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THE EFFECT OF IRRIGATION INTERVAL ON TEMPERATURE DISTRIBUTION IN SOIL PROFILE UNDER SOLARIZATION APPLICATIONS IN GREENHOUSES

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Summary

The aim of soil solarization is to control soil borne pathogens and weeds heating with solar energy of soil which is sufficiently wetted. Soil water content is the one of the most important factors affecting soil solarization. Humidity level is important to convey temperature from the upper layers to down layers of soil in solarized soil. For this purpose, the study was conducted in plastic greenhouse in Isparta province. Beginning of the study, all plots were irrigated to reach the field capacity, and then the all plots were irrigated in 5 days irrigation interval during the experiment periods. Temperature distribution was measured in 5, 10, 20 and 30 cm of the soil profile along the experiment periods. As a result of this study, increasing of soil temperature and effectiveness of solarization decreased with together the water content of soil in upper layers. However, the soil temperature increased with irrigation in the down layers.

Key words: Irrigation, solarization, soil profile

INTRODUCTION

Soil disinfection is the struggle against soil based pathogen, disease and weeds via chemical and physical methods in agricultural lands with high amounts of agricultural production. Following the banning of the most important chemical methyl bromide, researchers are now seeking new methods for a sustainable environment that is suited to the natural ecosystem. The most important and the oldest method among these is “Soil Solarization” which is the soil disinfectant method suited to the natural ecosystem. Soil solarization is an environmentally friendly method for the struggle against heat sensitive pests, which aims to destroy soil based pests by covering the soil with a polyethylene (PE) cover thereby heating up the soil for a period of one or two months during the hottest months of the year when there is no agricultural production.

The most important point in solarization application is the temperature strength of the organism to be destroyed. It is stated that by using PE cover material evaporation and thereby water loss to the atmosphere from the soil is prevented and a greenhouse effect is formed by preventing the passage of long wavelength light by the water droplets that accumulate on the soil surface and the water vapor from the atmosphere thereby heating up the soil more [Mahrer, 1979; Sesveren, 2007].

In solarization applications, the soil should be moist enough in order for the heat to reach the bottom layers of the soil profile. Researchers indicate that moisture is one of the most important factors determining the effectiveness of solarisation [Stapleton, 1990; Abu-Gharbieh et al., 1990; Katan and DeVay, 1991; Al- Karaghouli and Al- Kayysi, 2001; Tekin, 2000; Sesveren, 2007; Tülün, 2011].

The thermal conductivity of the soil is closely related with the amounts of the solid, liquid and gas phases that make up the soil. Solid phase is the most conductive among these phases. Liquid and gas phases follow the solid phase in this order. As the bulk density of a soil increases, its thermal conductivity increases given that all the other elements remain the same. Because as the bulk density increases, the soil void ratio and in turn its air amount decreases thereby causing the solid particles to contact more tightly. The filling of these voids with water instead of air increases thermal conductivity. The thermal conductivity of water is 25 times better than that of the air. Hence, as the water content of the soil increases, thermal conductivity also increases. When the other factors remain the same a moist soil conducts heat 10 times faster than dry soil [Kolyasev and Gupalo, 1958; Pilatin, 2007].

Heat change of soils is closely related with moisture amount and the mineralogical structure of the soil. The increase of organic material, attainment of optimum infiltration and decreasing evaporation brings heat capacity to the desired level in clayed soil. Soil components may have very different thermal conductivity components. The average thermal conductivity of the soil varies according to its mineralogical and textural properties, organic material and moisture content and its ventilation. Low amount of moisture and high amount of air decreases the thermal conductivity of the soil. Hence, drying of the soil surface results in the decrease of thermal conductivity and thereby heat flow towards the bottom layers. When compared with the heat capacity of the soil, thermal conductivity varies with moisture change up to a certain point. Whereas in the moisture interval of farm conditions volumetric heat capacity varies 3-4 times with moisture change, thermal conductivity may vary as 100 times or more [Bristow et al., 2001; Ekberli et al. 2005].

The objective of this study is to determine the solarization effectiveness of the moisture content of the soil in the solarization process used to control soil based pests in greenhouse cultivation and to determine its effect on the temperature increase in the lower layers of the soil.

MATERIAL AND METHODS

The study was carried out during June 23 – September 23, 2011 for a period of 8 weeks in a plastic material covered greenhouse with a base area of 90 m^2. Temperature measurements were carried out during the study in 30 minute intervals and at 4 different depths. The study consists of 4 subjects and 3 repeats for a total 12 parcels and 1 control parcel. The first subject is the transparent PE cover material, the second subject is the biofumigation subject where 1.5 $kg \cdot m^{-2}$ wet chicken manure is used, and the third subject is the cover material with 1.2 cm high air bubble nylon and in the fourth subject solarization process has been carried out by filling the water bubble nylon to attain the highest soil temperature.

Table 1. Study letter identification

Treatments	Definition
T_1	the trial used in 0.04 mm thick transparent polyethylene sheets
T_2	the trial used in spaced 30 mm and12.5 mm high air bubble nylon
T_3	the trial used in spaced 30 mm and12.5 mm high water bubble nylon
T_4	the trial used in 0.04 mm thick transparent polyethylene sheets with biofumigation (1.5kg·m^{-2})
T_5	non-solarized trial

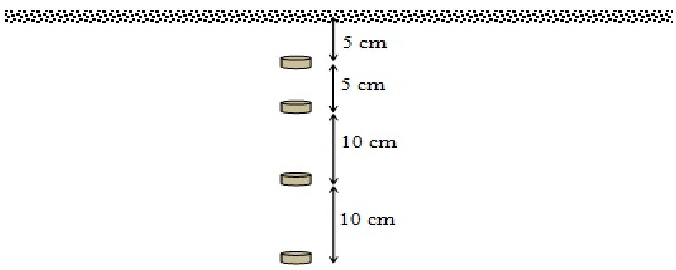

Figure 1. The vertical placement of the sensors to the parcels

Drippers with flow rates of 4 L h^{-1} were used in the study to irrigate the parcels. The moisture contents of the soil samples obtained from the parcels were determined prior to the trial and the study was started by irrigating the parcels until the field capacity was reached.

Table 2. Various soil constants of the greenhouse in the study

Soil depth	Field capacity (%)	Bulk density (gr·cm^{-3})	Clay (%)	Silt (%)	Sand (%)
0-30 cm	23.31	1.53	45.54	35.36	19.10

According to the calculations carried out, the system can apply 20 mm water in one hour to the field. During the first irrigation 40 mm water (2 hours) was given to reach field capacity.

RESULTS

The study was carried out during June 23 – September 23. The irrigation interval was selected as 5 days and the irrigation application was continued for a period of 1 month. Figure 2 shows the daily maximum temperature values at different depths according to the subjects during the 1 month interval of irrigation.

The first irrigation was applied on June 28 for a period of 1 hour following the start of the solarisation process. According to the temperature measurements taken prior to irrigation, the maximum temperature values obtained at a depth of 5 cm were 49.5°C, 51.3°C, 46.0°C , 47.5°C and 42.5°C respectively whereas the maximum temperature values obtained on the day of the irrigation were 49.0°C, 50.3°C, 45.3°C, 46.8°C, and 43.5°C respectively. The maximum temperature values obtained one day before August 17 which was the day of the last irrigation were 49.8°C, 51.0°C, 47.5°C, 48.5°C, and 44.0°C respectively. The maximum temperature values measured on the day of the irrigation were 46.5°C, 47.3°C, 44.3°C, 45°C and 41.0°C respectively. It was observed that the maximum temperature values on the day of the irrigation were 3.0°C lower than those measured one day before the irrigation.

Al-Karaghouli and Al-Kayysi [2001] have stated in their solarization studies that the maximum soil temperature decrease with increasing moisture content during the irrigation interval that was set as 5 days. They have determined that there is a direct relationship between the relationship of the increase of hourly soil temperature and soil heat flux.

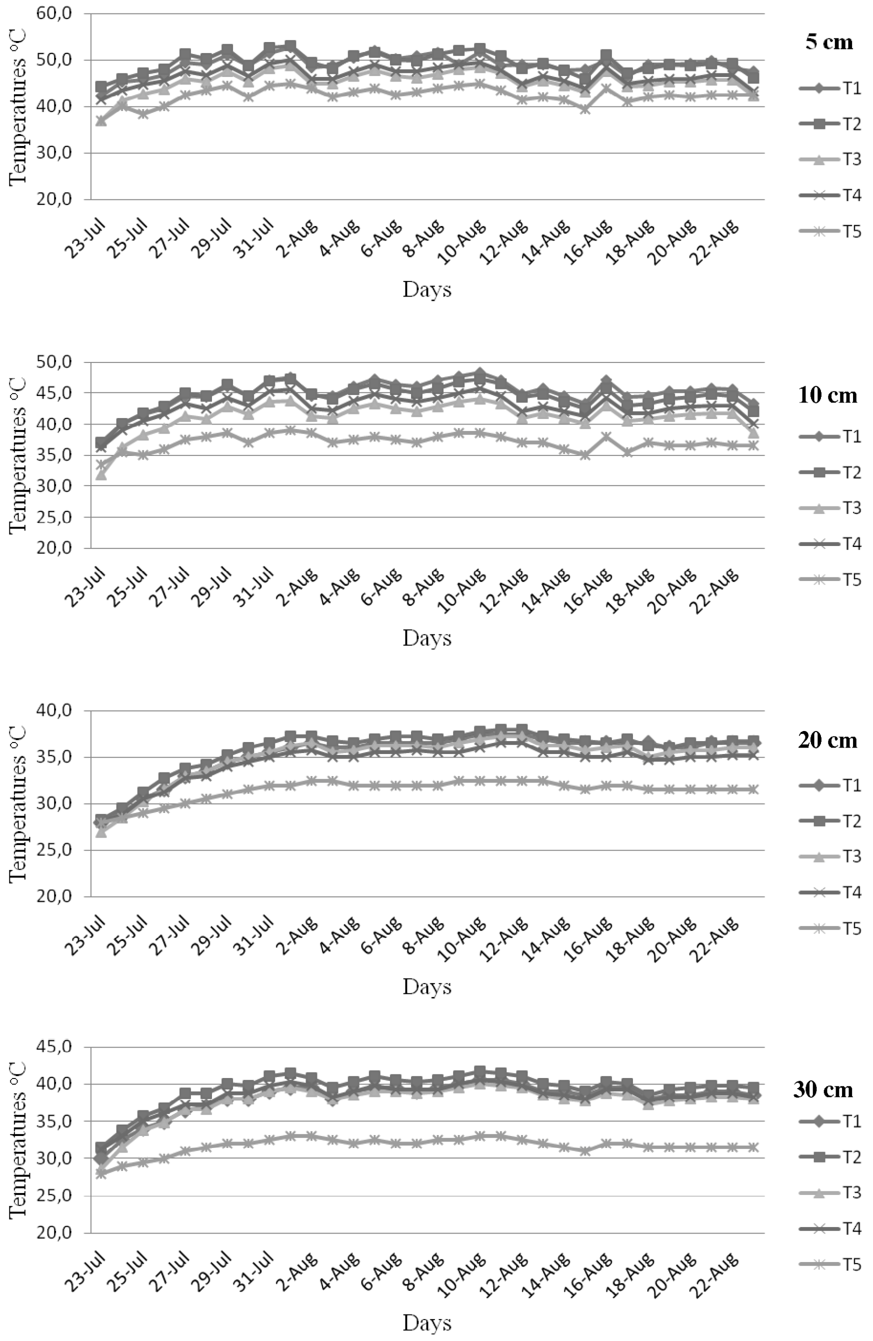

Figure 2. Daily maximum temperature changes at different heights according to treatments

DISCUSSION

It was determined as a result of the study carried out that soil moisture content is important for heat transfer in soil profile in solarization application and that irrigation decreases the soil temperature increase. Irrıgation is an important input in solarization applications which has to be applied in a controlled manner and irrigation should be decided by monitoring the soil moisture status and it has been determined that the average temperature of the irrigation water should be close to the soil temperature so that the daily maximum temperature increase is not affected. In their solarization study carried out in a greenhouse, Abu-Gharbieh et al. [1990], have prevented temperature decrease by using an irrigation water at a temperature of 75-90°C. As a result, it is apparent that soil moisture content has positive effects on the heat transfer in soil profile and that in addition it also acts as a factor limiting temperature increase in solarization applications. Therefore, since when irrigation applications are carried out in the morning hours the soil and irrigation water temperatures will have close values, the maximum temperature values reached at noon will not be affected from the temperature of the irrigation water.

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