# Anaerobic Soil Disinfestation

## Introduction

In 2013, Farm Fuel Inc. was awarded a grant by the California Department of Pesticide Regulation to better introduce anaerobic soil disinfestation (ASD) to conventional berry growers in California and facilitate its adoption; especially in light of the phase out of methyl bromide. Participating growers were provided with materials, consultation and monitoring for one-acre field trials to demonstrate the efficacy of ASD. In addition, larger demonstration plots were established to demonstrate application of ASD on a commercial acreage scale.

Since 2011, Farm Fuel Inc. has been working with researchers from UCSC, UC Cooperative Extension, the USDA, and berry farmers in California to test the efficacy and efficiency of ASD as an alternative to chemical fumigation. While more on-farm research and development is needed, ASD has great potential to be a viable alternative to methyl bromide—slated for phase out in 2016—and other fumigants such as chloropicrin and 1,3-D.

## Survey: ASD for Berry Farmers

Farm Fuel Inc. set up 22 trial sites—two 20-acre demonstration sites and 20 one-acre plots. They surveyed 15 responding strawberry and raspberry farmers, 12 of whom used ASD on strawberries. The intended participants of this study were conventional growers but growers were allowed to implement the trials on organic ground. Farms were located in Santa Barbara County, Ventura County, Monterey County and Santa Cruz County. Survey results were obtained through self-reporting and anonymity was guaranteed.

Twelve (80%) of the responding farmers used ASD on organic sites, while three used it on conventional sites. Growers reported that standard operating procedures on conventional ground included fumigation with chloropicrin, 1,3-D or Pic-Clor 60, a formula combining the two fumigants, while the farmers growing organically generally used nothing (7), crop rotations (4) and/or applications of mustard seed meal on their non-ASD acreage

### How does ASD work?

ASD works in part by creating anaerobic (signifying a lack of oxygen) conditions in which pests and diseases are unable to survive.

ASD starts with an initial application of a carbon source which acts as a food source for anaerobic soil organisms. Rice bran was the source of carbon in this project.

After adding the carbon source, the soil is irrigated to the level of saturation (filling every available pore space) and covered with a tarp to sustain anaerobic conditions.

Anaerobic soil organisms can then undergo respiration using the added carbon source for energy, which creates by-products that are harmful to pathogens.

After 21 days, the tarp is removed, or holes are punched in the tarp for planting, and anaerobic by-products degrade, allowing beneficial aerobic soil microorganisms to return.

# Survey Results

## Application methods & monitoring results

Of the 22 sites included in the project, 18 (82%) of the growers applied the material to a flat field at the start of field prep, while 4 (18%) of the growers applied the material with a bed-topped applicator followed by a roto-tilling bed-shaper (Farm Fuel Inc., direct grower communication). From the survey results, 12 (80%) of the responding growers reported that from the time of material application to the time the irrigation was turned on was five days or less, while two (20%) growers took 18 to 19 days to have irrigation installed and turned on. The current recommendation is to complete this process in seven days or less.

From the survey results, nine (60%) growers reported using compost, five of whom also used pre-plant NPK fertilizer. Of the six growers not using compost, four applied pre-plant NPK and the other two applied pre-plant organic amendments. Only seven growers reported conducting soil N tests. Six of those seven reported test results; all had higher N levels in the ASD treated sites and 3 of those growers reported applying less in season fertilizer on ASD sites as a result.

Farm Fuel technicians monitored each site for soil conditions including anaerobicity of the soil (measured in mVhrs), which is a measurement used to determine the success of the ASD process. Of the 22 sites, 41% measured strong anaerobic conditions, 23% moderate, and 36% of the sites had weak anaerobic conditions. From the limited responses, combined with the fact that factors that can affect anaerobic soil conditions are not universal across all farms, the conditions needed for the most anaerobic conditions are not entirely known at this time. Even incorporation of material followed by efficient field preparation and short waiting time before irrigation is applied combined with warm soil temperatures continue to be the recommendation for best success.

## Plant growth & yield

For the most part, ASD resulted in the same quality of crops, if not better, compared to adjacent non-ASD fields. Twelve of the 15 survey respondents (80%) reported an initial advantage in ASD blocks compared to their adjacent non-ASD blocks (either conventional or organic)—larger plants (9), earlier production (2), reduced disease (1). Fourteen of the respondents (93%) reported their ASD yields as "consistent" with yields in adjacent non-ASD blocks. Eight (53%) respondents reported a slight ASD advantage in terms of marketable yield.

While most of the farmers experienced no difference in insect pressure, and no diseases in their ASD fields compared to their non-ASD blocks, four of the 15 farmers reported that mildew was more prevalent in ASD blocks throughout the season. Only one out of the 15 farmers experienced salinity damage with ASD, while another reported that there was noticeably less salt stress.

## Will farmers use ASD again?

Nine survey respondents (60%) said they would use ASD again—Four on organic crops, four on both organic and conventional crops, and one on conventional crops. The 40% who would not implement ASD again stated high costs as their main hindrance. Nevertheless, 12 respondents (80%) said that they would use ASD in buffer zones.

## Costs

The main weakness of ASD that many of the farmers listed was its high economic cost. Because of this, some farmers have said it would only be economically advantageous to use ASD for organic crops, as higher organic prices could offset the cost. Similarly, while eight (53%) of the farmers experienced modest increases in marketable yield, some stated that the increased yield was not enough to compensate the increased expense. Most farmers reported that ASD required more time and labor compared to both conventional and other non-ASD organic methods.

***Pictured right:*** Bed top application of carbon
***Photo credit:***
Farm Fuel Inc., 2013

## Off-farm Costs & Benefits

While farmers are primarily concerned with direct costs of production, it is important to consider indirect costs associated with fumigant exposure among workers and near-farm community members. In 2012, DPR reported 106 cases of acute fumigant poisonings of workers on or near fumigant-treated fields statewide.[1] Due to potential under-reporting[2], actual numbers of fumigant-related adverse health effects may be higher.

## Room for Improvement

While initial results are quite promising, it is clear that in order for ASD to be both agriculturally and economically successful, more research and development—along with direct support for growers—is necessary.

Many of the farmers surveyed by Fuel Farm Inc. felt that they lack adequate time or money to use ASD regularly. Farmers and their workers need adequate time and resources to successfully use ASD or any other fumigant alternatives. This is a critical area in which the state should invest. While many of the surveyed farmers are hesitant to fully embrace ASD in its current state as a replacement for soil fumigants, some respondents did provide the following suggestions:

- Improve on the timing and efficiency of land preparation.
- Improve on the application methods generally.
- Research alternative C sources. In response to the question about interest in alternative C sources nine respondents (60%) said "yes."
- Continue experimenting with integration of ASD and mustard seed meal for improved control of soil-borne diseases.
- Experiment with the combination of ASD and crop rotation

Many of these topics are currently under investigation by Drs. Carol Shennan and Joji Muramoto at UCSC (see resource listed on back page).

## Future Research & Development Goals

In 2014, approximately 1000 acres of berry land in California was treated with ASD, nearly three times the amount of land from the previous year. This has been supported with more than 10 years of research at UCSC and internationally. To advance the efficacy and reliability of ASD at the production scale, more research and development should continue. This includes support to:

- Enhance pathogen and disease control by developing recommendations for how to optimize ASD for specific pathogens and environments;
- Continue to experiment with different sources of carbon;
- Experiment with different soil types, and cultural practices;
- Monitor and evaluate farmer experiences with ASD; and
- Support continued industry adoption.

## WHAT THE FARMERS ARE SAYING

*The plants had "larger, healthier, more vigorous shinier leaves, better roots, but plants at this state slowed down after peak."*

*"Plants were more advanced in development."*

*With ASD, "production was 30% better in some fields."*

*ASD was "easier on the neighbors."*

## Policy Recommendations

For more than a decade, the federal government as well as California Department of Pesticide Regulation and the California Strawberry Commission have been contributing funds to investigate alternatives to chemical fumigants. This policy approach should continue with the following emphases:

1) **Provide direct grants** to innovative fumigant alternative pilot projects including ASD;

2) **Invest in continued research and development** of alternative ASD inputs with an emphasis on field-scale trials including farmers' evaluation of efficacy;

3) **Create a low-interest loan program** for ASD implementation;

4) **Provide a crop insurance subsidy** to farmers who are willing to test ASD on their farms as an explicit replacement for soil fumigation. Insurance will encourage those with a greater perception of risk to try out ASD and/or other alternative pre-plant treatments.

5) Include **ASD in Healthy Soils Initiative Funding**

### Want to learn more about ASD?

- **University of California, Santa Cruz ASD webinar:** https://youtu.be/_7phq_p2JQk
- **Organic Pest Management Options Anaerobic Soil Disinfestation**: http://capca.com/assets/pdf/Berries/Organic_Pest_Control_Options_ODaugovish_Aug2015.pdf
- **ASD educational event held in 2013** (English): https://www.youtube.com/watch?v=EiQ73BqShv0
- **ASD educational event held in 2013** (Spanish): https://www.youtube.com/watch?v=9E5zF3x2bws

### Resources

1. California Department of Pesticide Regulation. CalPIQ Pesticide Illness Query database. Available at: http://apps.cdpr.ca.gov/calpiq/.

2. Reeves, M., A. Katten and M. Guzmán. 2002. Fields of Poison 2002: California farmworkers and pesticides. Pesticide Action Network, San Francisco, CA.

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