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Potent potato production with soil solarization

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Abstract
Soil solarization is a non-chemical environment friendly method which has beneficial effects in horticultural crop production. It is commercially use in area with very high temperature of air mainly in summer season, where much of the crop production area kept fallow because of excessive heat. Solarization of soil is mainly dependent on high levels of solar energy, as influenced by both climate and weather. Reviewing the information that is currently available on soil solarization reveals the many benefits of the method in relation to the production of horticultural crops. Soil solarization has been reported to manage lots of weed species, control soil borne insects and diseases, manage nematodes. Soil solarization also increase thermo tolerant micro fauna in the soil, which includes beneficial microorganisms, nutrient solubilizers, and nitrifiers and thus results in higher availability of required plant nutrient and improvement in soil tilth. Method of soil solarization in controlling soil borne is well demonstrated. In the case of potatoes, soil solarization is also known to improve tuber quality and increase potato yield by lowering the number of weeds and soil borne diseases.

Keywords: Soil solarization, soil borne pathogens, nutrients, potato, weeds, yield

Introduction

What is soil Solarization. Soil solarization is a non-chemical environment friendly method for controlling insects and pests using solar power to increase the soil temperature to levels at which many soil borne plant pathogens will be killed or greatly weakened. It is a successful technique that can be used in organic farming because it is nonhazardous and chemical free (Arora and Sharma 2013) [9]. Soil solarization was initially pioneered in countries in the Middle East, where intense solar radiation and high temperatures are appropriate for solar heating. Environmental and health concerns have prompted the appearance of stricter regulations for the usage of agricultural pesticides. Soil solarization is a pest management tactic that has potential application to IPM systems. It is compatible with and often enhances the performance of various chemical, biological and cultural treatments. soil solarization is mainly dependent on high levels of solar energy, as influenced by both climate and weather condition. Cloud cover, cool air temperatures and precipitation events during the treatment period reduce solarization efficiency. The potato tubers are grown underground and are exposed to various soil borne pathogens including bacteria, fungi and nematodes. Since, soil borne diseases of potato may lead to heavy losses in terms of tuber quality and quantity, this crop is an excellent candidate for investigating the effects even under conditions of temperate climate (Davis and Sorensen 1986) [1].

The soil solarization with the potato introduces a wide spectrum of possibilities for future food production with high quality and quantity. Therefore, an attempt has been made to review the work done on the various aspects of soil solarization with special reference to potato.

Steps for Conducting Solarization

1. **Where to do Solarization:** Solarization can be done on any soil type in Florida and has even been successful on rock soils in south Florida. For best results, it should be done in open and unshaded areas. We would not expect very good results if the sun is blocked by trees or buildings during the day.
2. **When to do Solarization:** The best times for solarization are during the summer months of June, July and August because these have the hottest temperatures. Although it has been tried in the spring and autumn, when the weather is colder, it might not be as dependable. Though this has not been confirmed; June might be the greatest month because it might have less rainfall than the other summer months.
3. **Site Preparation:** Remove any existing weeds and rubbish from the area that will be

solarized. In order to improve heat penetration into the top six inches of soil, tilling the area is beneficial. In order to prevent sticks, old roots, and other debris from poking holes in the plastic, they should be removed.

4. Soil Moisture and Heat Conduction Water helps to conduct heat, so best results occur if soil is moist but not waterlogged or muddy. The solarization process will not be as effective if the soil is extremely dry and dusty. The ideal circumstances for sandy Florida soils are those in which the soil was irrigated or received rain the day before plastic was applied. Rain or irrigation within a short period of time before applying plastic can make the soil difficult to work with muddy or heavy and it can also get the clear plastic dirty.
5. **Cover Soil with Clear Plastic:** Solarization can be done on raised beds or on flat ground. If beds are used, they should run north-south as opposed to east-west. This guarantees that in the morning or afternoon, direct sunshine will reach the elevated borders of the beds. The area that has to be treated is covered with a clear plastic sheet or strip. Because the edges will need to be buried in soil (see next step), the plastic piece should be somewhat larger than the area to be treated. The plastic sheeting used must be completely Clear. Other types of plastic should not be used. Black plastics or reflective plastics will get hot on the surface, but will not allow sunlight through to heat the soil below. Translucent or whitish plastics may allow some sunlight through, but that is insufficient to do a good job of solarization. There are currently no guidelines about the kind or brand of clear plastic that should be used. Though some argue that thinner plastic is preferable, maybe the most important factor to take into account is that the plastic needs to be robust enough to last six weeks in the summer sun in Florida without breaking up.
6. **Solarize for at Least Six Weeks:** For a minimum of six weeks, the plastic needs to be left in place with all of its edges buried. If edges are not completely sealed, heat will leak out and problems may result in these cooler areas.
7. **Solarize for at Least 6 Weeks:** The plastic should be left in place with all edges buried for at least 6 weeks. After that, the plastic can be removed and if the procedure was successful, weeds and soil pests should be reduced for 3-4 months. Since heat under clear plastic kills seeds and plants, don't plant anything until the plastic is removed. It might be difficult to dispose of used plastic, particularly if it is weak and breaks easily either during or after removal **(**Krueger, R., and R. McSorley. 2009) [5].

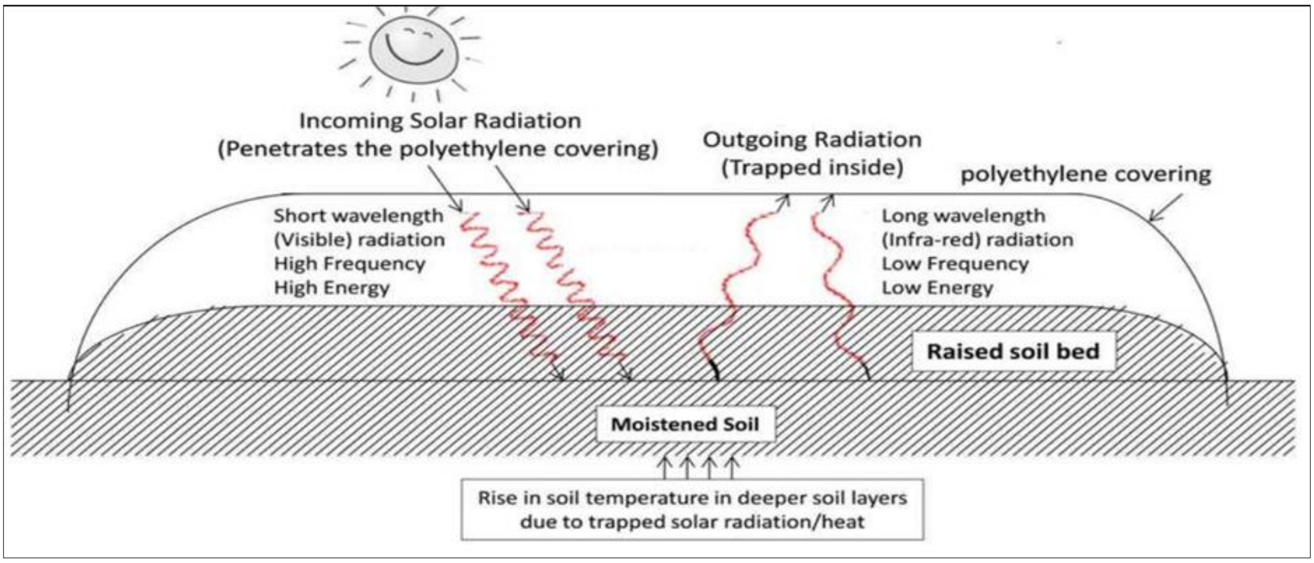

Fig 1: The Basic Principle of Soil Solarization

The success of soil solarization is based on the fact that most plant pathogens and pests are mesophilic, *i.e.,* they are unable to grow at temperatures above 31° to 32 °C; they are killed directly or indirectly by the temperatures achieved during the solar heating of moist soil under transparent plastic films which greatly restrict the escape of gasses and water vapour from the soil. Thermotolerant and thermophilic soilborne microorganisms usually survive the soil solarization process. However, all soilborne organisms, if not directly inactivated by heat, may be weakened and become vulnerable to changes in the environment in solarizing soil or to changes in the populations of other organisms which may exert a form of biological control. It is a hydrothermal process and its success depends on moisture for maximum heat transfer to soilborne organisms; it is a function of time and temperature relationships. The inverse relationship between soil temperature and exposure time determines the thermal decrease of soilborne organisms during solarization.

Applicability and potential of soil solarization:

- Non-hazardous
- User friendly
- Environmentally safe
- Non-dependent on fossil fuel
- Effective on a wide variety of pest including soil-born fungi, bacteria, nematodes and weeds
- Often effective for more than one season or a year
- Stimulatory to crop (Stapleton and DeVay,1986) [14]

Factors influencing effectiveness of soil solarization:

When the term "solarization" is used strictly, it means that sunshine or other ultraviolet radiation changes the chemical makeup of glass, causing a photochemical reaction that not only results in a perceptible colour change but also in a decrease in ultraviolet transmission (Koller, 1965) [4]. By using the term "solarization," we imply the thermal, chemical, and biological changes that occur in soil as a result of solar radiation when it is coated in a clear plastic film-especially in cases where the soil has a high moisture content. Katan (1981) [3] reviewed several of the physical bases of soil solarization. The following factors are involved:

- **Soil preparation:** To minimize the insulating effect of an air layer, it is advisable to put the plastic film close to the soil with as little space between it and the soil as possible. This allows the soil to absorb radiation and heat the soil. For the ground to be smooth and even, good preparation is necessary.
- **Soil characteristic:** Dark soils absorb more radiation than light-coloured soils, this may partly account for the higher maximum temperatures achieved in some soils. Substantial variations in soil properties or moisture content can result in significant variations in the properties of soil heat transmission (Smith, 1964) [11].
- **Polythene film types and characteristics:** The plastic film reduces heat losses from soil that would be caused by evaporation and heat convection. Clear transparent polyethylene is usually employed, mainly because of its low cost and high strength, and allows maximum transmittancy of radiation (Waggoner *et al.*, 1960) [16]. Thinner films, 19-25 µm are more effective for soil heating than thicker films (50-100µm) and are proportionally less expensive. The main impacts of solarization include the increased heating of damp soil during solarization and the ensuing effects on the physical, chemical, and biological conditions in solarized soil.
- **Color:** Clear or transparent polyethylene films should be used but not black films
- **Thickness:** Polyethylene film having 19-25 µm thickness is more efficient
- **Soil moisture:** Wet soil promotes heat transmission or conduction in the soil and improves the temperature sensitivity of soil-borne microflora and fauna. This can be achieved by watering the soil either before mulching or under the plastic film. Saturated soils are optimal. Soil can be moistened by 40-50 mm pre irrigation or by drip or furrow irrigation following laying of the polyethylene film (Mahrer *et al*., 1984) [7].

Time and duration of soil coverage

- Killing of weed seeds, weed seedlings and soilborne pathogen is related to time and temperature exposure
- April-June in northern part is the best time for solarization of soil (Stapleton and DeVay,1986) [14]

Need of soil solarization in potato

Potato is an important food source since it produces more food per unit area per unit time than the conventional cereal crops and thereby holds promise for food for the fast-growing human population. It is grown commercially in almost all the agro climates mainly under dry temperate, temperate and sub tropical conditions. Being grown underground, the potato crop is affected by soil borne pathogens causing soilborne tuber diseases of potato. All these soil pathogens not only lower down the tuber yield but also affect the tuber quality adversely. With the reduction in cultivable land due to fast urbanization and cultivation of potato year after year in the same land, the soil and tuber diseases are emerging as a major problem and pose great challenge for their management. Soil solarization has previously been found effective against various potato diseases and pests (Triki, 2001) [15]. It has been reported to reduce the weeds, soil pathogens and improve the quality of potato tubers. There have also been reports of improved potato tuber quality and increased yield due to a decrease in weeds and several soil-borne illnesses. Studies conducted using potatoes demonstrate that solarization is beneficial even in temperate climates (Davis and Sorensen, 1986) [1]. The use of soil solarization with the potato introduces a wide spectrum of possibilities for future food production. Therefore, an attempt has been made to review the work done on the various aspects of soil solarization with special reference to potato.

Effect of soil solarization on soil moisture content

Egley (1983) [2] studied the effects of soil solarization through transparent polyethylene covers upon soil moisture content and observed that the soil moisture content on soil surface was within the range of 2.2 to 2.6 percent on a dry weight basis when soil covers were put in place. On 30th June and 2nd July after a rainfall of 4.2 cm, soil moisture in the top 2.5 cm was significantly higher under the cover. Whereas, on 8th July, soil moisture dropped to 1.8 percent in the control plot, but still relatively high at 14.9 percent under the polyethylene cover. With no rainfall during the period, soil moisture content on 11th July under the cover fell to 3.7 percent as compared to 1.8 percent in the control.

Effect of soil solarization on soil temperature

Kumar *et al*. (1993) [6] studied the effect of soil solarization with PE film on soil temperature at three depths during mulching period. They recorded that mulching with PE increased the mean maximum soil temperatures by about 9 °C at 5 cm and 7 °C at 10 and 15 cm depths. Differences in mean minimum temperatures as a result of mulching was less than 2 °C.

Singh *et al*. (2009) [10] found that the average weekly maximum temperatures at all the soil depths was higher in solarized plots as compared to unsolarized plots. The mean maximum soil temperature recorded under the polyethylene mulch were 53.3 °C at the surface, 50.5 °C at 5 cm, 44.0 °C at 10 cm and 38.6 °C at 15 cm soil depth, which were higher by 10.96 °C, 9.4 °C, 5.6 °C and 3.9 °C, as compared to unsolarized plots at respective depths.

Effect of soil solarization on pathogens

Davis and Sorensen (1986) [1] studied the influence of soil solarization on severity of wilt caused by *Verticillium dahliae* among three potato clones. They observed that the clone NDA8694-3 was most susceptible, Russet Burbank was less susceptible and A68113-4 was most resistant. Solarization reduced colonization of *V. dahliae* in the resistant clone A68113-4, which again indicated reduction in soil population of *V. dahliae.*

Kumar *et al*. (1993) [6] found that the soil solarization drastically reduced nematode population by about 90 percent for parasitic and 70 percent for saprophytic species by the end of the mulching period. However, by 70 DAS population of parasitic nematodes recovered to about 70 percent of those on unmulched plots and the saprophytic species showed no effects of mulching**.**

Triki *et al.* (2001) [15] studied the effects of soil solarization on soil borne fungi and observed that the solarization reduced by 96 percent and 76 percent the inoculum density of *Fusarium* *solani* at the upper and lower 15 cm layers, respectively. They also observed that the population densities of *Pythium aphanidermatum* were heavily reduced by the solarization as nearly no oat seed (0.8 percent) was colonized by the solarized soil sample at 0-15 cm and only 6.7 percent at 15-30 cm deep soil sample.

Effect of soil solarization on weed

Kumar *et al.* (1993) [6] found that the soil mulching significantly reduced the population of emerged grasses and other weeds in the uncropped parts of the plots. Mulching for 32 days reduced the emergence of grasses in the first flush by 89 percent, *T. monogyna* by 98 percent, *D. arvensis* by 75 percent and of *C. rotundus* from seed by 90 percent.

Marenco and Lustosa (2000) [8] observed that the solarization reduced total dry matter accumulation and density of weeds at 15, 30 and 45 days after the removal of PE films. Weed DM accumulation was reduced from 11.9 g m^{-2} in control plots to 0.89 g m^{-2} in those solarized for nine weeks indicating the effectiveness of PE mulching on weed control.

Singh *et al*. (2009) [10] observed as a result of soil solarization significant reduction in weed population by 98 percent and fresh weight of weeds by 99.2 percent in the first year over unsolarized control, whereas corresponding figures in second year as 96.9 and 98.2 percent. In unsolarized soil, number of weeds were 110.5 and fresh weight 194.85 g m^{-2} during first year, whereas corresponding figures for second year were 193 and 273.3 g m^{-2}.

Effect of soil solarization on beneficial microbes

Stapleton and DeVay (1984) [12] observed that the population densities of *Agrobacterium spp*., *Fluorescent pseudomonas*, Gram-positive bacteria, *Actinomycetes* and *Pythium spp.* in the solarized soil differed significantly from those found in both the shaded and untreated control soils; they were reduced to 44-80 percent compared to the untreated soil.

Effect of soil solarization on nutrient content

Stapleton *et al.* (1985) [12] studied on soil nutrient as influenced by soil solarization and observed that NO^{-}_3-N was significantly increased by 1-11 fold, NH^+_4-N by 4.5-43 fold, P by 1.2-1.5 fold, Ca^{2+} by 1.7-2.2 fold, Mg^{2+} by 1.8-2.7 fold in the solarized soil compared to non treated one.

Singh *et al*. (2009) [10] found that the soil nutrients (N, P and K) were influenced by soil solarization both at planting and harvesting. The increase in available nutrients was 49.0 percent N, 67.3 percent P and 15.7 percent K at planting and 11.44 percent N, 13.1 percent P and 32.2 percent K at harvesting.

Effect of soil solarization on potato tuber Yield

Davis and Sorensen (1986) [1] found the mean total yield for the NDA8694-3 clone was increased in the range from 31 to 37 percent and in terms of U.S.#1, it was increased from 46 to 57 percent. Similarly, total yield increased for the clone Russet Burbank was from 31 to 46 percent; whereas in terms of U.S.#1, it was increased by 65 to 118 percent. The increase in tuber yield for the A68113-4 clone was in the range of 15 to18 percent and in terms of U.S.#1, it was from 18 to 25 percent.

Sharma and Arora (2013) [9] revealed a highly significant increase in tuber yield in almost all the cultivars, from 8.62 percent in Kufri Pukhraj to 73.67 percent in K. Chandramukhi. The increase in tuber yield was between 16-20 percent in K. Jyoti, K. Jawahar and K. Dewa, between 20-30 percent in Phulwa, K. Ashoka and K. Sherpa, between 30-40 percent in K. Giriraj, K. Bahar, K. Sutlej and K. Badshah. Due to solarization, the highest increase in yield was recorded in K. Chandramukhi (73.7 percent) followed by K. Lauvkar (62.02 percent).

Singh *et al*. (2009) [10] observed that the yield in solarized plots was 279.0 q ha^{-1} as compared to 193.2 q ha^{-1} in unsolarized plots. The mean tuber yield was highest in K. Ashoka (277.8 q ha^{-1}) followed by K. Pukhraj (234.2 q ha^{-1}) and K. Badshah (196.3 q ha^{-1}).

Conclusion

It can be concluded from the forgoing reviews that Solarization of soil is a beneficial practice in potato production. It maintains soil moisture relatively high 14.9% under the polyethylene cover. Mean maximum soil temperature recorded under the polyethylene mulch were higher by 3.9 ^{0}C to 10.96 ^{0}C at different depths from surface to 15 cm compared to control. It reduced nematode population by about 90 percent for parasitic and 70% for saprophytic species, the inoculum density of *F. solani* by 96 percent and 76 percent. Weed DM accumulation was reduced from 11.9 g m^{-2} in control plots to 0.89 g m^{-2} in those solarized for nine weeks. Mulching for 32 days reduced the emergence of grasses. It significantly reduced weed population by 98 percent and fresh weight of weeds by 99.2 percent. Population densities of *Agrobacterium spp*., *Fluorescent pseudomonas*, Gram-positive bacteria, *Actinomycetes* and *Pythium spp.* in the solarized soil were reduced by 44-80 percent compared to the untreated soil. It increased NO_3-N by 1-11 fold, NH^+_4-N by 4.5-43 fold and P by 1.2-1.5 fold in solarized soil. It increased available nutrients in soil namely N 49.0 percent, P 67.3 percent and K 15.7 percent at planting. It increased mean total tuber yield ranged from 31 to 46 percent. It increased tuber yield in K. Chandramukhi by 73.67 percent followed by K. Lauvkar by 62.02 percent. In nutshell, soil solarization helps in increasing tuber yield, managing weeds, controls nematodes, soil borne diseases and pathogens.

References

1. Davis JR, Sorensen LH. Influence of soil solarization at moderate temperatures on potato genotypes with differing resistance to *Verticillium dahliae*. Phytopathology. 1986;76(10):1021-1026.
2. Egley GH. Weed seed and seedling reductions by soil solarization by transparent polyethylene sheets. Weed Science. 1983;31(3):404-409.
3. Katan J. Solar heating (solarization) of soil for control of soilborne pests. Phytopathology. 1981;19:211-236.
4. Koller LR. Ultraviolet radiation. 1965, 2.
5. Krueger R, McSorley R. Solarization for pest management in Florida. Entomology and Nematology Department, UF/IFAS Extension; c2009.
6. Kumar B, Yaduraju NT, Ahuja KN, Prasad D. Effect of soil solarization on weeds and nematodes under tropical Indian conditions. Weed Research. 1993;33(5):423-429.
7. Mahrer H, Naot O, Rawitz E, Katan J. Temperature and moisture regimes in soils mulched with transparent polyethylene. Soil Science Society of America Journal. 1984;48:362-367.
8. Marenco RA, Lustosa DC. Soil solarization for weed

control in carrot. Pesquisa Agropecuária Brasileira. 2000;35:2025-2032.
9. Sharma J, Arora RK. Efficiency of soil solarization in reducing tuber russet and improving yield of different potato cultivars. Potato Journal. 2013;32(3-4):185-186.
10. Singh A. Effect of soil solarization on multiplication of *in-vitro* planting materials of potato under field conditions. Potato Journal. 2009;36(3-4):143-148.
11. Smith EM. Potential field for heat transfer in soil covered by different plastic mulches. Proceedings of the National Agricultural Elastics Conference. 1964;5:80-92.
12. Stapleton J. Soil solarization: effects on soil properties, crop fertilization and plant growth. Soil Biology and Biochemistry. 1985;17(3):369-373.
13. Stapleton JJ, DeVay JE. Thermal components of soil solarization as related to changes in soil and root microflora and increased plant growth response. Phytopathology. 1984;74(3):255-259.
14. Stapleton JJ, DeVay JE. Soil solarization: a non-chemical approach for management of plant pathogens and pests. Crop Protection. 1986;5(3):190-198.
15. Triki A. Effects of soil solarization on soil-borne populations of *Pythium aphanidermatum* and Fusarium solani and on the potato crop in Tunisia. Potato Research. 2001;44(3):271-279.
16. Waggoner PE, Miller PM, DE Roo HC. Plastic Mulching: Principles and Benefits. Connecticut Agricultural Experiment Station Bulletin 634; c1960. p. 44.