

SOIL SOLARIZATION FOR GARDENS & LANDSCAPES

Integrated Pest Management for Home Gardeners and Landscape Professionals

Soil solarization is a nonchemical method for controlling soilborne pests using high temperatures produced by capturing radiant energy from the sun. The method involves heating the soil by covering it with a clear plastic tarp for 4 to 6 weeks during a hot period of the year when the soil will receive the most direct sunlight. When properly done, the top 6 inches of the soil will heat up to as high as 140°F, depending on the location. The plastic sheets allow the sun's radiant energy to be trapped in the soil, heating the top 12 to 18 inches and killing a wide range of soilborne pests, such as weeds, pathogens, nematodes, and insects.

The effect of solarization is greatest at the surface of the soil and decreases at deeper soil depths. The maximum temperature of soil solarized in the field is usually 108° to 131°F at a depth of 2 inches and 90° to 99°F at 18 inches. Control of soil pests is usually best for organisms found in the upper 6 inches of earth.

Solarization leaves no chemical residues and is a simple method appropriate for the home gardener or the large scale farmer (Fig. 1). It can improve soil structure by increasing the availability of nitrogen and other essential nutrients for growing healthy plants, as well as controlling a range of pests.

BENEFITS

Solarization during the hot summer months can increase soil temperature to levels that kill many disease causing organisms (pathogens), nematodes, and weed seeds and seedlings. It leaves no toxic residues and can be easily used on a small or large scale garden or farm. Soil solarization also

speeds up the breakdown of organic material in the soil, often resulting in the added benefit of release of soluble nutrients such as nitrogen (NO_3^- , NH_4^+), calcium (Ca^{++}), magnesium (Mg^{++}), potassium (K^+), and fulvic acid, making them more available to plants.

Plants often grow faster and produce both higher and better quality yields when grown in solarized soil. This can be attributed to improved disease and weed control, the increase in soluble nutrients, and relatively greater proportions of helpful soil microorganisms.

Effectiveness on Various Pests

The degree various pests can be controlled is related to the intensity, depth, and duration of the elevated soil temperatures. Although some pests may be killed within a few days, 4 to 6 weeks of exposure to full sun during the summer is required to ensure control of many others. See UC ANR Publication 21377 in References for more information about solarization and specific pests controlled.

Fungi and Bacteria. Solarization controls many important soilborne fungal and bacterial plant pathogens, including those that cause Verticillium wilt, Fusarium wilt, Phytophthora root rot, Southern blight, damping off, crown gall disease, tomato canker, potato scab, and many others. A few heat-tolerant fungi and bacteria are more difficult to control with solarization.

Nematodes. Soil solarization can be used to control many species of nematodes. Solarization for nematode control is particularly useful for organic and home gardeners. However, soil

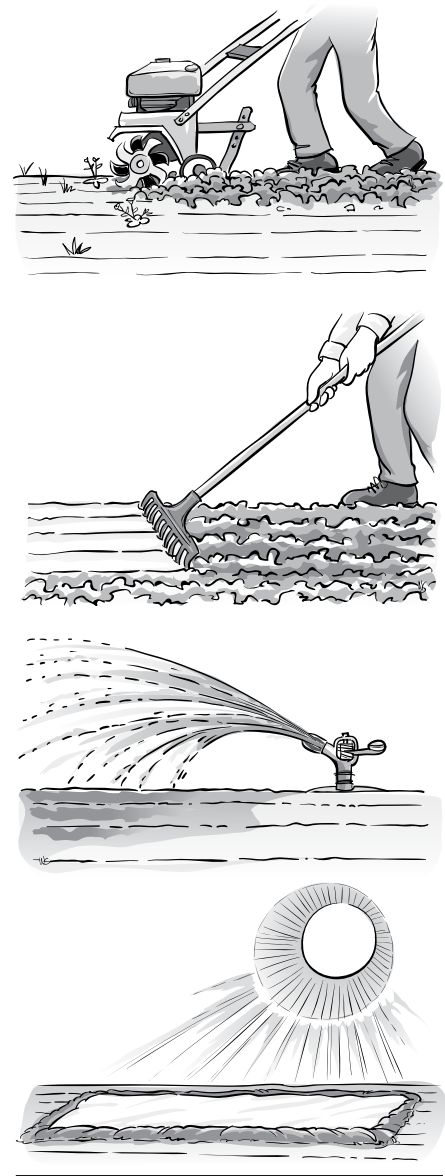


Figure 1. Follow these four steps to solarize your soil: cultivate and remove plant matter; level and smooth the soil; irrigate; and lay a clear tarp on the soil surface for 4 to 8 weeks, depending on local conditions.

PEST NOTES

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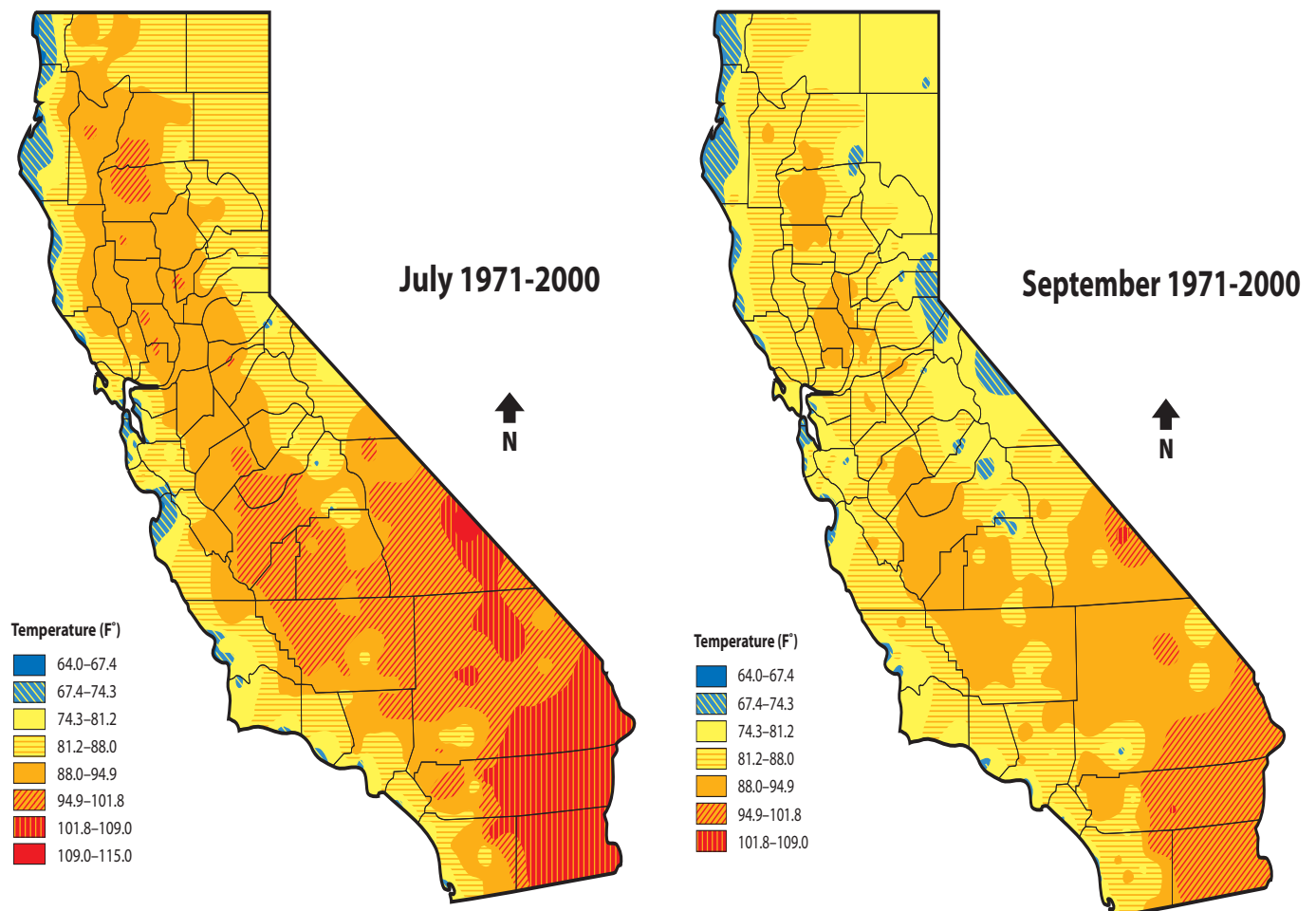


Figure 2. Mean Maximum Air Temperatures in California. July is the hottest and most reliable time for initiating solarization in most of California (left), except for coastal areas, which are warmer in September (right) when there is less fog (adapted from <http://solar.uckac.edu>).

solarization is not always as effective against nematodes as it is against fungal disease and weeds, because nematodes are relatively mobile and can recolonize soil and plant roots rapidly. Control of nematodes by solarization is greatest in the upper 12 inches of the soil. Nematodes living deeper in the soil may survive solarization and damage plants with deep root systems.

Weeds. Soil solarization controls many of the annual and perennial weeds present in California. While some weed species seeds or plant parts are very sensitive to soil solarization, others are moderately resistant and require optimum conditions for control (good soil moisture, tight-fitting

plastic, and high solar radiation). Solarization generally does not control perennial weeds as well as annual weeds because perennials often have deeply buried underground vegetative structures such as roots and rhizomes that may resprout. Rhizomes of bermudagrass and johnsongrass may be controlled by solarization if they are not deeply buried. Solarization alone is not effective for the control of the rhizomes of field bindweed. Control of purple and yellow nutsedge, as well as field bindweed arising from rhizomes and some clovers, can be inconsistent, even under favorable conditions.

Beneficial Soil Organisms

Although many soil pests are killed by soil solarization, many beneficial soil organisms are able to either survive solarization or recolonize the soil very quickly afterwards. Important among these beneficials are the mycorrhizal fungi and fungi and bacteria that parasitize plant pathogens and aid plant growth. The increased populations of these beneficials can make solarized soils more resistant to pathogens than nonsolarized or fumigated soil. Earthworms are generally thought to burrow deeper in soil to escape the heat.

METHOD

WHERE

Soil solarization is most effective in warm, sunny locations such as the Central Valley, desert valleys, and other inland areas of California. It also has been used successfully in the cooler coastal areas of California during periods of high temperature and no fog.

WHEN

Highest soil temperatures occur when days are long, air temperatures are high (Fig. 2), skies are clear, and there is no wind. The soil heating effect is not as great on cloudy days. Wind will disperse the trapped heat and may loosen or damage the plastic sheets. Shady areas may not be suitable for effective treatment.

Solarization is most effective when done during the hottest weeks of the year. The best time for solarization of soil in inland California is from June to August, although good results may be obtained starting as early as late May or as late as early September in the southern California desert regions. July is the most reliable time to solarize, except for coastal areas, where persistent, warm, fog-free periods may not occur until August or September.

How

1. Soil Preparation

A smooth bed, with clods and litter raked away, is best because the plastic will lie snugly against the soil and have fewer air pockets. Air pockets between the plastic and the soil can greatly reduce soil heating and promote "sailing" of the plastic in the wind. Solarization can be done on flat areas or raised beds. Flat areas are easiest to solarize (prior to lawn re-seeding, for example), but care should be taken if raised garden beds are going to be formed later so as to not disturb the soil much more than several inches. It is much better to form the beds first and place the plastic tarp on the preformed beds rather than forming beds after solarization. Disturbing the soil after solarization may bring up new viable weed seeds. If possible, when using raised beds lay them out

going north to south rather than from east to west to improve the uniformity of heating. The best solarization will occur on areas where there is little or no slope or where the slope has a south or southwest exposure. Solarizing areas on north-facing slopes is not as effective and may result in reduced pest control.

2. Irrigate the Soil

Wet soil conducts heat better than dry soil and makes soil organisms more vulnerable to being killed by heat and antagonistic microorganisms. Wet the soil to at least 12 inches deep. In larger areas it is easiest to do this prior to laying the plastic, but in smaller areas it can also be done after the plastic is applied by placing a garden or soaker hose, or drip tape under the plastic tarp. Otherwise, place the covers over the site as soon as possible after the water has been applied to reduce evaporation. Unless the soil gets dry during the course of soil solarization, do not irrigate again as this will lower the soil temperature and lengthen the time required for successful solarization.

3. Plastic Tarp Choice

Plastic material: In general, transparent or clear plastic is most effective for solarization, as the heating rays from the sun will pass through the sheet and be trapped to heat the soil below. Usually, black plastic is less effective because it absorbs and deflects part of the heat rather than trapping as clear plastic does. However, in cooler or coastal areas, black plastic is sometimes better than clear, because weeds won't grow beneath it, as they will under clear plastic when the air temperatures are too low to kill them. In this case, the black plastic should be left in place for several weeks during the hottest part of the year.

Several thicknesses of plastic tarp are available.

- Thin plastic provides greater heating, but is also more susceptible to tearing from wind or animals walking on it (1 mil).
- Slightly thicker plastic is better in

windy areas (1.5 to 2 mils).

- Thicker plastic can be used if the treated area is small (4 mil, for example).

(Note: 1 mil = 0.001 inch or 0.025 mm)

Plastics designed for large-scale solarization are usually treated with an ultraviolet (UV) inhibitor so they will not break down as quickly in sunlight. For use in gardens, the rolls of 1 to 4 mil "painter's" plastic are available at larger hardware stores and are easier to obtain. They will last just about long enough for the 3 to 5 week period of solarization, before beginning to break down. The plastic sheets should be watched closely so they can be removed before deteriorating to the point where removal and disposal are difficult. If a longer solarization period is desired, small areas can be covered again with fresh plastic. Any holes or tears should be patched with durable patching tape.

For small treated areas in a small garden or on a lawn in cooler climates, it may be helpful to use a double layer of plastic with air space created by objects such as plastic bottles or PVC pipe between the layers. This has been shown to raise soil temperatures an additional 2° to 10°F over temperatures obtained with a single layer of clear plastic.

4. Plastic Tarp Placement

Flat beds: The plastic must be held as tight as possible against the soil. One way to hold it down is to dig a trench 4 to 6 inches deep around the area that is going to be solarized. Lay the plastic out over the area with one edge in the trench. Cover that edge with soil to hold it down. Pull the plastic tight from the other side and bury that edge in the corresponding trench. Do the same with the other sides and then walk around the perimeter of the trenched area to pack the soil down around the edges of the plastic. The closer to the soil surface the plastic is, the better the heating.

Raised (formed) beds: As with flat beds, the plastic must be held close to the

soil. Multiple beds can be covered by a single sheet of plastic, but heating may be less and the plastic may “sail” when it is windy. If only single beds are covered, the furrows between the beds are left uncovered. Each bed is covered with a strip of plastic tarp that is wide enough to cover the entire bed width and have enough plastic material left over to bury the edges to hold it down. Avoid moving soil from the untreated furrows to the beds because this may re-infest the treated beds with pests.

5. Solarizing Period

Solarization is both time and temperature dependent. The cooler the soil temperatures, the longer the plastic needs to remain in place to raise the temperature to desired levels. In general, 4 to 6 weeks of soil heating during the warmest time of the year is sufficient to control most soil pests. In some cases, such as in cooler, windier, or cloudier locations, or if there are pests that are harder to control, it may be necessary to leave the plastic in

place 6 to 8 weeks. On the other hand, under persistent conditions of very hot weather, some pests can be controlled with a shorter period of solarization. Soil in the Central Valley and desert regions can be solarized for 4 weeks any time June through September. Most of California, except the north-east mountain areas and some inland valleys, can be reliably solarized late June through August.

The goal is to maintain daily maximum temperatures in the top 6 inches of soil at, or above, 110 to 125°F. Use of a soil thermometer or temperature probe can verify achievement of these temperatures.

6. Post-solarization

Removal of Plastic. After solarization, the plastic may be removed, taking care that the underlying soil is disturbed as little as possible to avoid bringing up viable weed seed. The area can be planted with seeds or transplants for a fall or winter crop or a lawn. Alternatively, the plastic may

be left on the soil as a mulch by cutting holes and transplanting plants through the plastic. Clear plastic may be painted white or silver to cool the soil and repel insect pests. However, the plastic tarp may degrade and fall apart during the growing season.

If the soil must be cultivated for planting, the cultivation must be shallow (less than 2 inches deep) to avoid bringing viable weed seeds and pathogens to the surface.

SOLARIZING SOIL IN CONTAINERS

Soil solarization has been shown to be effective for disinfesting small amounts of moist, containerized soil and soil in cold frames. Soil can be solarized either in bags, pots, plastic buckets, or flats. These containers are placed on an elevated surface such as wooden pallets and covered with a “double-tent” of transparent plastic (Fig. 3). Soil temperatures should be monitored closely in this planting media to assure that temperatures are high enough to control pests. As an

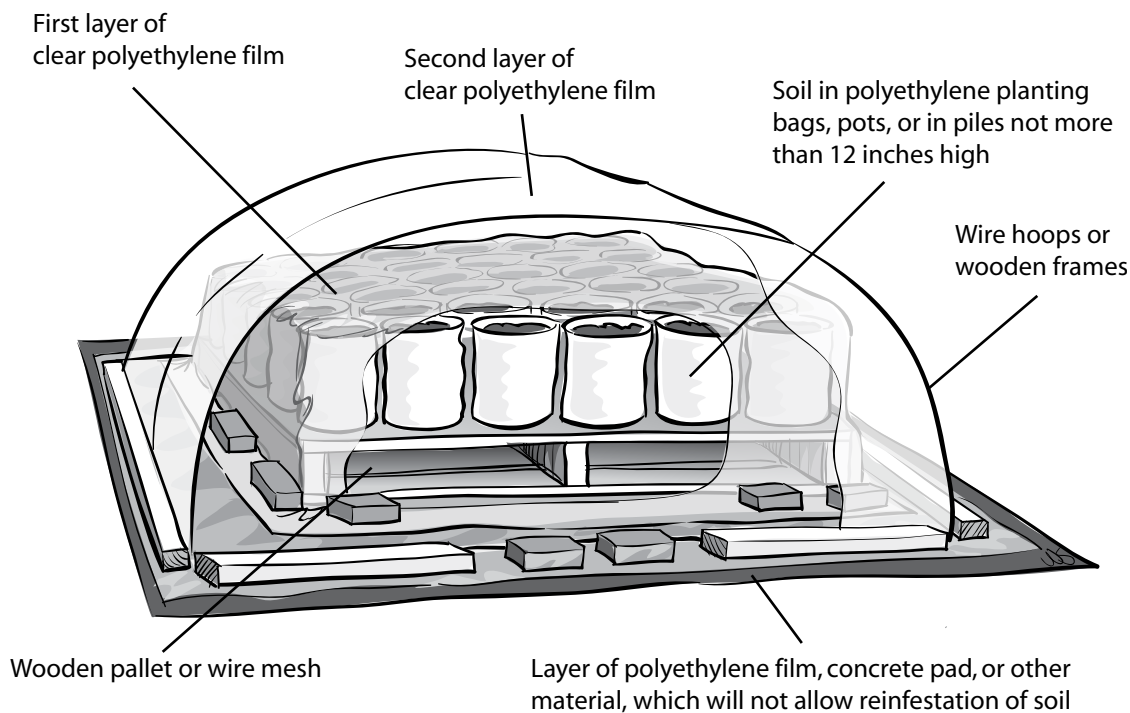


Figure 3. To solarize soil in containers, place soil in buckets or bags on an elevated surface and cover with a double tent of two layers of clear polyethylene film.

example in warmer areas of California, soil inside black plastic bags can reach more than 160°F during solarization. This is equal to target temperatures suggested for commercial soil disinfestation using aerated steam. At these temperatures, all soil pests can be killed within one hour. The double layer of plastic can increase soil temperatures by up to 50°F, and placing containers on pallets allows for heating from all sides of the soil mass. Alternatively, moist soil in pots, or as

a mass, may be placed in closed, black trash bags and placed on pallets. Soil temperatures can be monitored using simple soil thermometers inserted into the center of the soil mass, or by using thermocouples and a digital reading logger. Temperatures can be monitored at multiple locations, but the duration should be lengthened to raise the temperature at the coolest location to the desired level. As a guideline, to completely eliminate pests, maintain 158°F or higher for 30 minutes, or 140°F or higher for one hour.

For more information contact the University of California Cooperative Extension in your county. See your telephone directory for addresses and phone numbers.

AUTHORS: J. J. Stapleton, UC Statewide IPM Program, Kearney Agricultural Center, Parlier, C. A. Wilen, UC Statewide IPM Program, San Diego Co., R. H. Molinar, UC Cooperative Extension, Fresno Co.
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COORDINATION & PRODUCTION: P. N. Galin
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 Figure 3 adapted from Calif. Dept. of Food and Agric. Nursery Inspection Procedures Manual Online: Approved Nematode Certification Program. Details of double-tent technique for solarizing containerized soil. Accessed Sept. 11, 2008. <http://www.cdffa.ca.gov/phpps/pe/Nursery/NIPM.html>

Produced by UC Statewide IPM Program, University of California, Davis, CA 95616

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To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Pesticides applied in your home and landscape can move and contaminate creeks, rivers, and oceans. Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash or pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

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