Soil solarization for restorationists

Solar energy can be used to kill weeds, seeds, and soil pathogens on restoration sites.

by David A. Bainbridge

Soil solarization is the use of sunlight, aided by clear polyethylene sheeting, to heat areas being prepared for planting to kill weeds, weed seeds, and pathogens in the top 5–15 cm (2–6") of the soil. This technique, which is increasingly used by farmers and gardeners, but not yet widely known among restorationists, is a good alternative to herbicides, fumigants, and other conventional methods of weed control under some conditions.

Solarization can be useful in many restoration situations. I have used it under the most difficult conditions, preparing a clean seedbed for native plant production in a very weedy garden, and it worked better than VAPAM, a very toxic herbicide. It is well suited for small to medium scale restoration efforts in areas where summer temperatures are high, with air temperatures greater than 30 degrees C (90 degrees F) during the midafternoon. It should be well suited for the preparation of prairie restoration sites, where weeds often present serious problems before the perennial native plants become established.

Like many "sustainable" agricultural techniques, soil solarization has a long history. Farmers of the Deccan plateau in India have long exploited a solar form of heating soil in the summer to control weeds. They plow the weedy soil just before the hottest summer period, when maximum daily air temperatures usually exceed 40 degrees C (104 degree F), and leave it fallow long enough for the high soil temperatures to kill weeds, weed seeds, and soil pathogens. However, this technique is effective for bare soil only if the air temperatures are very high and solar radiation is intense. Adding a clear plastic cover makes it possible to heat the soil to similar temperatures under somewhat more temperate conditions. Recent studies have suggested that a double layer of plastic (bubble-pack may work well) can provide similar soil temperatures even under relatively cool conditions. With a single layer of plastic solarization should be effective in areas with plenty of sun and average maximum air temperatures near 30 degrees C for at least six to eight weeks. A single layer of plastic provided sufficient solar heating to raise the soil temperature at the International Center for Research In the Semi-Arid Tropics (ICRISAT)in India to 54 degrees C (130 degrees F) at a depth of 5 cm and 48 degrees C (118 degrees F) at a depth of 10 cm, with mean air temperatures of 43 degrees C. Under the clear plastic, soil temperatures at 5 cm deep remained at or above 45 degrees C (113 degrees F) for 48 days, more than twice as long as this temperature was maintained in bare soil. Moreover, while the soil temperature of bare soil at 10 cm deep never reached 45 degrees C, it remained at or above this temperature for 23 days under plastic.

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Table 1. Response of some common weeds to solarization

Effective control	
Cocklebur	*Xanthium spinosum*
Common chickweed	*Stellaria media*
Common groundsel	*Senecio vulgaris*
Field bindweed (seed)	*Convolvulus arvensis*
Henbit	*Lamium amplexicaule*
Jimsonweed	*Datura stramonium*
Lambsquarters	*Chenopodium album*
Miner's lettuce	*Montia perfoliata*
Nettleleaf goosefoot	*Chenopodium morale*
Prickly lettuce	*Lactuca serriola*
Prickly sida	*Sida spinosa*
Shepherd's purse	*Capsella bursa-pastoris*
Tolerable control	
Large crabgrass	*Digitaria sanguinalis*
Purslane	*Portulaca oleracea*
Partial control (more effective if repeated)	
Bermuda grass	*Cynodon dactylon*
Field bindweed (plant)	*Convolvulus arvensis*
Johnsongrass	*Sorghum halepense*
Nutsedge	*Cyperus* spp.
Lovegrass	*Eragrostis* spp.

(Pullman et al., 1984)

The influence of these high temperatures on weeds, seeds, and pathogens is complex and not fully understood. Solarization is especially effective, however, in controlling cool-season weeds and grasses that make up a large share of the problem plants restorationists have to deal with, especially in the early stages of a project (Table 1).

In general, deep-rooted summer weeds with rhizomes are usually knocked back but may not be killed. Control can be improved by repeating the solarization process after retilling the soil. Adding compost and other soil amendments may improve control of the more resistant species by increasing microbiological activity in the soil.

In addition to its effectiveness against many weeds, solarization also controls a number of common plant pathogens, including Fusarium and Verticillium fungi, and in fact most of the research on solarization has been carried out for this reason (Katan et al., 1987). Fortunately for restorationists, the heating apparently has little effect on beneficial organisms such as mycorrhizae and actinomycetes. There is also evidence of control of some insect pests. Because most of the research has been carried out in connection with agriculture, the effects of solarization on earthworms and various other beneficial and native organisms have not been explored in depth, but I didn't observe any obvious change in earthworm populations in my test.

One of the interesting effects of solarization is an increase in growth rates. This effect is greater than can be accounted for by effects on pathogens and weeds alone. While this effect is not fully understood, some studies suggest that an increase in available nutrients may account for much of the improvement (Stapleton et al., 1985). For example, nitrate nitrogen tripled in the surface soil during one solarization trial at ICRISAT. This is presumably the result of accelerated microbiological activity and the release of nutrients from the detritus. In any event, this process may be advantageous in some restoration situations where it would allow native plant species a head start on weeds.

The most common restoration-oriented use of soil solarization may be for preparing seed beds for prairie and meadow plantings on sites with full sun. It can also be used on many other sites that are being restored from the ground up, though it is unlikely to work on north-facing slopes. It may also prove useful in open woods and shrublands where summer temperatures are high (at least 40 degrees C [104 degrees F]) and canopy cover is limited. Solarization is also excellent for preparing seed beds for nursery production of native plants. While little has been published on the use of solarization in the preparation of soil mixes, it should be effective for controlling diseases and weeds in soil mixes without the adverse effects associated with steam heating or chemical fumigants.

To Solarize Your Soil

Although techniques may vary with climate, solar exposure, soil type, plant community, specific weed problems, and planting techniques the following approach has been refined by studies with many types of crops and in many climates:

Soil solarization should be undertaken during the sunniest, hottest part of the year, and should continue for at least four weeks and preferably six weeks or even more. Soil temperatures of more than 40 degrees C (104°F) for several weeks are desirable. In cooler areas with periodic cloudy periods, solarization may still be effective if the plastic is left in place longer. Soil thermometers are inexpensive, under $15, and two or three set at different depths make it easy to monitor soil temperatures. If temperatures are not high enough, try adding a second layer over a small area. The small bags of dirt used to hold the first sheet down can be arranged to support the second sheet a couple of centimeters above the bottom sheet.

Begin by cultivating the area thoroughly; then carefully level the surface to eliminate clods, stubble, sticks, and stones that might tear the polyethylene sheeting. If the soil is dry, apply about 2.5 cm (one inch) of water immediately before laying the sheeting. The moisture improves the heat capacity of the soil and enhances heat transfer for better soil heating. Fertilizer and other soil amendments may be applied and tilled in before the plastic is laid.

Apply sheets of clear (not black or colored) 1–2 mil polyethylene (4–6 mil in windy areas) at dawn, or when it is the least windy. The thinner plastic is preferred because it lets more solar energy through. The plastic doesn't have to lie flat on the ground for good heating, but it may flap less if it is smooth and in contact with the surface. If plastic with UV inhibitors is used, the plastic can be lifted and reused. Non- stabilized plastic may begin to become brittle and break down in 2–3 months, and on agricultural fields it is often left in one place and allowed to disintegrate. Since heating is less intense at the edges, extend the covering a meter or so beyond the planted area, if possible. When planning the layout, be sure to allow for access to other areas and for drainage, either to a drain furrow or to other plantings nearby. This is especially important on slopes, where special care should be taken to avoid erosion problems caused by runoff from covered areas. Straw bale dams or grassed waterways may be advisable in some situations. In semi-arid and arid areas, on the other hand, runoff water may be used to irrigate plants started in the spring or the year before. Use wide sheets to minimize joints (6 m [20 ft] and 12 m [40 ft] widths are common), and place the edges of adjacent sheets in furrows and cover them with soil. The free edges should also be buried and the soil around them compacted by tramping to minimize the loss of heated air and moisture. To keep the plastic from flapping and tearing in the wind, place weights 2–3 m (6–10 ft) apart on the sheeting. Small plastic bags (sandwich size) filled with soil should work well on all but the windiest sites. These can be gently tossed into place to avoid walking on the plastic.

During the solarization period inspect the site regularly. If holes develop in the polyethylene sheeting, they should be patched with wide clear plastic (package) tape. You can find holes by looking for areas without condensed moisture on the bottom of the plastic. Avoid walking on the plastic, and use smooth-soled shoes or bare feet if you have to walk on the sheeting to make repairs.

Although farmers often plant into holes punched in the sheet following solarization, restorationists may prefer to remove the plastic for reuse. Remember that the soil may be wet when the plastic is removed, and make take several days to dry to a workable condition. If you cultivate before planting, keep cultivation shallow (2–5 cm) to avoid moving viable weed seeds from the deep soil to the surface.

Soil solarization is not perfect. It does not work against all weeds and pathogens, requires the use of chemicals and energy to make the polyethylene, and leaves waste plastic. But it is much cleaner and safer than herbicides and fungicides and at least as effective. Best of all it is inexpensive [polyethylene costs around 18 cents per square meter (2 cents/sq. ft.) for non UV-stabilized 2 mil (4 cents for 4 mil, 6 cents for 6 mil, 10 cents for bubble pack)]—generally far less than costs of machine or handweeding.

Let us know how it works for you.

References

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