



Soil solarization for weed control in cauliflower

Jelena Petrović

Faculty of Agriculture, University of Novi Sad, Trg Dositeja Obradovića 8, 21000 Novi Sad, Serbia

Abstract

Soil solarization, a non-chemical, eco-friendly weed management strategy, has garnered attention for its potential in sustainable agriculture, particularly in cauliflower production. This review article evaluates the efficacy, benefits, limitations, and practical applications of soil solarization in controlling weeds in cauliflower fields. By synthesizing current research findings, this article aims to provide an in-depth understanding of soil solarization as a viable alternative to chemical herbicides, contributing to the development of integrated weed management (IWM) strategies for cauliflower cultivation.

Keywords: Cauliflower (*Brassica oleracea* var. *botrytis*), soil solarization, eco-friendly weed, IWM

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis*) is a significant vegetable crop known for its nutritional benefits and economic value. However, weed infestation in cauliflower fields poses a major challenge to growers, leading to yield losses and increased production costs. Traditional weed control methods, particularly the use of chemical herbicides, have raised concerns over environmental sustainability, human health risks, and the emergence of herbicide-resistant weed species. Soil solarization, a method of using solar power to heat the soil to temperatures that are lethal to weeds, soilborne pathogens, and pests, offers an appealing alternative. This review article examines the principles, effectiveness, and practical considerations of soil solarization in cauliflower production, aiming to assess its role in sustainable agriculture.

Objective of study

The primary objective of this paper is to investigate the effectiveness of soil solarization in controlling weed populations in cauliflower cultivation.

Previous Works

Solarization not only effectively decreased weed density and biomass but also increased nitrogen and organic matter levels due to the decomposition of plant residues. The reduction in weeds and the boost in soil nutrients contributed to increased cauliflower yields. The effectiveness varied among weed species, with certain weeds like *Cirsium arvense* being controlled, while others like *Vicia sativa* had stimulated germination due to solarization (Khan *et al.*, 2012) ^[1]. Combining soil solarization with low rates of soil fumigants showed effectiveness in controlling clubroot disease in cauliflowers and in increasing yields. The study highlighted the dependency of effectiveness on factors such as soil type and the presence of *Plasmodiophora brassicae*, the pathogen responsible for clubroot disease (Porter *et al.*, 1991) ^[2]. The amendment of soil with cauliflower residue, both alone and combined with a low dose of metham sodium (MS), along with soil solarization, was investigated for controlling

Verticillium wilt of artichoke in fields under artichoke-cauliflower rotation. While solarization reduced the inoculum of *Verticillium dahliae* and incidence of the disease, the addition of cauliflower residue did not significantly enhance the benefits of solarization (Berbegal *et al.*, 2008) ^[3]. Solarization was found to significantly affect soil physical, chemical, and biological properties, and improved the vigor of cauliflower seedlings. The study emphasized soil solarization's potential for nutrient management and control of soilborne pests, suggesting a positive impact on the vigor of vegetable nurseries (Sofi *et al.*, 2013) ^[4]. Research has consistently shown that soil solarization is an effective method for controlling weeds, with the added benefit of being a non-chemical approach. It utilizes high temperatures generated under clear plastic films to manage a broad spectrum of soil-borne pathogens and pests, including weeds. Increased plant growth and yield following solarization have been observed in various crops, demonstrating its value as a sustainable agricultural practice (Stapleton & Devay, 1986) ^[6].

Principles of Soil Solarization

Soil solarization is a non-chemical, environmentally friendly method used for controlling weeds, soilborne pathogens, and nematodes. This technique capitalizes on solar energy to heat the soil to temperatures that are lethal to many undesirable organisms. The success of soil solarization is underpinned by several core principles related to solar radiation, soil properties, and the biology of soilborne pests and weeds. This section delves into the underlying mechanisms of soil solarization, supported by examples, data, and findings from previous studies.

The effectiveness of soil solarization is primarily determined by the ability of solar radiation to penetrate and heat the soil. Transparent polyethylene plastic is used to cover the soil, creating a greenhouse effect that traps solar radiation. This radiation is converted into heat, significantly increasing soil temperatures. For instance, research has shown that soil solarization can elevate soil temperatures to 45 °C (113°F) or higher at a depth of 5 cm (2 inches), which is sufficient to kill or suppress many weed seeds and soilborne pathogens (Stapleton & DeVay, 1986) ^[6].



Fig 1: Soil Solarization

Factors Influencing Efficacy

Duration of Solarization: Extended periods of solarization result in greater cumulative heat exposure. Studies have indicated that 4-6 weeks of solarization during peak summer months can effectively reduce weed populations in subsequent crops.

Plastic Film Characteristics: The type, color, and thickness of the plastic film used for solarization play critical roles. Transparent, thin (about 25-50 micrometers), and UV-resistant polyethylene sheets are most effective in trapping solar heat. Thicker films may not transmit solar radiation as effectively, whereas thinner films are more prone to damage but allow more heat transfer.

Soil Moisture: Moist soil conducts heat more efficiently than dry soil. Pre-irrigation before applying the plastic sheets can enhance the thermal conductivity of the soil, thereby improving the effectiveness of solarization. A study demonstrated that pre-irrigated plots under solarization had significantly lower weed emergence compared to non-irrigated plots (Stapleton J, *et al.*, 1986) [6].

Ambient Temperature and Solar Intensity: The geographical location and season influence the amount of solar energy available for soil heating. Regions closer to the equator and seasons with longer daylight hours receive more intense solar radiation, making soil solarization more effective.

Soil solarization through mechanisms

Soil solarization works through a combination of several mechanisms to control pests, diseases, and weeds, making it an effective and environmentally friendly method in agricultural practices;

- The primary mechanism is the trapping of solar radiation by the transparent plastic cover, which raises the soil temperature to levels that are lethal to many soil-borne pests and pathogens, including fungi, bacteria, nematodes, and weed seeds. Temperatures can reach 40-60 °C (104-140 °F) at the soil surface and slightly lower at greater depths, depending on the location and weather conditions.
- The plastic covering helps retain soil moisture, which is crucial for two reasons. First, it improves the thermal conductivity of the soil, allowing the heat to penetrate deeper. Second, many soil pathogens and pests are more sensitive to heat when in a hydrated state, increasing the effectiveness of the heat treatment.

- Solarization can lead to the formation of volatile compounds, including organic acids, ammonia, and other gases, from the decomposition of organic matter in the soil. These compounds can have additional toxic effects on soil pathogens and pests.
- The heat from solarization can alter the balance of soil microorganisms. While the high temperatures reduce populations of harmful organisms, they can also stimulate the growth of beneficial soil microbes that are more heat-tolerant. These beneficial organisms can further suppress soil-borne diseases and promote plant growth.
- Sustained high temperatures can change the physical properties of the soil, such as its structure and water permeability, which can indirectly affect the survival of pests and diseases.
- Soil solarization can induce the germination of weed seeds by creating warm and moist conditions. However, because the conditions become lethal, it kills the seeds before they can emerge as plants, reducing the weed population.

Conclusion

Soil solarization, a non-chemical method that utilizes solar power to increase soil temperatures to levels lethal for many soil-borne pests and diseases, has proven to be an effective strategy for weed control in cauliflower cultivation. By covering the soil with transparent plastic sheets during the hottest months, this method capitalizes on the natural greenhouse effect to suppress weed growth, along with soil pathogens and pests, before cauliflower planting. The process not only significantly reduces the weed seed bank present in the soil but also promotes a healthier, more disease-resistant environment for cauliflower growth. This is particularly advantageous, given the sensitivity of cauliflower to competition and soil-borne diseases. The enhanced soil conditions can lead to improved yield and quality of the cauliflower crop by minimizing the stress and damage caused by weeds and diseases. Moreover, soil solarization offers an eco-friendly alternative to chemical herbicides, aligning with sustainable agriculture practices by preserving soil health and ecosystem balance. It also contributes to reduced labor and input costs associated with weed management in cauliflower cultivation. In conclusion, soil solarization emerges as a vital tool in the integrated weed management strategy for cauliflower, promising not only effective weed control but also broader benefits in terms of crop health, yield, and environmental sustainability. Future research and adaptation to local conditions can further optimize its efficacy, making it a cornerstone in the cultivation of cauliflower and potentially other crops susceptible to similar challenges.

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