A NEW SOLAR HEAT PULSING TECHNOLOGY AS A POTENTIAL PEST-CONTROL STRATEGY

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Problem: Growers in California and Florida face intense regulation of soil fumigants due to bystander-exposure and near-surface ozone issues. For example in Ventura County, a prime strawberry growing region of California, fumigation was temporarily suspended placing growers at extreme risk of crop failure and near certain death of an essential agronomic industry. Subsequent lifting of the ban has helped producers in the short term, and has heightened awareness of a significant economic vulnerability in this region. New non-fumigant methods to control pests are needed to assist growers located in regions influenced by urbanization, or where tropospheric ozone is problematic. Solarization has been proposed as a non-chemical alternative to fumigation and is conducive for fields located in urban environments. However, there has been limited adoption of this technology due to insufficient reliability, inadequate heating depth, and climate constraints that reduce soil heating efficiency. For crop production to continue in areas influenced by urbanization, new tools to control pests are essential.

Hypothesis: A new technology, Solar Heat Pulsing, will control plant pests without the need for soil fumigation, improve public & environmental health, and enable growers to continue producing crops in highly urbanized areas.

Objectives: To conduct a pilot study to compare *passive solarization* and *solar heat-pulsing* to a control plot to determine if increased soil temperatures, improved soil temperature uniformity and penetration depth occur.

Location: The field experiment was conducted (9/26/08 – 10/31/08) in Field 2B, at the University of California, Riverside, Agricultural Experiment Station. The soil type was an Arlington sandy loam (coarse-loamy, mixed, thermic Haplic Durixeralf), consisted of 64% sand, 29% silt, 7% clay and 0.92% organic matter, and had a pH of 7.2. The soil had remained fallow for several years and was fairly dry and aggregated. Several weeks before starting the experiment, the soil was repeatedly irrigated and plowed to bring the moisture content and soil tilth to typical agricultural conditions prior to soil fumigation. The initial water content was a fairly uniform 0.08±0.01 $cm^3\ cm^{-3}$ below 0.1 m and 0.04±0.01 $cm^3\ cm^{-3}$ in the surface layer (6 cm). The bulk density was 1.42±0.05 g cm^{-3} in the upper 16 cm of soil and 1.57±0.07 g cm^{-3} below.

Results: A cumulative heat index was used to infer control of plant pests in the experimental plots. The cumulative heating index, CHT_{To} [^oC-*hr*] is defined using:

$$HT_{T_o}(t) = \begin{cases} 0, & T < T_o \\ [T(t) - T_o]\Delta t, & T \geq T_o \end{cases}$$

with

$$CHT_{T_o} = \int_0^t HT_{T_o}(\tau)\, d\tau$$

where T_o is the threshold level, and Δt is the time interval. Although T_o should be determined for each organism, a value of 30^{o}C was used since, in a laboratory study, the survival of citrus nematode began to decrease when this temperature was exceeded. Furthermore, the laboratory study indicated that values of a cumulative heat index above 900 $^oC\text{-}hr$ were sufficient to control citrus nematode. Heating above about 1200 $^oC\text{-}hr$ was found to controlled barnyardgrass and fusarium oxysporum.

The field experiment was conducted after the warmest summer months (i.e., October). Results were obtained for the CHT_{30} values over the course of the experiment at three depths in the active solarization, passive solarization, and control plot. The data indicate that placing plastic film over the soil surface significantly increases soil heating compared to bare surface (i.e., control plot). After 30 days of passive solarization, the 5 cm depth observes CHT_{30} values that exceeded 800 $^oC\text{-}hr$; compared to less than 100 $^oC\text{-}hr$ for the control plot.

For the solar heat pulsing plot, the CHT_{30} at 5 cm increased to 1400 $^oC\text{-}hr$ after 30 days and is 63% higher than the passive solarization plot. Active solarization also has higher values at the 10 cm (206%) and 20 cm (250%) depths compared to passive solarization. This data confirms field observations that passive solarization is not as effective in heating deeper soil regions. Solar heat pulsing increases the depth of heating to 20 cm, but more study is needed to determine if sufficient pest control can be routinely obtained. Additional research is also needed to improve thermal efficiencies, to optimize timing and reduce the treatment period.

Summary: The approach of using a solar heat pulsing technology to increase soil temperatures appears to have promise. A significant advantage of this approach, if shown to work in production systems, is the reduced dependence on soil fumigants and associated reduction in public and environmental health risks.

This approach may also be useful for continued crop production in fumigant buffer zones, since no fumigant chemicals would be used.

For situation where heating is not sufficient for the target organism, solarization followed by a reduce-dose application of fumigants may be another option that will lead to significantly reduced emissions.