Research and implementation efforts continue to advance the knowledge needed to provide effective and economical alternatives to agricultural soil fumigation. There are many reasons to support these efforts, including protection of human and animal health, protection of the environment, and development of organically-acceptable farming technology desired by consumers. Solarization and biosolarization are two, closely related approaches that have had significant adoption by end-users in various parts of California. The process known as anaerobic soil disinfestation (ASD) is another, similar treatment. Solarization and biosolarization both rely upon plastic film covering moist soil, which is passively heated by solar radiation during warm weather (Figure 1). Numerous field studies have shown that, under proper conditions, these approaches can provide fumigant-like reductions in soilborne pests. Many organic and conventional growers have worked within these conducive conditions and successfully adopted these methods (for details, see Stapleton et al., 2007). Biosolarization is simply solarization with the deliberate addition of selected organic soil amendment(s). Because there are a number of non-optimal conditions which can decrease the efficacy and/or predictability of solarization, biosolarization seeks to improve the pesticidal activity of the treatment, while simultaneously contributing to the overall fertility and microbial richness of the treated soil.

Neither solarization nor biosolarization are new concepts or practices in California agriculture. They have been used successfully as soil disinfestation treatments, mostly by organic producers, for 30 years (for details, see Stapleton et al., 2006). Practitioners use a wide choice of organic amendments for their biosolarization treatments. As an example, an early biosolarization trial in a field infested with southern root knot nematode (*Meloidogyne incognita*) was conducted in 1991 to 1992 at the UC Kearney Agricultural Research and Extension Center, in the central San Joaquin Valley (for details, see Gamliel and Stapleton, 1993). Ten tons per acre of commercially-available chicken compost was used as the soil amendment, with and without four weeks of solarization during the summer. Following soil treatment, the plots were double-cropped to fall- and spring-harvested leaf lettuce. The study showed that, while composting or solarization alone each moderately lowered nematode galling on lettuce roots, both treatments together reduced galling to undetectable levels (Figure 2). Furthermore, soil disinfestation by the combined biosolarization treatment provided the highest lettuce yields in both fall and spring crops (Figure 3).

In order to improve these soil fumigation alternatives, research must utilize results obtained from field trials to more deeply explore the physical, chemical, and biological underpinnings of their pesticidal activity and impacts on soil health. To this end, we have conducted a number of recent studies on the components of biosolarization. Among other solid waste materials, we have continued to focus on use of composts as amendments, although our interests have been on plant-based materials, rather than on animal by-products. There are useful similarities between finished composts and solarization: both are heat-based processes that tend to select for heat-tolerant microbial communities. With...
a few exceptions, heat-tolerant soil organisms tend to be competitors to plant pest organisms. In addition to compost, we have evaluated wheat bran and pomaces of processing tomato and red and white wine grapes as soil amendments (Figure 4).

An initial step of our recent, in-depth evaluation of biosolarization mechanisms was to examine heat generation during treatment. Both biological activity and potential phytotoxicity in solarized soil amended with mature greenwaste compost plus wheat bran were measured. Our earlier results were confirmed, showing that organic matter amendment increased soil heating during first week of solarization, by means of aerobic heat of respiration. Measurements showed that approximately 85% of the total respiration potential of the amended soil was exhausted during the 22-day treatment period. Freshly-amended soil was initially phytotoxic to lettuce seedlings prior to solarization, but was remediated following the treatment period (for details, see Simmons et al., 2013).

In addition to the heat generation and respiration evaluations, microbial community structures in the same amended soils were studied. Bacterial composition was found to vary with depth in the biosolarized soil. Bacterial communities were enriched in the amended and solarized soils. As might be expected, the new bacterial community structures reflected a significant degree of thermostolerance. This change was associated both with the bacterial consortia added with the compost, and with the soil heating during solarization. The soil amendments affected levels of agriculturally-relevant bacteria after solarization, which may have overall ramifications for soil health (for details, see Simmons et al., 2014). Apart from the soil ecological aspects, biosolarization using greenwaste compost plus wheat bran gave excellent initial weed control results in field trials (for details, see Hernandez et al., 2012). Black mustard (Brassica nigra) test seeds buried at five inch depth in biosolarized plots showed 100% mortality after 3 days of treatment, while those in solarized plots without organic amendment tested at 87% mortality after 22 days of treatment (Figure 5).

More recently, the biosolarization potential of tomato and grape processing wastes was assessed. Simulated and field biosolarization gauged weed seed inactivation mechanisms in amended soil. Processing tomato and white wine grape pomaces provided significant soil heating via respiration, as well as a moderate drop in soil pH. Oxygen availability in soil influenced the magnitude of heat of respiration, and of acidification. Pest inactivation conditions induced during biosolarization with red wine grape pomace appeared to be less promising (for details, see Achmon et al., 2015).

Our biosolarization studies will continue, with the objectives of improving nonfumigant (and organically-acceptable) soil disinfection efficacy, optimizing treatment technologies, and promoting overall soil health.
In addition to the research reports cited herein, a UC Agriculture and Natural Resources website devoted to resources on solarization, biosolarization, and related techniques is available online (for details, see Stapleton, 2015).

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For More Information:

Figure 4. Promising biosolarization results have been found following soil amendment and solarization treatment with plant-based solid waste materials: (L) finished greenwaste compost and (R) processing tomato pomace. Photos: J. Stapleton

Figure 5. Mortality of black mustard (Brassica nigra) seeds buried at a five-inch depth in a field trial at UC Kearney Agricultural Research and Extension Center. Red bars represent seed mortality in soil biosolarized with greenwaste compost plus wheat bran, while yellow bars show seed mortality in solarized soil without amendment.
Figure 6. Pole tomato plants on biosolarized beds in the San Joaquin Valley. Photo: J. Stapleton


