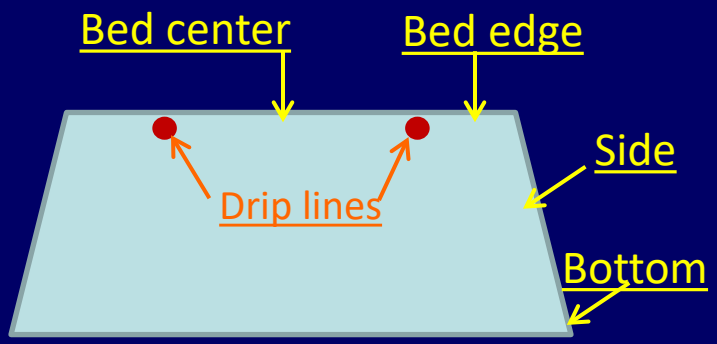
- Field monitoring during crop season (October 2014 - June 2015):
  - Berry production.
  - Plant growth.
  - Pest occurrence.

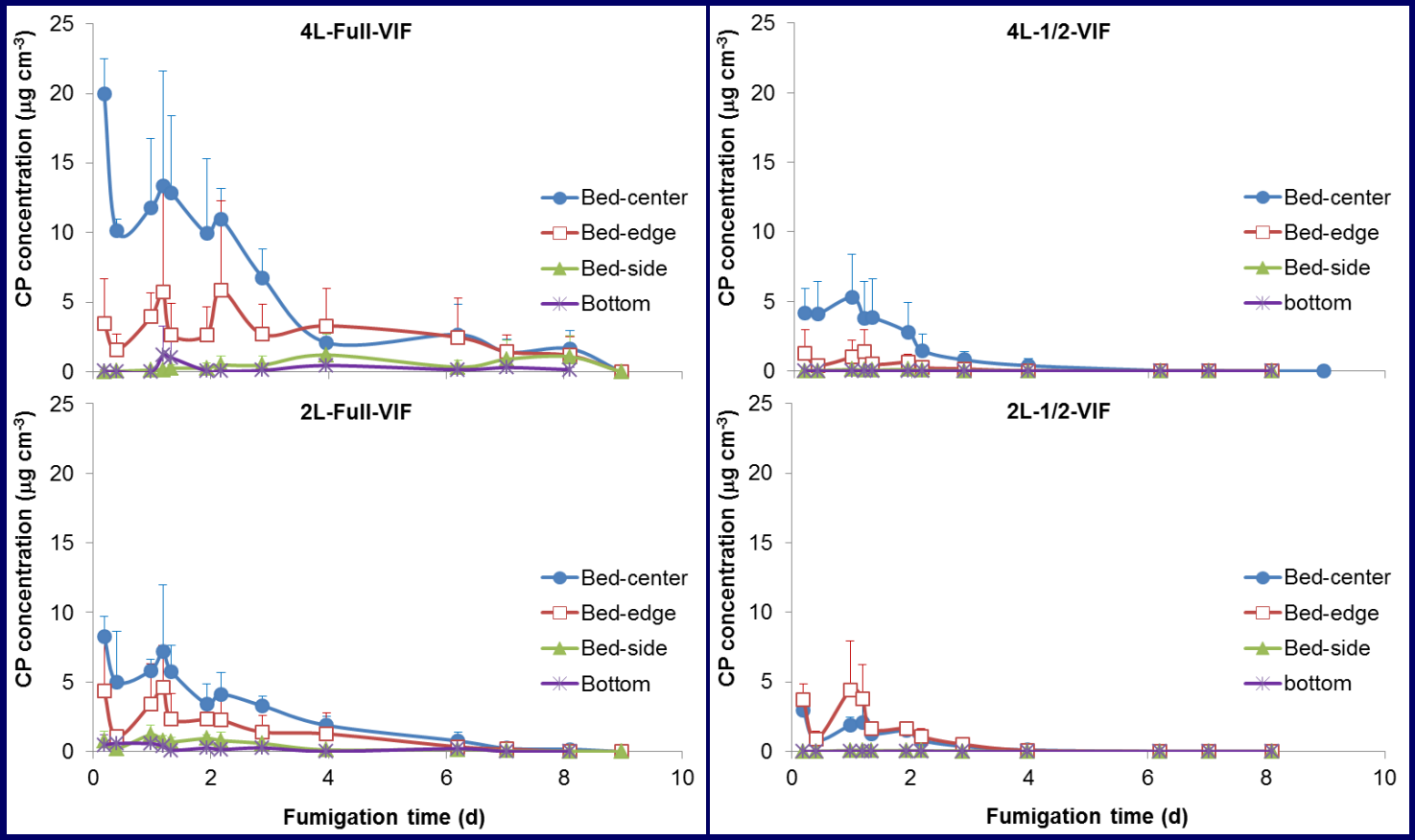
- Plant growth measurement:
  - Strawberry plant cover on bed
    - With a multispectral camera
  - Canopy size
  - Stomatal conductance and resistance
    - with a Leaf Porometer Model SC-1.
  - Leaf greenness
    - with a SPAD-502.

Results

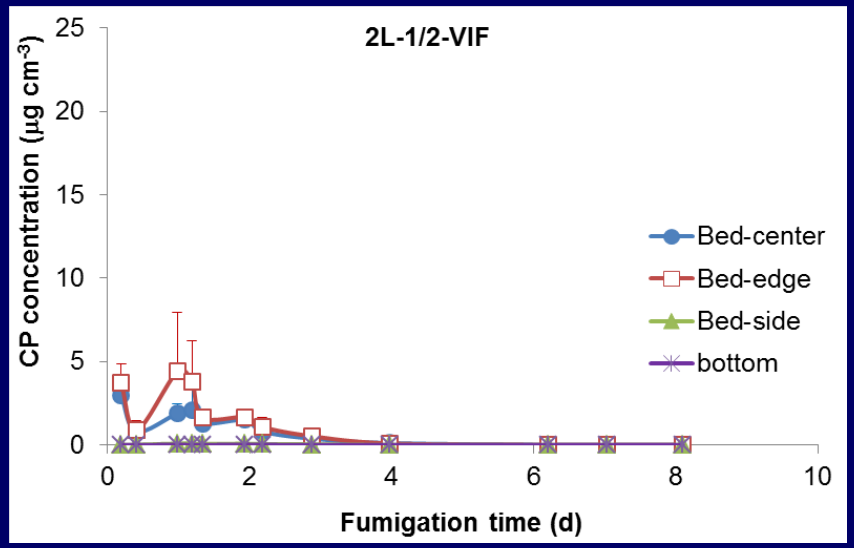
- Fumigant concentration under film (AU).
- Fumigant distribution in soil profile.
- Fumigant emission.
- Pest.
- Berry production.

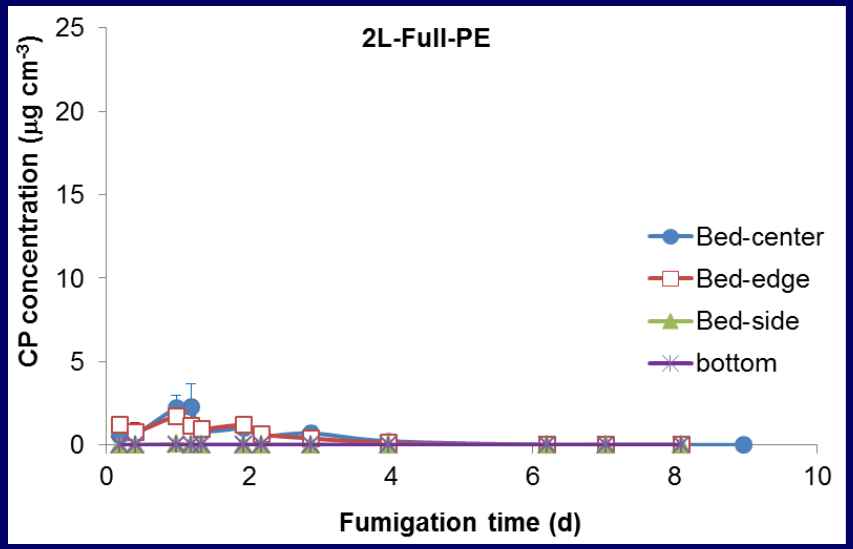
- Fumigant concentration under film (1):
  - Bed top >> side ≈ bottom.
  - Half-rate < full rate.
  - 4 lines > 2 lines.



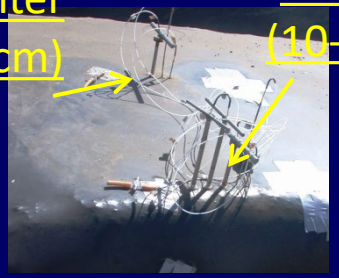


- Fumigant concentration under film (2):
  - Full rate under PE had lower concentrations than half rate under VIF.

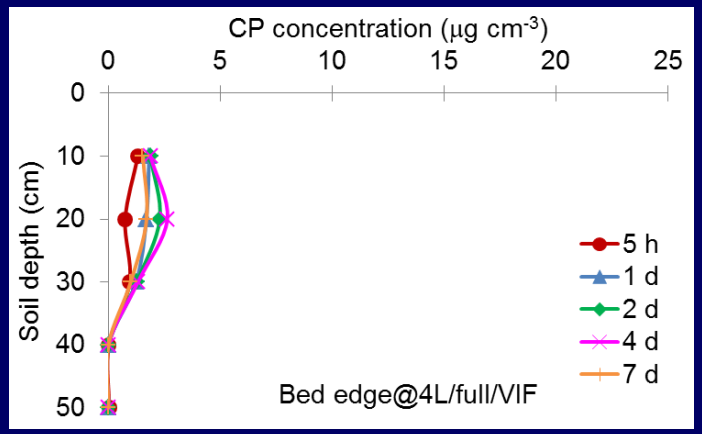


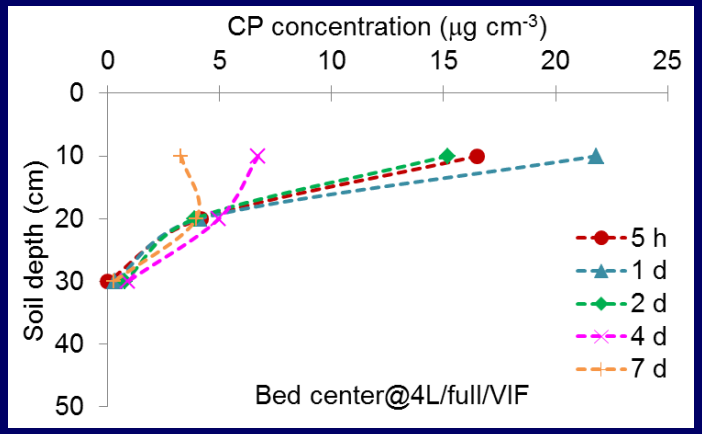


- Fumigant distribution in soil —— full rate under VIF:

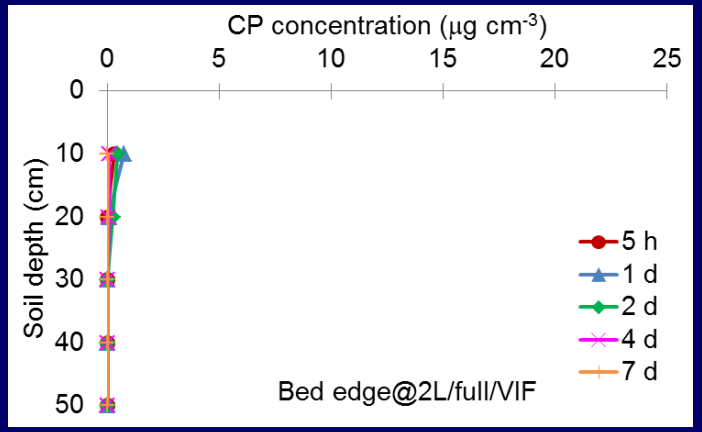


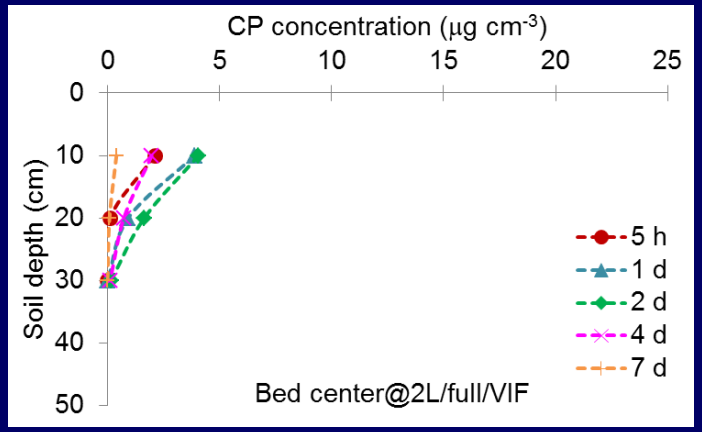
– 4 drip line application



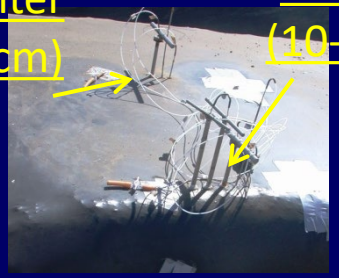


– 2 drip line application

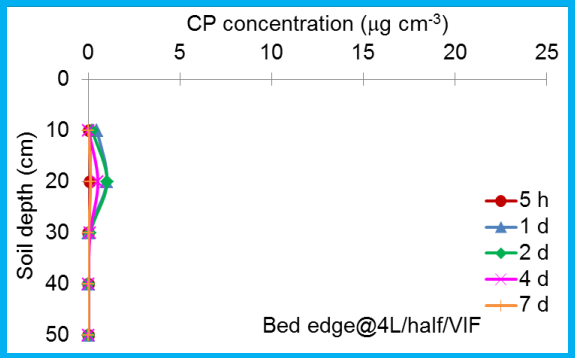


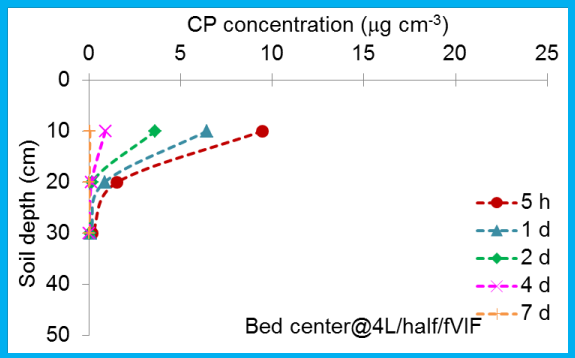


- Fumigant distribution in soil
  - half rate under VIF vs. full rate under PE:

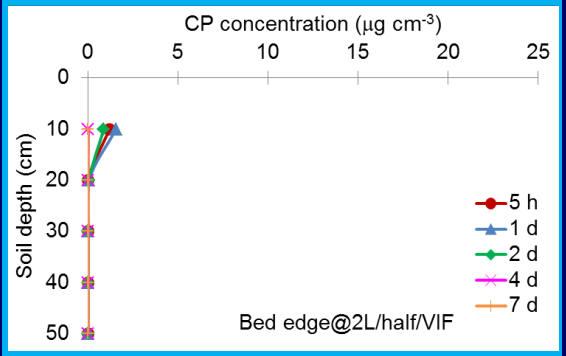


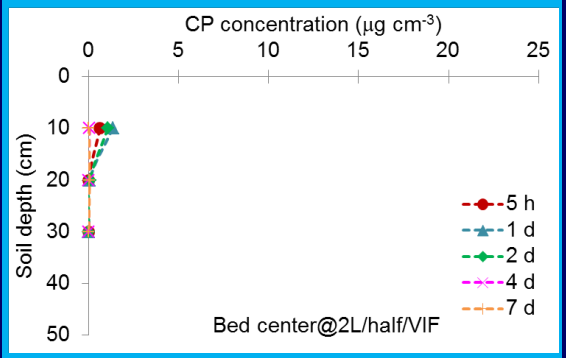
– 4 drip line/VIF



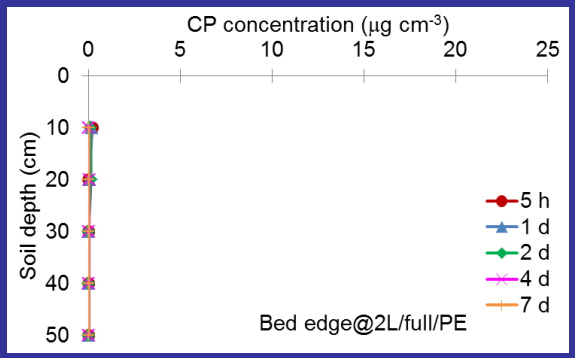


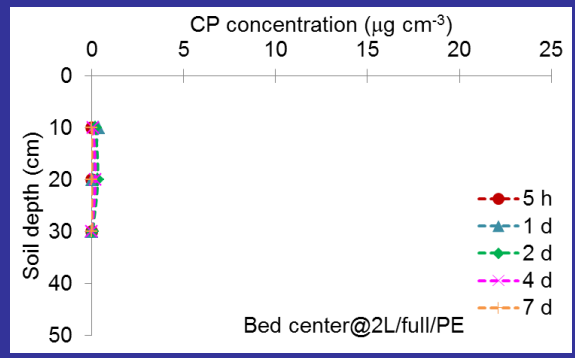
– 2 drip line/VIF



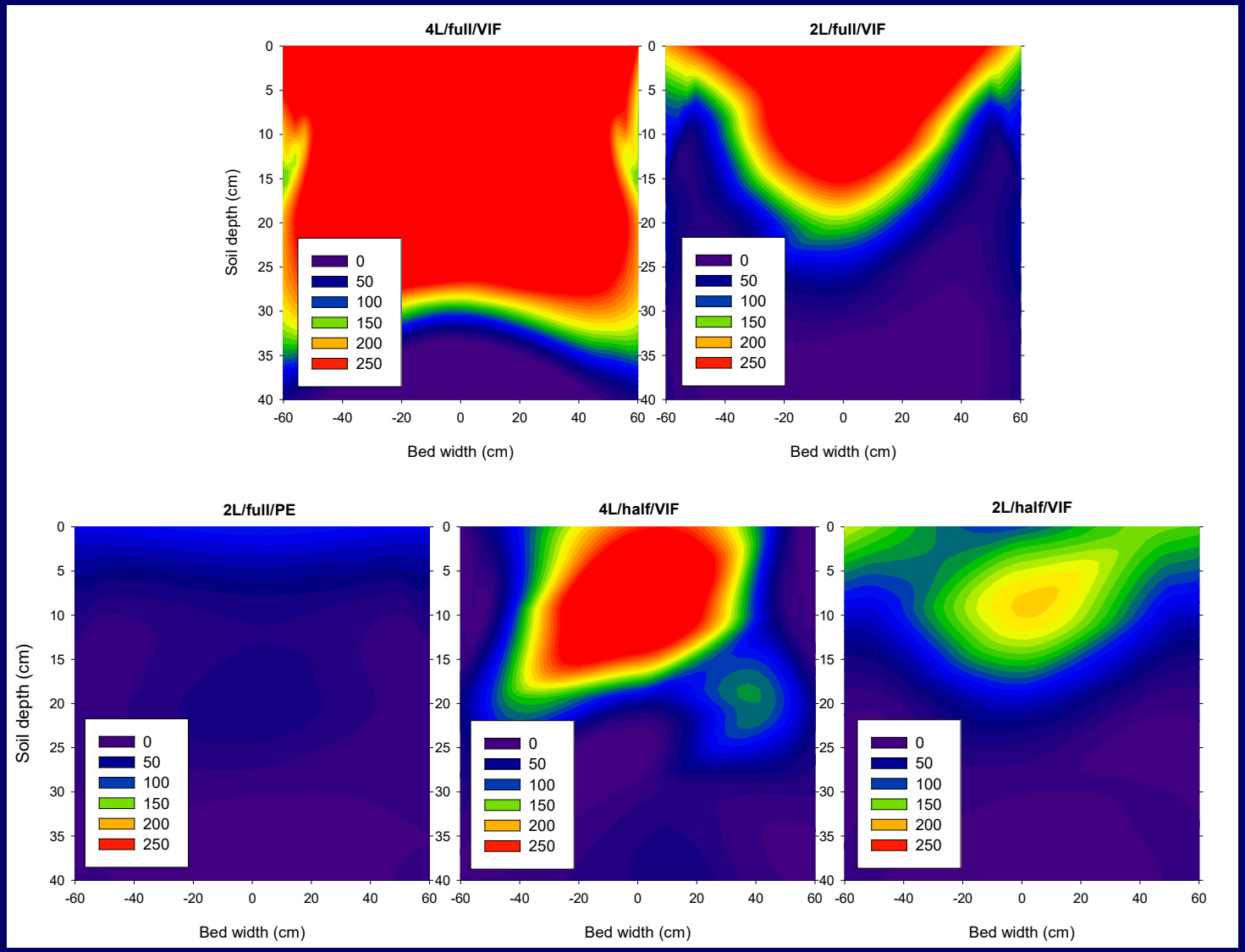


– 2 drip line/PE

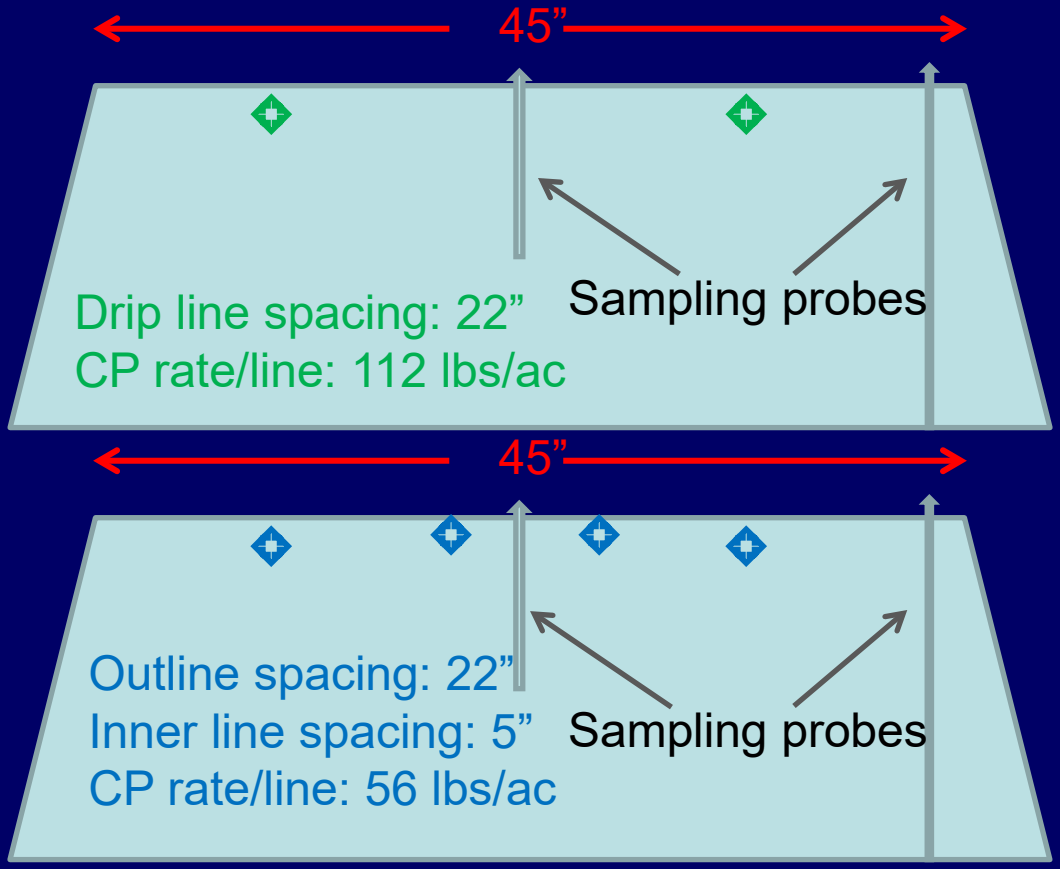




- Concentration-time exposure index (μg cm^{-3} h):



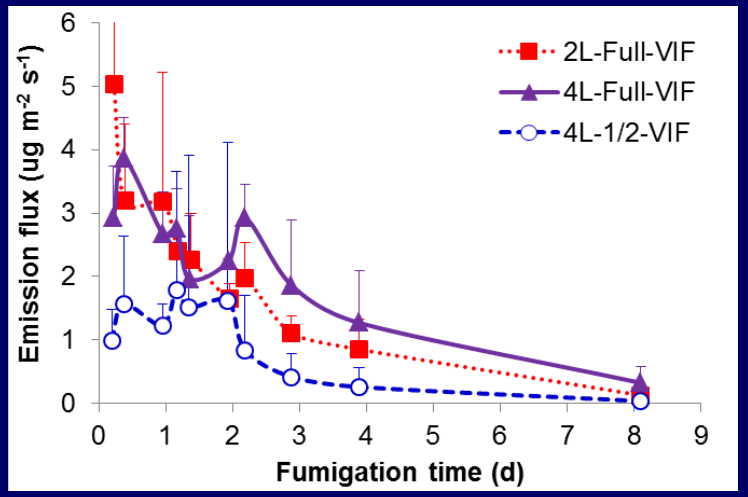
- Raised-bed configuration, drip lines, and sampling probes:

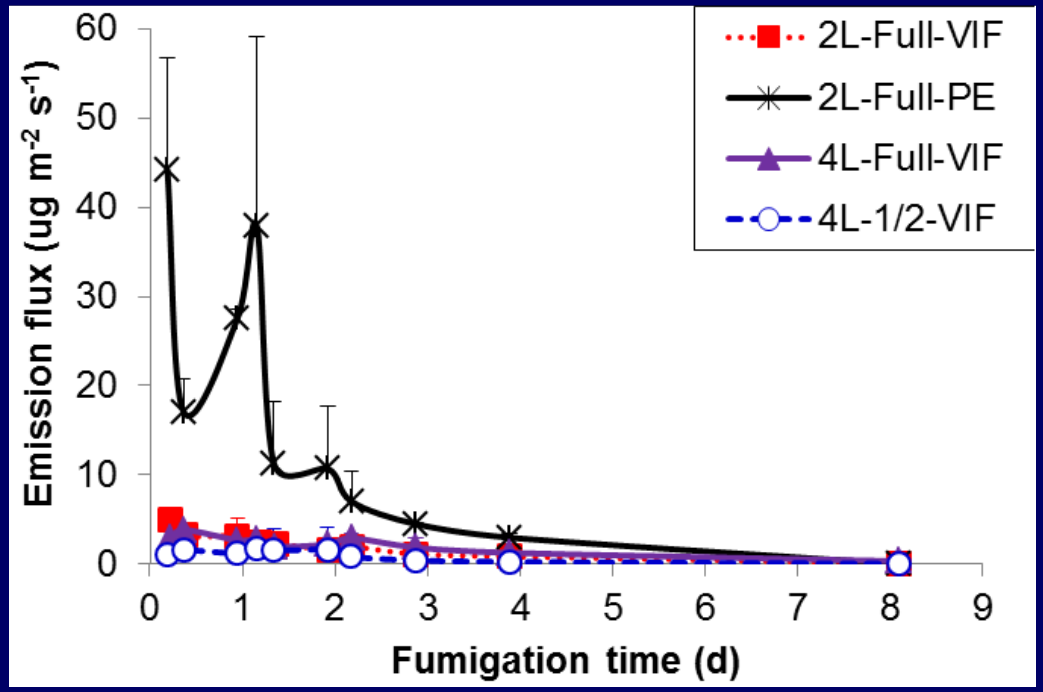


- Fumigant emissions:

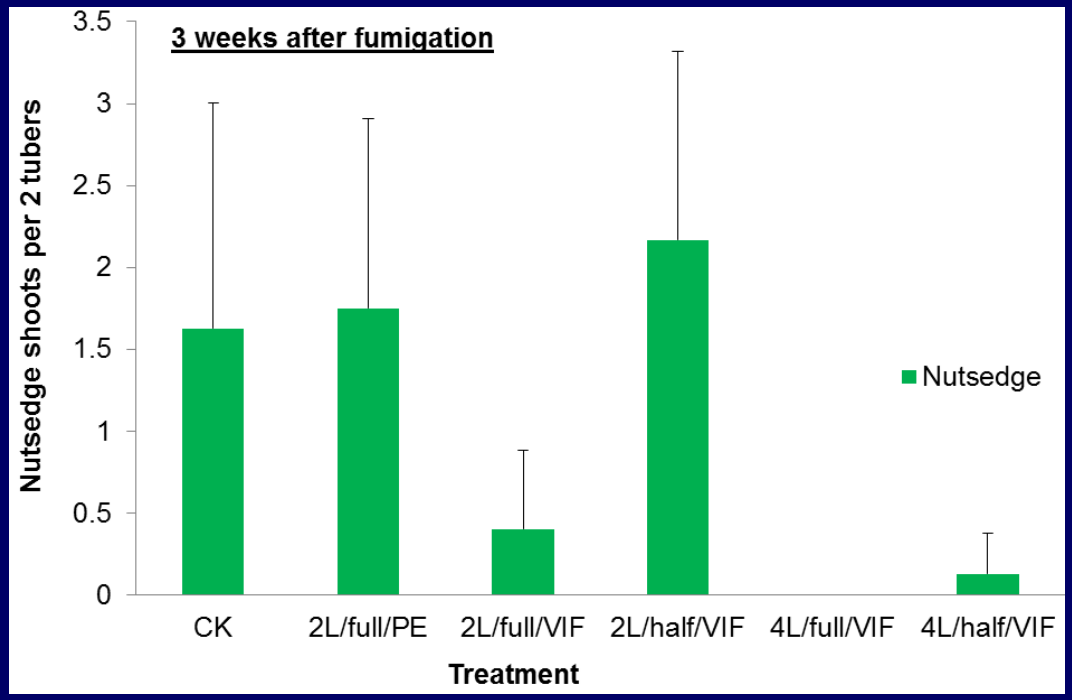
  - VIF tarped-beds had dramatically lower emission flux than PE tarped-beds.

  - Emissions from furrows were at trace level regardless tape number, application rate, and film type.

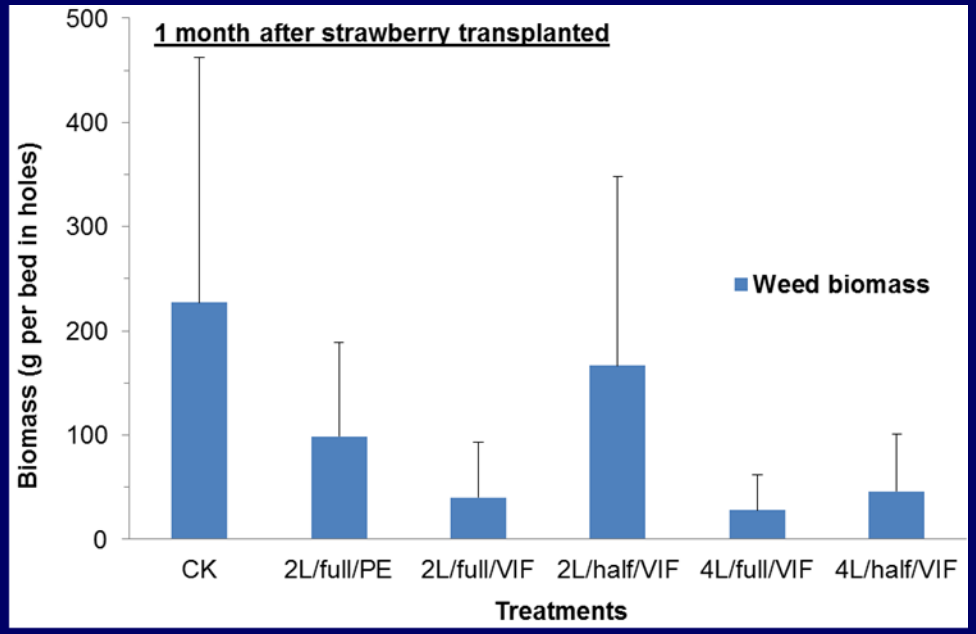




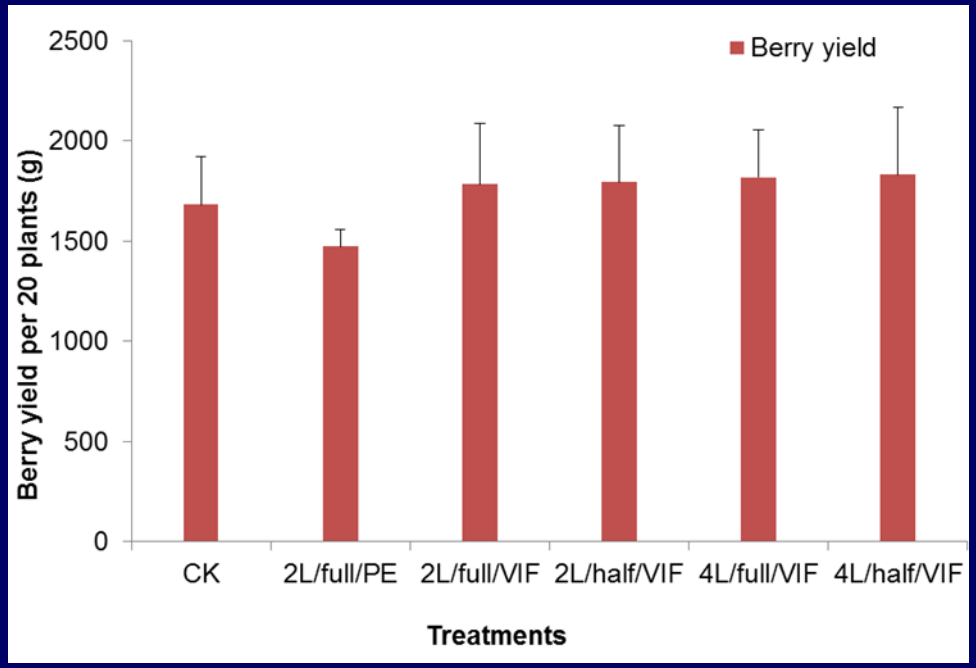
- Pre-buried nutsedge control:
  - Pre-buried nutsedge tubers at 6” depth at bed centers and near bed edge.



- Weed occurrence post fumigation:
  - The occurrence of weeds at the holes where strawberry plants grow:



- Strawberry growth during early stage:
  - VIF treatments showed a better yield.
  - No significant difference was found for strawberry growth, such as canopy size, leaf conductance, and leaf greenness.



*** The measurement was on 20 plants per beds.**

On-going measurement

- Residual fumigant determination.
- Soil fumigation on controlling pathogen.
- Pest occurrence during strawberry growth season.
- Strawberry growth and yield throughout the season.

Summary

- Reducing 50% application rate under VIF may achieve better results than full rate under PE.
- Increasing drip line number contributed to higher fumigant concentrations.
- Low emissions occurred from the VIF tarped-beds.
- Emission from furrow was not a concern.
- Increasing drip line numbers and/or VIF tarping provided better pest control and early yield.
- Our data suggest that increasing drip line number and VIF covering will be the optimized fumigation technology in raised-bed production systems.

Future research need

- How to improve fumigant concentration at deeper depth?
  - Fumigant concentration at deeper depth is relatively low, which may compromise the pest control result.
  - Applying fumigant deeper should be a solution.

- How to improve the uniformity of fumigant distribution?
  - Studying water distribution pattern and determine the best dripping tape spacing.

Acknowledgment

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