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Pest Management through Soil Solarization

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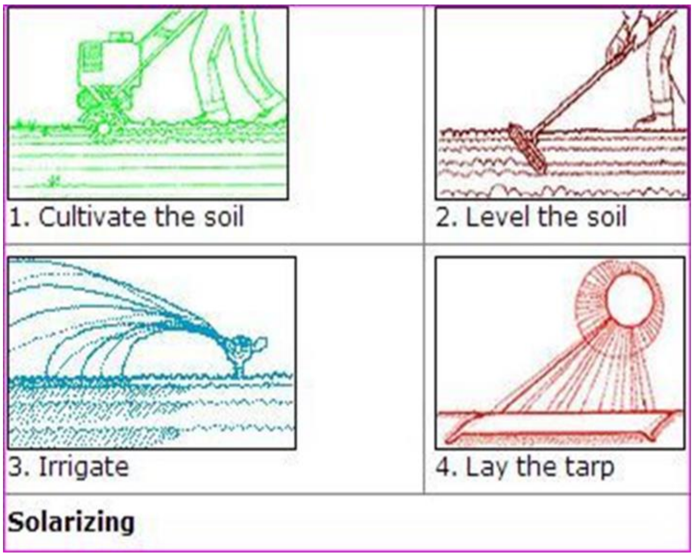
INTRODUCTION

Pre-plant applications of insecticides, such as the fumigants methyl bromide, chloropicrin, and metham sodium, can reduce soil-borne pests in vegetable and fruit crops. The toxicity of these substances toward humans and animals, their persistence in plants and soils, the difficulty of treating the soil, and their high cost make their use frequently unattractive. Furthermore, when current environmental legislation is implemented, restrictions on the use of soil-applied pesticides appear impending. As a result, there has been an increased emphasis on reduced-pesticide or non pesticidal control methods. Soil solarization is a nonpesticidal method of controlling soil-borne pests by placing plastic sheets on moist soil during periods of high ambient temperature.



(Source : http://ipm.ucanr.edu/PMG/GARDEN/ENVIRON/ soilsolarization.html.)

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The plastic sheets allow the sun's radiant energy to be trapped in the soil, heating the upper levels. Solarization during the hot summer months can increase soil temperature to levels that kill many disease-causing organisms (pathogens), nematodes, and weed seed and seedlings. It leaves no toxic residues and can be easily used on a small or large scale.

HOW TO SOLARIZE SOIL

Soil Preparation

Solarization works best when the plastic sheet (tarpaulin) is placed as close to the smooth surface of the ground as possible. Soil preparation begins with discs or rolling the soil by hand to break up clumps and smooth the surface of the soil. Remove large rocks, weeds, and other objects and debris that may lift or puncture the plastic.

Laying the Plastic

Plastic sheets may be laid by hand or machine. The open edges of the plastic sheeting should be anchored to the soil by burying the edges in a shallow trench around the treated area. Plastic is laid either in complete coverage, where the entire field or area to be planted is treated, or strip coverage, where only beds or selected portions of the field are treated. Complete coverage is recommended if the soil is heavily infested with pathogens, nematodes, or perennial weeds, since there is less chance of reinfestation by soil being moved to the plants through cultivation or furrow-applied irrigation water

Soil moisture

Soil moisture is a critical variable in soil solarization because it makes organisms more sensitive to heat and also transfers heat to living organisms (including weed seeds) in soil. The success of soil solarization depends on moisture for maximum heat transfer; maximization of heat in soil increases with increasing soil moisture. Soil moisture favors cellular activities and growth of soil-borne microorganisms and weed seeds, thereby making them more vulnerable to the lethal effects of high soil temperatures associated with soil solarization. The interaction between temperature and soil moisture brings about cycling of water in soil during soil solarization. As the effect of soil solarization penetrates deeper in the soil, the movement of moisture becomes more pronounced, changing the distribution of salts and improving the tilth of the soil and a reduction in soil salinity. A drip irrigation line under the tarp / plastic mulch to maintain moisture levels, flood-irrigation in the adjacent furrows, or pre-tarping irrigation may be enough to keep good moisture inside the soil throughout the treatment period.

Treatment Duration

The longer the soil is heated, the better and more deeply controlled all soil pests and weeds are. Best.The plastic sheet should be left in place for 4-6 weeks to allow the ground to be heated as deeply as possible.Leave the plastic in place for 6 weeks to control the most resistant species.

Removal of the Plastic and Planting

After solarization is complete, the plastic may be removed before planting. Or, the plastic may be left on the soil as mulch for the following crop by transplanting plants through the plastic. A disadvantage of leaving the plastic on the soil is that it may degrade and be difficult to clean up in the spring.

RESULTS OF SOIL SOLARIZATION

Improved Soil Physical and Chemical Features

Solarization initiates changes in the physical and chemical features of soil that improve the growth and development of plants. It speeds up the breakdown of organic material in the soil resulting in the release of soluble nutrients such as nitrogen (NO_3, NH^{4+}), (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+) and fulvic acid making them more available to plants. Improvements in soil tilth through soil aggregation are also observed.

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Effect on soil borne pathogens

Efficacy of soil solarization for control of soil-borne pathogens and pests is a function of time and temperature relationships; for example, 2-4 weeks of exposure at 99°F (37°C) may be required to kill 90% of populations for most of mesophylic fungi—an organism that grows best in moderate temperatures. During soil solarization, temperatures commonly reach up to 95°F to 140°F (35-60°C) depending on soil type, season, location, soil depth and other factors. These high temperatures induce changes in soil volatile compounds that are toxic to organisms already weakened by high temperature. Soil solarization is effective against fungal pathogens such as *Verticillium* spp. (wilt), *Fusarium* spp. (several diseases), *Phytophthora spp.* (*Phytophthora* root rot) and bacterial pathogens such as *Streptomyces scabies* (potato scab) and *Agrobacterium tumefaciens* (crown gall).

Effect on weeds

Soil solarization at 99°F (37°C) for 2-4 weeks almost completely prevents the emergence of many annual weeds, especially at the top layer because temperature increases more slowly at deeper depths. Soil solarization effectively controls broomrapes (*Orobanche* spp.) and many other weeds, but not *Cuscuta* species, bindweed, or purple nutsedge due to their deeply buried underground vegetative structures such as roots and rhizomes. Efficacy of soil solarization for weed control in the field is increased by providing irrigation at least 2-3 week prior to solarization, letting the weeds grow, and incorporating them in soil before establishing the solarization treatment.

Effect on beneficial microbes

Mild temperature increases during soil solarization are more selective towards thermophilic and thermotolerant (above 113°F or 45°C) biota, including actinomycetes. These may survive and even flourish under soil solarization, but poor soil competitors, such as many pathogens, are killed by soil solarization. Solarization initially may reduce populations of beneficial microorganisms (beneficial, growth-promoting and pathogen-antagonistic bacteria and fungi), but their populations quickly recolonize in the solarized soil. Plant-pathogenic fungi weakened by high soil temperatures are more susceptible to the antagonists. Nitrogen-fixing *Rhizobium* bacteria are also sensitive to high soil temperatures and reduction in root nodulation of legumes such as peas or beans in solarized soils is also temporary. Applying inoculum to legumes planted in solarized soil may be beneficial.

Effect on plant nutrients

The increased availability of plant nutrients and the relative increase in rhizosphere populations of favorable bacteria, such as *Bacillus* spp. (which contribute to the marked increase in the growth, development and yield of plants grown in solarized soil) are other major components of soil solarization benefits. Soil solarization increases nitrogen, calcium, and magnesium availability, in addition to extractable P and K. The increased availability of mineral nutrients following soil solarization includes those tied up in the organic soil fraction (e.g., NH^4-N, NO^3-N, P, Ca, and Mg). An increase in soil nitrate nitrogen by more than 3000 kg/ha was obtained in our study by adding chicken manure and growing mustard and incorporation in soil before soil solarization. Ultimately, these nutrients, especially the nitrogen, will benefit crop growth.

Addition of soil amendments

Addition of different types of organic matter, e.g., animal manures and crop residues, to the soil before soil solarization increases its efficacy for controlling soil-borne pathogen and weeds. Organic matter addition increases the rate of decomposition of these materials in the soil and thereby the rate of heat generation during decomposition; it also increases the heat-carrying capacity of the soil. Volatile biotoxic compounds are released when organic matter is heated during the process of

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solarization. Thus, organic amendments augment the biocidal activity of the soil solarization. In addition, organic and inorganic ammonia-based fertilizers applied to the soil and followed by soil solarization may be effective against natural soil populations of the damping off fungus (*Pythium* spp), *Verticillium dahliae* (in some cases), and root-knot nematode (*Meloidogyne incognita*).

CONCLUSION

Soil solarization is trouble-free, safe, cost-efficient and ecofriendly technology toward sustainable development of farming community of India. It appears to be adaptable to a wide range of agricultural applications, alone and in combination with agricultural chemicals and biological control agents. As Population and temperature is increasing parallely at global level and this high temperature can be utilized by using the concept of soil solarization to feed the people high quality produce by mitigating the harmful effect of climate change as well as harmful pesticides.

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