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Effect of Biosolarization with Agricultural green waste on Biological control of Microbial and Nematode population in Tomato field

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Abstract

Non-chemical alternatives have come into focus as a result of stricter regulations pertaining to the registration of new biocidal chemicals and the progressive phase-out of pesticides due to their significant environmental effect. An appealing substitute is the biofumigation method, which includes adding chopped plant material, agricultural green wastes to the soil to regulate the microbial population and soil borne nematodes. This aspect of soil disinfestation involves introducing biological control agents and flavoring or strengthening the beneficial soil microflora in order to create a healthier soil, rather than using harsher methods to eradicate soil borne pathogens and pests. The goal of the experiment was to determine how biosolarization might be used to manage nematode and microbiota populations in an environmentally responsible manner. In order to comprehend how biosolarization affects microbial and nematode population, a study was carried out. In this study, biosolarization is carried out using a variety of additives, including waste from the processing of tomatoes, grapes, cruciferous crops, tomato plants, and *Allium* sp. Based on documented findings, the microbial and nematode populations have been found to be regulated by cruciferous and *Allium* sp waste.

Key words : Biosolarization, Biocidal molecules, cruciferous waste, *Allium* sp. waste.

Solanaceae family includes the tomato (*Solanum lycopersicum* L.), which is widely grown for its edible fruits. For nutritional reasons, it is labelled as a vegetable since it is high in lycopene, phytochemical and vitamin C. Common uses for the fruits include pickling, serving them as cooked vegetables, adding them to other recipes, and eating them raw in salads. Furthermore, processing accounts for a significant portion of the global tomato production; products include tomato juice, puree, ketchup, canned tomatoes, and dehydrated pulp. The widespread cultivation of tomatoes has increased the use of chemical fertilizers, which has ultimately caused a shift in consumer demand toward organically farmed tomatoes eventually resulting in less reliance on artificial fertilizers and alternative methods of raising tomato crops.

An essential agronomic technique in the cultivation of numerous high-value fruit and vegetable crops is soil fumigation. Conventional soil fumigants, such as methyl bromide, which is bad for the environment and people, are used to get rid of pest and nematodes in agricultural soils. Alternative soil fumigants are unwanted and particularly dangerous for urban farms because they provide a risk to human health even though they pose less of a threat to the ozone layer[1,10]. Furthermore, these fumigants are indifferent to beneficial bacteria or unwanted pests. Finding sustainable alternatives to control nematodes and microbes is therefore imperative[9].

Fungal, nematode, insect, and weed pests have all been effectively rendered inactive by soil biosolarization[3,16]. In order to heat soil sufficiently during warmer months to kill soil-borne pests including weeds, insects, disease pathogens, nematodes and others, a developing strategy for the management of soil-borne plant diseases combines soil solarization with organic amendments[5]. Through a number of methods, the inclusion of organic matter can improve insect inactivation. First, through biological heating, the amendment's increased bacteria and nutrient source can improve soil heating. For instance, adding compost and organic matter to the soil raised the temperature by 2 to 5° C when both were heated by the sun, higher than un amended soil[12]. Although the effects of soil biosolarization have not yet been measured, they will probably have an impact on the biomass and diversity of soil microbes. Following soil biosolarization, notable alterations in the microbial diversity within the soil profile have also been noted. Since dark-colored organic modified soils absorb more solar radiation than light-colored soils, higher soil temperatures may be achieved[14].

Plant-parasitic nematodes seriously harm crop plants by severely affecting the growth of the root system (either by inducing gall or feeding on the cortical tissues), stunting the plant's growth due to reduced nutrient uptake from the soil, and predisposing the roots to secondary pathogen invasion[7]. It has long been known that using soil fumigants to bring PPN population down to an economic threshold level[11]. The field of fumigant or non-fumigant nematode control is always evolving because of long-term registration requirements at the state level as well as deregistration concerns. As a result, biofumigation has become a popular non-chemical nematode pest management technique.

An experiment was carried out based on the aforementioned requirements to determine how bio solarization with agricultural green wastes affects microbial and nematode population management.

Field plots in the Dindigul district's Vattalagundu underwent soil biosolarization. Ec (mS/m) was 0.11 to 0.15 and pH ranges from 6.8 to 7.8 in the soil. Randomized Factorial Field layout was used with 10 treatment choices. Combinations of treatments include: biosolarization with waste from tomato and grape processing, biosolarization with cruciferous plant waste, biosolarization with waste from tomato plants and biosolarization with *Allium* sp. waste in addition to control. Tomato plant debris was gathered from a local tomato farmer's field, tomato processing waste was procured from local ketchup manufacturing, farmer producer organization, cruciferous and *Allium* sp waste was gathered from nearby market and grape processing waste was transported from the Praja Juice Company in Theni. The biosolarization process began in April of 2022–2023. The experimental field was divided solarized and non solarized plots with a spacing of 4x3 m. Agricultural green waste was placed in respective plots. Agricultural green waste were spread out in plots and then covered for two months with a 0.05-mm clear polyethylene plastic sheet. Regular observations have been made in the corresponding plots that were coated in various types of green agricultural waste.

The microbial and nematode populations were largely regulated by temperature because the experimental field was left undisturbed for two months. While compared with non-solarized plots, W3 (cruciferous waste) showed the lowest populations of bacteria (18.89 $x10^6$ cfu g^1), fungus (14.49 $x10^3$ cfu g^1), actinomycetes (13.72 $x10^3$ cfu g^1) and nematodes (9.92 no of nematode per 200 g soil). When compared to S_0, the solarized plots (S_1) had the lowest microbial population among the non-solarized plots as shown in Table-1. Significant results were obtained regarding the relationship between solarized plots and agricultural green waste. Minimal bacterial population 14.39 $x10^6$ cfu g^1 was recorded in treatment combination S_1W_3 (solarized plots with cruciferous waste).

Similarly, minimal populations of fungi and actinomycetes were identified in S_1W_3 (solarized plots with cruciferous waste), recording 9.32 $x10^6$ cfu g^1 and 10.63 $x10^6$ cfu g^1. In comparison to solarized plots, non-solarized plots showed a higher nematode population. W_3 (cruciferous waste), out of all the agricultural green waste types, had the lowest nematode population. S_1W_3 solarized plots with cruciferous waste followed by S_1W_5 solarized plots with *Allium* sp. waste were the treatment combinations that showed the lowest nematode populations (Table-2).

Among the solarized and non solarized plots, soil microbial population was significantly influenced by increase in soil temperature. S_1 (solarized plots) recorded maximum temperature when compared to non solarized plots. Four weeks of temperature observation on an average recorded 34.1 ºC in various agricultural green waste followed by *Allium* sp. waste (Figure 1-4). Rise in soil temperature was consistent with findings from the majority of the studies. Furthermore, the use of 0.5 mm transparent polyethylene sheet may potentially be the cause of the rise in soil temperature.

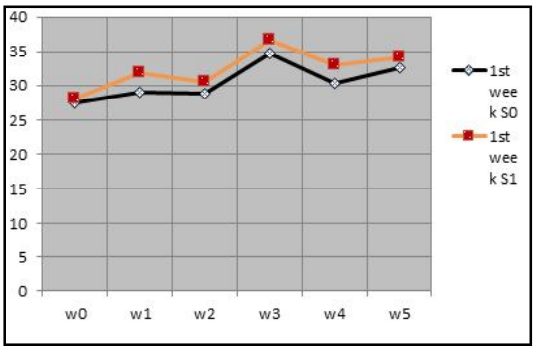

Figure 1. Temperature recorded on 1st week of biosolarization

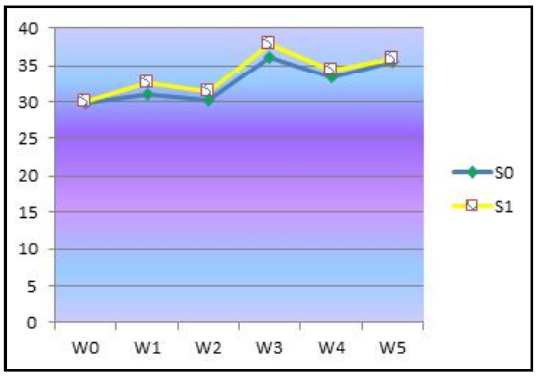

Figure 2. Temperature recorded on 2nd week of biosolarization

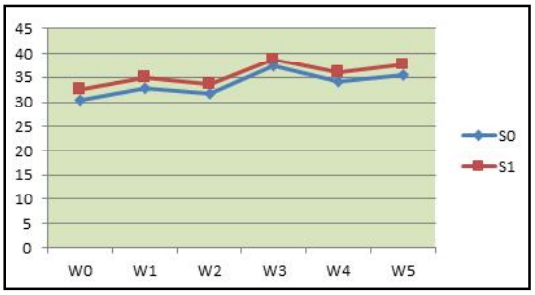

Figure 3. Temperature recorded on 3rd week of biosolarization

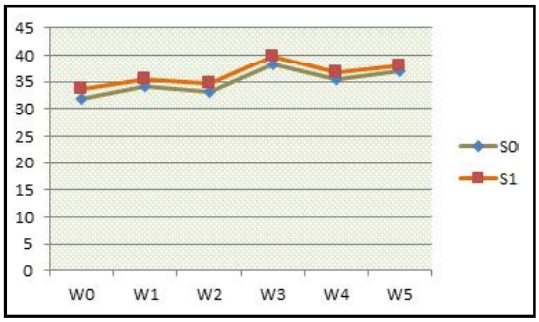

Figure 4. Temperature recorded on 4th week of biosolarization

Beneath the polyethylene layer, microorganisms and agricultural green waste initiated germination and multiplication, leading to a warming of the environment. A significant amount of CO_2 was generated throughout this process as a result of microorganisms respiring which gathered beneath the polyethylene layer and water evaporating under the cover increased the humidity beneath it. In contrast, the greenhouse effect produced by CO_2 and water vapor raises the temperature of the soil[13]. The results of the observations showed that the types of wastes employed and solarization caused a rise in soil temperature on all the days of observation.

Similar findings have been observed by other workers also. When it comes to different types of agricultural green waste, W_3 (cruciferous waste) and W_5 (*Allium* sp. waste) had the lowest populations of bacteria, fungi, and actinomycetes. Application of waste from *Brassica* sp. (cauliflower, cabbage) has a number of characteristics that kill microbes. Several workers have also found a decrease in the microbial population[2].

The microbial population has been profoundly impacted by the interaction between solarization and green waste from

Table-1. Effect of biosolarization with agricultural green waste on microbial population

Treatment combi-nation	Bacteria (x10^6 cfu g^1)							Fungi (x10^3 cfu g^1)							Actinomycetes (x10^3 cfu g^1)						
	W_0	W_1	W_2	W_3	W_4	W_5	Mean	W_0	W_1	W_2	W_3	W_4	W_5	Mean	W_0	W_1	W_2	W_3	W_4	W_5	Mean
S_0	31.65	27.59	29.41	23.38	26.38	24.59	27.17	28.68	24.48	26.27	19.66	22.72	20.96	23.79	22.19	19.75	20.46	16.81	18.96	17.92	19.35
S_1	21.71	18.79	20.15	14.39	17.38	15.89	18.05	17.69	14.32	15.94	9.32	12.67	10.92	13.47	15.77	13.74	14.74	10.63	12.74	11.65	13.22
Interaction mean	26.68	23.19	24.78	18.89	21.88	20.24	22.61	23.19	19.40	21.11	14.49	17.70	15.94	18.63	18.98	16.75	17.60	13.72	15.85	14.79	16.29

LEVEL OF SIGNIFICANCE

	W	S	WS	W	S	WS	W	S	WS
S.E(d)	0.099	0.169	0.240	0.059	0.102	0.145	0.126	0.220	0.312
CD(P=0.05)	0.200	0.346	0.489	0.121	0.209	0.295	0.256	0.444	0.628

Table-2. Effect of biosolarization with agricultural green waste on nematode population

Treatment combination	Nematode population (no of nematode per 200 g soil)						
	W_0	W_1	W_2	W_3	W_4	W_5	Mean
S_0	18.68	16.26	17.30	13.05	15.13	14.09	15.75
S_1	11.90	9.86	10.95	6.79	8.86	7.51	9.31
Interaction mean	15.29	13.06	14.13	9.92	11.99	10.80	12.53

LEVEL OF SIGNIFICANCE

	W	S	WS
S.E(d)	0.054	0.099	0.139
CD(P=0.05)	0.115	0.199	0.282

agriculture. The lowest microbial population was seen in S_1W_3 (solarization with cruciferous waste) and S_1W_5 (solarization with *Allium* sp. waste). The minimal microbial population has been caused by the combined effects of greater temperature caused by the polyethylene sheet and volatile chemicals found in cruciferous and *Allium* sp. waste. A wide range of soil microorganisms are most severely killed by elevated soil temperatures. The results of this experiment are consistent with ecology and ecosystems, which are environments in which groups and populations interact along the food chain. In irrigated soil, a high temperature beneath a mulch that was 25 µm thick killed off the population of actinomycetes, bacteria, and fungi[4]. The observations in the present study reveal that the population of fungi, bacteria and actinomycetes were significantly increased after removing polyethylene sheet when compared with non solarized plots at different treatment combinations. Similar findings have been observed by Lalitha, *et al*.,[8].

The nematode population in the soil has been significantly reduced by solarization in conjunction with agricultural green waste in both months; among the solarized and non-solarized plots, S_1 (solarized plots) recorded minimum nematode population when compared with S_0 (non solarized plots). The interaction effect of S_1W_3 (solarization with cruciferous waste) followed by S_1W_5 (solarization with *Allium* sp. waste) also recorded minimum microbial population in the nematode population. Sub lethal heating of the nematodes in the soil profile may be the cause of the decrease in nematode population and poor recovery following solarization. This might lead to decreased potential, fewer worms reproducing or hatching later on and potentially even induced bio control. Numerous investigations have revealed that soil solarization can regulate plant nematodes in numerous nations[15]. Furthermore, it is evident that for farmers earnings, soil solarization plus organic amendment is more advantageous than soil fumigation alone or fumigant half-dose. In conclusion, this study's findings on nematode and microbiota populations at the agricultural level show that agricultural green waste as supplements have a significant short-term, global and local impact.

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