Popular Article

SOIL SOLARIZATION: AN APPROACH TOWARDS SUSTAINABLE AGRICULTURE

Vinod Kumar[1*], Ankush[2], S.K. Tehlan[3], Ankit Kumar[4] and Priyanka[5]
[1,3]Department of Vegetable Science, [2]Department of Soil Science, [4]Department of Entomology,
[5]Department of Agronomy, CCS Haryana Agricultural University, Hisar-125004, India
**Corresponding author's E-mail: vinoddudhyan68@gmail.com*

KEY WORDS:
Plastic sheet,
Soil borne pathogens,
Crop growth,
Ecofriendly

ARTICLE INFO
Received on:
27.04.2017
Revised on:
18.05.2017
Accepted on:
20.05.2017

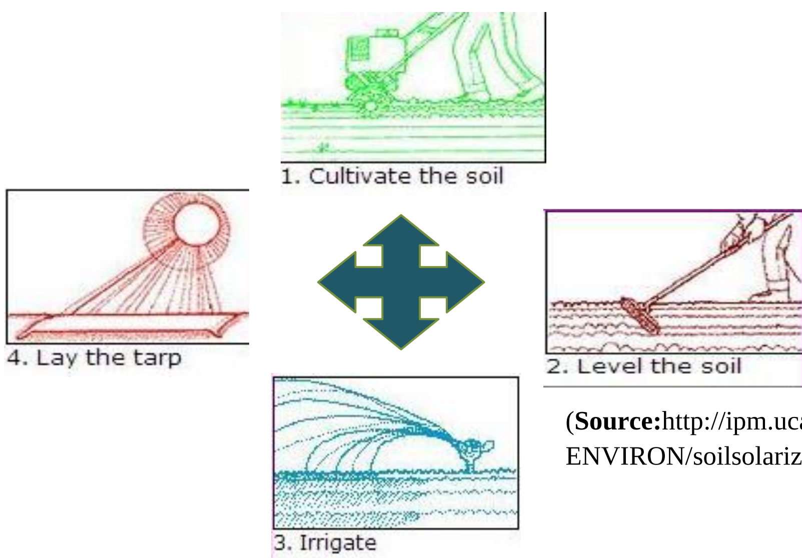
ABSTRACT

Soil solarization is an organic approach for managing soil-borne pests using high temperature produced by absorbing radiant energy from the sun. The method involves soil heating by covering it with a clear plastic film (2-4 mil, Note: 1 mil = 0.001 inch or 0.025mm) for 4 to 6 weeks during summer months of the year when the soil receives the highest amount of direct sunlight. It is an effective tool for managing the population of soil-borne pathogens, weed flora, eggs and larvae of harmful insects. Being non-chemical in nature, it can be a useful eco-friendly option for pest management in organic food production. Increased plant growth and yield of annual and perennial field crops, vegetables and fruit crops usually occur by adopting this technique

INTRODUCTION

Soil-borne pests can be controlled in vegetable and fruit crops by pre-plant application of pesticides, including the fumigants methyl bromide, chloropicrin, and metam sodium. The use of these materials, however, is often undesirable due to their toxicity to animals and people, their residual toxicity in plants and soils, the complexity of soil treatment, and their high cost involvement. Furthermore, restrictions on the use of soil-applied pesticides seem imminent as existing environmental legislation is implemented. 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 (2-4 mil) on moist soil during periods of high ambient temperature.

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. Soil solarization also improves soil structure and increases the availability of nitrogen (N) and other essential plant nutrients.



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

How to solarize soil?

Soil Preparation

Solarization is most effective when the plastic sheeting (tarp) is laid as close as possible to a smooth soil surface. Preparation of the soil begins by disking, or turning the soil by hand to break up clods and then smoothing the soil surface. Remove any large rocks, weeds, or any other objects or debris that will raise or puncture the plastic.

Laying the Plastic

Plastic sheets may be laid by hand **(Fig. 1.)** or machine **(Fig. 2.)**. 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 **(Fig. 3.)**, where the entire field or area to be planted is treated, or strip coverage **(Fig. 4.)**, where only beds or selected portions of the field are treated (Elmore, 1997). 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.

Fig. 1. Laying polythene sheets by hand

Fig. 2. Laying polythene sheet by machine

Fig. 3. Complete coverage of planting area

Fig. 4. Strip coverage

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 deeper the control of all soil pests and weeds will be. Thus, long, hot sunny days work best to kill soil-borne pathogens and weed seed. The plastic sheets should be left in place for 4 to 6 weeks to allow the soil to heat to the greatest depth possible. To control the most resistant species, leave the plastic in place for 6 weeks.

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.

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). It also reduces the populations of different plant parasitic nematodes in soil, especially *Meloidogyne* spp. (root-knot) and *Pratylenchus* spp. (root lesion) nematodes which are the most important ones for crop growers.

Treatments	**Location/Agro-climate**	**% disease control relative to check**	**References**
Solarized treatment (0.013 mm thick)	San Jaoquin Valley, California	65-78 per cent of total reduced fungi	Gamliel and Stapleton (1993)
Solarization	Arid climate	69-89 per cent reduction of dry root rot pathogen *Macrophominaphaseolina*	Lodha *et al.*,1997
Solarizarion	Coastal plain region of North Carolina	62 per cent reduction in number of sclerotia in tomato	Ristanio *et al*., 1991
Trichoderma harzianum + soil solarization	Israel	48 per cent disease control	Sivan and Chet (1993)

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 theirdeeply 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 increase 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 a 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 (Pokharel and Hammon, 2010).

Addition of soil amendments to increase solarization efficiency

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 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 dahlia* (in some cases), and root-knot nematode (*Meloidogyne incognita*). Combining soil solarization with organic amendments leads to the generation of toxic volatile compounds that accumulate under the plastic mulch and consequently enhance the vulnerability of soil organisms to soil solarization. The elevated soil temperature also increases the sensitivity of soil pests to the toxic effect of the captured volatiles, (Gamliel *et al*., 2000). Sivan and Chet (1993) tested the combined use of *Trichoderma harzianum* and soil solarization under field conditions, successfully controlling *F. oxysporum f. sp. radicis-lycopersici* and increasing tomato yield.

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 parallel 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.

REFERENCES

Elmore, C.L. 1997. Soil solarization a nonpesticidal method for controlling diseases, nematodes, and weeds. University of California, Division of

Agriculture and Natural Resourses Publication, 21377.

Gamliel, A., M. Austeraweil and M. Kritzman. 2000. Non-chemical approach to soilborne pest management-organic amendments. *Crop Protection*, **19**: 847- 853.

Gamloiel, A. and J.J. Stapleton. 1993. Effect of chicken or ammonium phosphate and solarization on pathogen control, rhizosphere microorganism and lettuce growth. *Plant Diseases*, **77**: 886-891.

Lodha, S., S.K. Sharma and R.K. Aggarwal. 1997. Solarization and natural heating of irrigated soil amended with cruciferous residues for improved control of *Macrophominaphaseolina*. *Plant Pathology*, **46**(2): 186-190.

Pokharel, R. and R. Hammon. 2010. Increased efficacy of biofumigation by soil solarization and integrating with Brassica meal cake and poultry manure to manage soil-borne problem in onion. *Report Submitted to EPA*, *PESP program*. pp 23.

Pullman, G., J. DeVay, R. Garber and A. Weinhold. 1981. Soil solarization for the control of Verticillium wilt of cotton and the reduction of soil-borne populations of *Verticilliumdahliae*, *Pythium spp.*, *Rhizoctoniasolani*, *and Thielaviopsisbasicola. Phytopathology*, **71**: 954-959.

Ristania, J.B., K.B. Pery and R.D. Lumseden. 1991. Effect of soil solarization and *Gliocladiumvirans* on sclerotia of *Sclerotiumrolfsii*, soil microbiota and the incidence of southern blight of tomato. *Phytopathology*, **81**: 1117-11124.

Sivan, A. and I. Chet. 1993. Integrated control of Fusarium crown rot and root rot of tomato with *Trichoderma harzianum* in combination with methyl bromide or soil solarization. *Crop Protection*, **12**: 380-386.

How to cite this article?

Vinod Kumar, Ankush, S.K. Tehlan, Ankit Kumar and Priyanka. 2017. Soil solarization: an approach towards sustainable Agriculture. *Innovative Farming*, **2**(2): 126-130.