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Role of Soil Solarization in Plant Disease Control

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Soil solarization is a method of heating soil by covering it with transparent polythene sheeting during hot periods to control soil borne diseases. The technique has been commercially exploited for growing high-value crops in diseased soils in environments with a hot summer (maximum daily air temperatures regularly exceeding 35°C). It is a non pesticidal method of controlling soilborne pests by placing plastic sheets 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. Solarization is a simple, safe, and effective method that has been used with field, vegetable, and flower crops and in orchards, vineyards, greenhouses, gardens and landscapes.

HOW TO SOLARIZE YOUR SOIL

Soil Preparation

Solarization is most effective when the plastic sheeting is laid as close as possible to a smooth soil surface. Preparation of the soil begins by disking, rootling, 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 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.

Irrigation

Wet soil conducts heat better than dry soil and makes soil organisms more vulnerable to heat. The soil under the plastic sheets must be saturated to at least 70 percent of field capacity in the upper layers and moist to depths of 24 inches (60 cm) for soil solarization to be effective. Soil may be irrigated either before or after the plastic sheets are laid. If the soil is irrigated beforehand, the plastic must be applied as soon as possible to avoid water loss; The soil does not usually need to be irrigated again during solarization, although if the soil is very light and sandy, or if the soil moisture is less than 50 percent of field capacity, it may be necessary to irrigate a second time. This will cool the soil, but because of the increased moisture the final temperatures will be greater

Duration of Treatment

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. Experience has shown that there is little or no need to take the temperature of the soil. The greatest concern is to solarize the soil during a period of high solar radiation with little wind or cloud cover.

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 a mulch for the following crop by transplanting plants through the plastic. Clear plastic may be painted white or silver to cool the soil and repel flying insect pests in the following crop. A disadvantage of leaving the plastic on the soil is that it may degrade and be difficult to clean up in the spring. Treated soil can be planted immediately to a fall or winter crop or left fallow without the plastic until the next growing season. If the soil must be cultivated for planting, the cultivation must be shallow-less than 2 inches (5 cm) to avoid moving viable weed seed to the surface.

PLASTIC SHEETING

Black vs. Colored Plastic

Transparent or clear plastic is most effective for solarization. Black plastic, often used for mulching, does not heat the soil as well as clear plastic. It can be used for solarization but its main effect is reducing weed growth. In areas where solarization is ineffective because of low solar radiation or a heavy infestation of weeds, black plastic may combine some solarization benefit with residual weed control. It can also be used for solarizing existing crops, for example, by disinfesting soil while establishing permanent tree or vine crops.

Since soil temperatures are lower with black plastic, the treatment time must be lengthened for best results. Other colors of plastic required longer treatment times. These other colors of plastic give so much less effective solarization that they should probably only be used as mulch.

FACTORS THAT LIMIT EFFECTIVENESS OF SOLARIZATION

Location

Soil solarization is most effective in warm,sunny during periods of highest air temperatures and clear skies. Greenhouse, nursery, and seedbed (containerized) media solarizationare are more effective in cooler climates than field solarization.

Weather

Highest soil temperatures occur when days are long, air temperatures are high, skies are clear, and there is no wind. The soil heating effect may be limited on cloudy days. Wind or air movement across the plastic will rapidly dissipate the trapped heat. Also, strong winds may lift or tear sheets.

Timing

The best time for solarization of soil is from April to June, although good results may be obtained in May and September, depending on weather and location, where summer temperatures are too hot for many crops, soil can be solarized during summer and planted during fall or winter.

Duration of Treatment

The longer the soil is heated, the better the control of pests will be. However, heating the soil longer than required for effective control (6 to 8 weeks) may be deleterious to the soil. Although some pest organisms are killed within 14 days, 4 to 6 weeks of treatment in full sun during the summer is recommended for field application. Solarization of containerized growth media and greenhouses may be done in a few days during the heat of summer. Some relatively heat-resistant organisms may require longer (up to 8 weeks) solarization for control. The combination of pesticides, fertilizers, and certain organic amendments with solarization may reduce the needed treatment time.

Soil Preparation

A smooth seedbed is ideal for solarization. Air pockets between the plastic and the soil greatly reduce soil heating. Solarization will be ineffective if the seedbed is not smooth and the plastic does not rest directly on the soil.

Soil Moisture Content

If the soil is too dry (less than 70 percent of field capacity), weed seed and pathogens may not imbibe enough water to make them vulnerable to the increased heat.

Soil Color

Dark soils absorb more solar radiation than lighter colored soils and reach higher temperatures during solarization. However, adding dark material, such as charcoal, to a light loam soil has only raised maximum temperatures 1° to 2°F. Organic material such as manure may give the same limited effect.

Orientation of Beds

The heating of soil in raised beds will be most uniform if the beds are oriented north to south rather than from east to west. More uniform heating gives better control of pests. Solarization is most effective when there is no slope or when the slope has a south or southwest exposure. Lower temperatures and poor control of pests will occur on north-facing slopes Cultivation after Solarization Cultivation deeper than 3 inches (7.5 cm) after soil solarization should be avoided because it may bring weed seed and pathogens to the upper soil layer, causing severe weed and disease problems Integrity of Plastic Sheeting Holes or tears in the plastic will adversely affect solarization . Animals and people should be prevented or discouraged from walking on or otherwise disturbing the plastic.

RESULTS OF SOLARIZATION

Soil Temperature

The maximum temperatures at various depths of soil were reached daily at 1500. The plots covered with polythene sheeting had markedly higher maximum temperatures at all depths at which temperature measurements were made. At 5 cm, solarization increased temperature by about 10°C. The range of temperature increases with solarization and was less in the surface layers (5 cm and 10 cm) of irrigated plots as compared to the non irrigated plots. The temperatures higher than 40° C and 45° C, which could be lethal for microorganisms, were recorded for most of the duration of solarization at 5 cm and 10 cm depths. In the non solarized treatment, such high-temperature days were fewer.

Chemical properties of the soil

Solarization did not significantly affect pH, EC or available Phosphorus levels. Soil ammonia & Nitrogen levels were not affected by solarization at any depth.

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 (N03, NH4+), calcium (Ca++), magnesium (Mg++), potassium (K+), and fulvic acid, making them more available to plants. Improvements in soil tilth through soil aggregation are also observed.

Control of Pests

Repeated daily heating during solarization kills many plant pathogens, nematodes, and weed seed and seedlings. The heat also weakens many organisms that can withstand solarization, making them more vulnerable to heat-resistant fungi and bacteria that act as natural enemies. Changes in the soil chemistry during solarization may also kill or weaken some soil organisms.

Sensitivity to Solarization

Although many soil pests are killed at temperatures above 86° to 91°F (30° to 33°C), plant pathogens, weeds, and other soil born organisms differ in their sensitivity to soil heating. Some pests that are difficult to control with soil fumigants are easily controlled by soil solarization. Other pests are also affected but cannot be consistently controlled by solarization. These may require additional control measures.

Fungi and bacteria.

Solarization controls populations of many important soilborne fungal and bacterial plant pathogens, including *Verticillium dahliae* which causes *Verticillium* wilt in many crops; certain *Fusarium* spp. that cause *Fusarium* wilt in some crops; *Phytophthora cinnamomi*, which causes *Phytophthora* root rot; *Agrobacterium tumefaciens*, which causes crown gall disease; *Clavibacter michiganensis*, which causes tomato canker; and *Streptomyces scabies*, which causes potato scab. Other fungi and bacteria are more difficult to control with solarization, such as certain high temperature fungi in the genera *Macrophomina*, *Fusarium*, and *Pythium*, and the soil borne bacterium *Pseudomonas solanacearum*

Nematodes

The population of all parasitic nematodes of pigeon pea and chickpea was markedly affected by solarization. Included in this population were *Heterodera cajani* cysts, eggs, and larvae; *Rotylenchulus reniformis; Helicotylenchus retusus;* and *Pratylenchus* spp.; *Tylenchorhynchus* spp.; and *Heterodera* spp. Solarization with irrigation was most effective in reducing populations of cysts, eggs, and larvae.

Weed growth

Solarization markedly decreased weed growth in both chickpea and pigeon pea fields. Most annual weed species were effectively suppressed by solarization; however, the perennials, such as *Cynodondactylon*, *Cyperusrotundus*, and *Convolvulus arvensis*, gradually recovered. Solarization for 2 successive years was most effective in suppressing weeds.

Rhizobial population and nodulation

Solarization did not significantly affect rhizobial population or nodulation of either crop in the non irrigated treatments but it caused a significant reduction in these parameters in the irrigated treatments. Despite these reductions, shoot dry matter was not reduced in the solarized treatment at the time of nodulation sampling, perhaps due to the compensatory effect of solarization in enhancing nitrate concentrations in this treatment.

CONCLUSION

Soil Solarization is a non-pesticidal method of controlling soil borne phytopathogens by placing plastic sheets on moist soil during periods of high ambient temperature. It is a simple, safe and effective method that has been used with field, vegetable and flower crops, in orchards, vineyards, greenhouses, garden and landscapes. It can be combined with organic soil amendments are reduced rate of chemicals, large increases in plant growth, harvestable yield and crop quality. Solarization should not be regarded as a universal method, but rather as an additional option for disease control, for use in conjunction with other methods.

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