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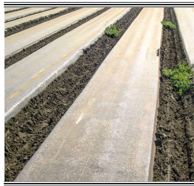

Soil solarization – An eco-friendly alternative

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Soil borne plant pathogens (plant parasitic nematodes, fungi and some bacteria) and weed pests are serious challenger to the farmers and home gardeners. Use of soil fumigants including methyl bromide, chloropicrin and methane for pest control are often undesirable due to their residual toxicity effect in plants and soils. They also have unfavourable for humans and animals. They are costly because of their demand for organic agriculture. Concerns over environmental hazards and increased public health issues caused by pesticides have directed much attention to alternative practices for chemical pest control.

Soil solarization or solar heating is a non-chemical disinfectant practice that has potential to control many soil borne pathogens and pests. It is compatible with many integrated diseases management practices. It is a hydrothermal process occurs in most soil when covered by plastic film and heated by exposure to sunlight during the hot summer months. Sunlight increase the soil temperature to levels lethal to many soil borne plants pathogens, weed seeds and nematodes. It also improve soil health and increase the availability of essential plant nutrients. The effects of solarization have been investigated for many vegetable crops such as artichokes, bell pepper, cabbage, cucumber, eggplant, garlic, melon, onion, potato, strawberry, sweet potato and tomato, among others. Katan *et al.* (1987) provided an extensive list of documents published during the first decade of soil solarization.

When to solarize soil? Long day lengths, high air and soil temperature, clear sky and no wind are suitable conditions for soil solarization. The heat peak in many areas of Punjab (North-Western India) is around May 15. Therefore, the best time for soil solarisation in Punjab is May and June months.

Procedure for Soil solarization:

Soil preparation : The soil to be solarized must be loose and friable with no large clods or other debris on the soil surface. Soil preparation should focus on creating a fine textured matrix with only small soil particles and pores, to allow moist air to penetrate the soil particles and reach the place where soil borne pathogens are located. A rotary hoe or roto-tiller may be used to eliminate clods or other debris that otherwise create air pockets which slow down soil heating. A clean flat surface will also prevent the accidental puncturing of their plastic mulch by debris.

Spread of transparent plastic sheet: Clear or transparent U.V. stabilized plastic sheets are required instead of black plastic sheets. Transplant plastic results in greater transmission of solar energy to soil, which allows the soil to heat much higher temperature compared to black. Transparent sheets contain U.V. inhibitors that slow down the deterioration of polyethylene and allow the soil to be solarized longer. The plastic to be reused or the plastic to be left in place is used as a mulch during the following growing season.

The polyethylene prevents the escape of long wave radiation and water evaporation from the soil to the atmosphere, consequently exerting a green house effect. In addition, the water vapour accumulated on the inner surface of the sheet, further enhances the green house effect, resulted in higher soil temperature. On the contrary black sheet absorb most of the solar radiation and heats up but does not transmit the radiation, due to the insulating air layer between plastic mulch and soil surface. Thus, black plastic mulch unusually provides a lower soil temperature and poorest pest control. Therefore, avoid using black sheet for soil solarization

Polyethylene plastic having 100 gauze thicknesses is most efficient and economical for soil warming. However, it is easier to puncture and less able to withstand high winds than thicker plastic. In windy area, 150 – 200 gauze thickness of plastics are preferable to use. If holes or tear occur in plastic they should be patched with patching tape. Thick transparent plastic reflect more solar energy than the thinner plastic and results in slightly lower temperature.

Transparent polyethylene sheet are anchored to soil by burying the edges in a trench around the treated area. To prevent air pockets that retard the soil heating process, there should be a minimum space between tarps and soil surfaces. The plastic should be left in place 4 to 6 weeks to allow the soil to heat to the greatest depth possible. The plastic should then be removed and the soil allowed drying to the workable texture. The soil can be use for planting for a fall or winter crop or left fallow until the next growing season. If the soil is cultivated for planting, the cultivation should be shallow (< 2 inches) to avoid moving viable weed seed to the surface.

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

Benefits of soil solarization: The global changes and the constant increase in the erosion of the natural ecosystem emphasize the importance of soil solarization as a viable environmental IPM tool in agricultural production systems. 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 micro-organisms. The rise in temperature achieved during solarization has a direct effect on soil ecology. Many soil-inhabiting organisms are inactivated when exposed to the high temperatures achieved during this process (Stapleton, 1991). 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 ($N0_3^-$, NH_4^+), calcium (Ca^{+2}), magnesium (Mg^{+2}), potassium (K^+) and fulvic acid, making them more available to plants. Increases in soluble mineral nutrients including NH_4^+-N, NO_3^--N, Phosphorus, K^+, Ca^{+2}, Mg^{+2}, Mn^{+2}, Fe^{+3}, Cl^- and Cu^{+2} have been detected in solarized soils in several studies (Chen *et al.*, 1991).

Disease: Soil solarization has been demonstrated to control disease caused by many fungal pathogens such as *Rhizocotania solanii*, *Fusarium* spp., *Pythium* spp., *Phytophothora* spp., *Verticillium* spp.. *Sclerotium rolfsi* etc. in many crops. Solarization initially may reduce the population of beneficial micro-organisms (Bacteria, growth promoting and pathogen antagonistic bacteria and fungi), but their population recolonize in solarized soil.

Weeds: It completely prevents the emergence of many annual weeds especially at the top layer because temperature increases more slowly at deeper depth. The efficiency 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 growth and incorporating them in the soil before establishing the solarization treatments. Stevens *et al.* (1990) achieved better weed control with solarization than with applications of the herbicide chlorthal-dimethyl. Tamietti and Valentino (2000) observed changes in the composition of the weed communities in solarized soil, reporting that monocotyledons were less susceptible to 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 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. Ioannou (2000) reported that control of *Meloidogyne incognita* by soil solarization was inferior to fumigation with methyl bromide, which also was superior in residual effectiveness. However, both treatments resulted in similar increases in the yield of greenhouse tomato.

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