EFFECT OF SOIL SOLARIZATION USING LDPE-MULCH ON MOISTURE CONSERVATION AND SOIL TEMPERATURE VARIATION

By

ANU VARUGHESE

THESIS

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Department of Land and Water Resources & Conservation Engineering
KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
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DECLARATION

I hereby declare that this thesis entitled "**Effect of soil solarization using LDPE-mulch on moisture conservation and soil temperature variation**" is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Tavanur

ANU VARUGHESE

CERTIFICATE

Certified that this thesis entitled "**Effect of soil solarization using LDPE-mulch on moisture conservation and soil temperature variation**" is a record of research work done independently by Smt. Anu Varughese under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Tavanur

Dr. K. John Thomas
(Chairman, Advisory Committee)
and Dean, K.C.A.E,T.
Tavanur

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Smt. Anu Varughese,** a candidate for the degree of Master of Technology in Agricultural Engineering majoring in Soil and Water Engineering, agree that the thesis entitled **"Effect of soil solarization using LDPE-mulch on moisture conservation and soil temperature variation"** may be submitted in partial fulfilment of the requirement for the degree.

Dr. K. John Thomas
(Chairman, Advisory Committee
and Dean, K.C.A.E.T., Tavanur)

Dr. Jobi V. Paul
Associate Professor
Department of LWRCE
K.C.A.E.T., Tavanur
(Member)

Dr. Habeeburrahman, P.V.
Asst. Professor (Sr. Scale)
Department of SAC
K.C.A.E.T., Tavanur
(Member)

Dr. K.P. Visalakshy
Asst. Professor (Sr. Scale)
Department of IDE
K.C.A.E.T., Tavanur
(Member)

External Examiner

2-8-97

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ANU VARUGHESE

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

SYMBOLS AND ABBREVIATIONS

Agric	-	Agricultural
Am.	-	American
Asst.	-	Assistant
cm	-	centimetre(s)
Dept	-	Department
Edn	-	edition
Engg	-	Engineering
et al.	-	and others
FAO	-	Food and Agricultural Organization
Fig	-	figure
g	-	gram(s)
ha	-	hectare(s)
ICRISAT	-	International Crop Research Institute for Semi Arid Tropics
Inter	-	International
Irri.	-	Irrigation
J	-	Journal of
K.C.A.E.T	-	Kelappaji College of Agricultural Engineering and Technology
IDE	-	Irrigation and Drainage Engineering
LDPE	-	Low density polyethylene
LWRCE	-	Land and Water Resources and Conservation Engineering
m	-	metre
mm	-	millimetre(s)

No.	-	number
PE	-	Polyethylene
Proc.	-	Proceedings
Publi	-	Publication
PVC	-	Poly Vinyl Chloride
Res.	-	Research
SAC	-	Supportive and Allied Courses
Sci.	-	Science
SH	-	Solar Heating
Soc.	-	Society
t/ha	-	tonnes per hectare
TP	-	Transparent Polyethylene
w/sq.m	-	watt(s) per square metre
%	-	per cent
°C	-	degree centigrade
°F	-	degree Farenheit
μm	-	micro metre

Introduction

INTRODUCTION

India being a non - industrial country, its wealth mainly lies in agriculture. An increase in the agricultural productivity is of vital importance, since it enhances national income and personnel welfare. The use of plastics in agriculture or 'plasticulture', is one of the recent tools which has been developed for increasing agricultural production and productivity.

Mulching seed beds with plastic sheets has become a common practice in many foreign countries for uses such as weed control, raising soil temperature, soil solarization, retention of soil moisture, improving the thermal environment etc. Many parts of India, being in the tropical region, experiences medium to high temperatures during the summer months and that could be well utilized for soil solarization.

Soil disinfestation is needed to reduce the load of soil-borne pathogens, nematodes and weed seeds in the soil. The systems usually used for this may be either chemical (use of fumigants) or physical (heat treatment by steaming, hot water etc.), both have their own drawbacks. Thus the search for a new control method is a continuous one. At the end of the 70's a new non hazardous physical method of partial soil sterilization, based on the use of solar energy or soil heating, called soil solarization was introduced in Israel and spread to other hot climatic countries. This method is based on mulching or tarping the wet soil with transparent polyethylene (PE) sheets which capture the solar radiation and thus heat the soil to a level lethal for various soil pests, including weeds. This system offers great advantages to agro-ecosystem and consumer protection.

This method has been named as solar sterilization, heating or pasteurization or plastic mulching or polyethylene tarping. The role of the plastic is to prevent evaporation and thereby decreasing heat losses from the soil and to reduce return of long wave radiation. Soil solarization is a less labour and low energy consuming method for soil disinfestation in regions with high temperature and intense solar radiation.

In agriculture, especially in arid and semi arid regions, rain is the primary source of water to the soil plant system. In conformity with Indian conditions 73 per cent of total rainfall occur during monsoon months, i.e., June to September, 2 to 6 per cent occur as winter rain, 13 per cent as post monsoon rain and 10 per cent as pre monsoon rain. There is a high degree of uncertainty in spatial distribution and in the time of commencement and recedence of rainfall during monsoon months. The remaining 8 months tend to be dry. The erratic occurrence of monsoon and their varying degrees of distribution aggravate the problems of water availability for crop production. Today, the increased demand of water calls for intensive water conservation. The solarization technique conserves the moisture present in the soil to a considerable extent to the end of summer, when there is peak demand for water. There is also a possibility for avoiding pre-sowing irrigation for crops, making use of the moisture conserved during solarization.

Solarization by means of transparent polyethylene sheets for 1 week in mid summer significantly reduces the number of viable weed seeds. Maximum temperatures at the 1.3 cm soil depth under the polyethylene sheets reached 65 to 69°C as compared with 43 to 50°C at 1.3 cm in the soils that were not covered (Egley, 1983). This increase in temperature results in reduced weed growth and increase in surface soil moisture levels. Solarization is useful in the control of parasitic weeds and certain annuals, but it is not that much effective against perennials. It was found that 2 to 4 weeks of mulching with plastic in the summer controlled annual weeds effectively and that control was still appreciable even one year later (Horowitz *et al.*, 1983).

The prime requirements for soil solarization are:

(1) Summer season with intense solar radiation (2) availability of land free from crops for one to two months during the summer (3) Well ploughed and thoroughly levelled land to minimise air space between sheeting and land (4) Irrigation prior to mulching and (5) availability of transparent polyethylene sheets. In India, solarization technique is not popularly used for the intention of moisture conservation or weed control due to fear of cost incurred on transparent polyethylene. Utilization of plastic in agriculture which was started in developed countries is now a common practice in the developing country like India. A large quantity of cheaper recycled plastics coming into the market also brightens the future of solarization.

At ICRISAT, Hyderabad, in solarized plots, soil temperature reached 53.9°C, 46.6°C and 38.3°C at 5, 10 and 15 cm depths as against 43.7°C, 37.6°C and 32.4°C in non-solarized plots (Chauhan *et al.*, 1988). This high temperature available can be exploited for efficient weed control and moisture conservation, by mulching with polyethylene sheets. Solarization thus helps in improving the thermal environment of the soil. It also contributes significantly to the increase in yield and vegetative growth of many crops.

Under these circumstances, a detailed study entitled "Effect of soil solarization using LDPE-mulch on moisture conservation and soil temperature variation" was taken up with the following objectives.

(1) To determine the influence of low density polyethylene (LDPE) mulch on the soil moisture held at different soil depths

(2) To determine the effect of LDPE mulch on soil temperature

(3) To study the effect of solarization on weed control

(4) To study the effect of the LDPE mulch on the amount of solar radiation reaching the soil surface

(5) To analyse the effect of thickness of LDPE on moisture conservation and soil temperature

(6) To study the effect of solarization on the performance and yield of the succeeding crop.

Review of Literature

REVIEW OF LITERATURE

The use of solar energy in agriculture dates back to the ancient civilization of India when attempts have been made to use solar energy for controlling biotic agents in soil and in plant materials (Raghavan, 1964). Soil solarization, which is one among the numerous attempts to harness the solar energy in modified and efficient ways involves covering of moist soil with transparent polyethylene sheet during hot months for sufficient time to raise the soil temperature to the level lethal for soil borne pests such as weeds, insects, disease pathogens, nematodes etc. and also to conserve the soil moisture. The studies on various aspects of this method started only in 1970's and so the review of previous works is restricted to the last 25 years.

The review of literature pertaining to the effect of soil solarization on increasing the soil temperature, moisture conservation, weed control and the resultant effect on the performance and yield of the succeeding crops etc. is briefly reviewed hereunder.

2.1 Effect of soil solarization on soil temperature

The primary effect of solarization is the increase in soil temperature. This increase in soil temperature by transparent polyethylene is due to a decrease in the soil heat loss that mainly occurs through evaporation.

A temperature rise of about 10°C was reported in Israel by Katan *et al.* (1976) in the arable soil layer where the majority of the harmful organisms for the crops are to be found. Typical maximal soil temperatures in solarized plots were 8 to 12°C higher than the corresponding non mulched plots (Katan, 1980). An experiment was conducted by Kumar *et al.* (1992) to assess the effect of soil solarization on soil temperature and chemical properties. The average maximum temperature under covered soil was 7 to 9°C higher than that in the uncovered soil.

2.1.1 Effect of type of polyethylene on temperature increase

Experiments at various places in Jordan, Israel, USA etc. have proved a higher efficiency of transparent polyethylene over black polyethylene and thin transparent polyethylene over thick transparent polyethylene, in increasing the soil temperature.

2.1.1.1 Effect of colour of polyethylene on temperature increase

Among different mulches including transparent polyethylene and black polyethylene, the former recorded maximum rise in soil temperature at IARI, New Delhi (Chopra and Choudhary, 1980).

Field experiments conducted by Horowitz *et al.* (1983) at various locations in Israel, using transparent and black polyethylene indicated that higher temperatures were recorded under transparent than under black polyethylene.

Solar heating of soil by mulching it with transparent polyethylene elevated the surface soil temperature by 10 to 18°C, but the increase due to black polyethylene was much lesser (Rubin and Benjamin, 1983). In a study conducted to find the effect of solarization on soil weed seed population, transparent as well as black polyethylene mulches were used. The extend of rise in maximum soil temperature under black mulch was 6°C lower than that under transparent polyethylene mulch (Standifier *et al.*, 1984).

During a certain experiment in Tamil Nadu using transparent polyethylene and black polyethylene, a temperature of 44.1°C was noted in transparent, followed by black (39.6°C) as compared to 37.5°C in uncovered plots (Sivakumar and Marimuthu, 1987).

In Iraq, an experiment was conducted to study the influence of different colour plastic mulches used for soil solarization on the effectiveness of soil heating. Black, blue, green, yellow, red and transparent polyethylene mulches were used for the study. The highest soil temperature was recorded under the red mulch followed by transparent green, blue, yellow and black mulches (Al-kayssi and Alkaraghouli, 1991).

Experiments conducted in USA using different colours of plastic and the bare ground as control treatment indicated the occurrence of highest soil temperature under clear plastic and the lowest with bare ground (Himelrick *et al.*, 1993).

An increase in soil temperature of 10 to 13°C, 5 to 7°C and 3 to 5°C was observed due to transparent polyethylene of 0.04mm, transparent polyethylene of 0.1mm and black polyethylene respectively over non solarized treatments (Habeeburrahman, 1992). Soil solarization by mulching a clay loam soil with transparent polyethylene of 0.05mm and 0.1mm thickness for 10, 20, 30 and 40 days and black polyethylene of 0.125mm thickness for 40 days was performed in an experiment in India. Maximum soil temperature at 5cm depth was greater with transparent polyethylene than with black polyethylene (Meti and Hosmani, 1994)

Trials were conducted in Mexico with clear, white and black polyethylene film mulches. All mulches increased weekly measurements of soil temperature, and among them the clear film significantly increased soil temperature compared with black and white films (Larios, 1994).

2.1.1.2 Effect of thickness of polyethylene on temperature increase

Various studies conducted all over the world have proved that thinner the polyethylene, greater will be the rise in soil temperature.

Higher temperatures and better weed control were produced by 0.03mm transparent polyethylene than 0.1mm thick transparent polyethylene (Horowitz *et al.*, 1983). With transparent polyethylene (40 μm), soil temperature at 5cm was elevated to 53°C in a clayey soil in Israel (Katan *et al.*, 1983).

Solarizing with thin transparent polyethylene of 50 μm thickness led to an increase in soil temperature maximum by 7°C at Giza, Egypt, (Osman and Sahab, 1983). Mulching wet soils with thin transparent polyethylene (0.04 to 0.05mm) increased soil temperature by 10 to 18°C (Rubin and Benjamin, 1983).

Transparent plastic film (generally polyethylene 25-50 μm thick) laid over the soil during the months of highest temperature increased the soil temperature by about 10°C (Melero *et al.*, 1989).

Soil solarization trials carried out in Portugal using transparent polyethylene film (50 μm thick) increased the soil temperatures significantly. The soil temperature at 5 cm depth rose upto 53°C, when the air temperature was around 39.4°C (Silveria *et al.*, 1990).

When solarization was done with 100 μm polyethylene, the average maximum temperature under covered soil was 7 to 9°C higher than in uncovered soil (Kumar and Yaduraju, 1992). The average maximum soil temperature under 0.05mm thick transparent polyethylene was higher than under the 0.1mm thick polyethylene. On an average, there was an increase of 10 to 13°C and 5 to 7°C respectively due to 0.05mm and 0.1mm polyethylene (Habeeburrahman, 1992).

Maximum soil temperature was greater in the 0.05mm than the 0.1mm thick transparent polyethylene in an experiment conducted in India. The maximum temperatures were 53°C, 49°C, and 39°C for 0.05mm, 0.10mm thick transparent polyethylene and no mulch respectively (Meti and Hosmani, 1994).

Plastic mulching inside greenhouses with 100 μm thick transparent polyethylene sheets increased the soil temperatures by 11.9, 10.8, 9.8 and 8.9°C over the control at the 2, 5, 10 and 20 cm depth, respectively (Streek *et al.*, 1994).

2.1.2 Effect of soil solarization on the temperature increase at various depths

It is a proven feature that with increase in soil depth the maximal soil temperature attained through solarization decreases.

When solarized with 50 μm transparent polyethylene the maximum soil temperature was between 45 to 53°C at 5cm depth and was only 40 to 44°C at 20 cm (Grinstein *et al.*, 1979).

At Jerusalem, it was observed that soil temperature at surface was increased to 56°C by solarization and the pattern of temperature rise at 5 cm also closely followed that at the surface (Jacobsohn *et al.*, 1980).

Unlike the results in the field, with greenhouse solarization (Tamietti and Garibaldi, 1981) lethal temperatures at greater depths of more than 30 cm were reached and they were such to involve the active rooting depth layer of many greenhouse crops. This is due to a more reduced heat loss either by radiation, due to the presence of the covering material of the greenhouse, or to convection, because of the high air temperature in the greenhouse.

Experiments conducted at Mississippi on solarization effects indicated that maximum temperatures at the 1.3 cm soil depth under the polyethylene sheets reached 65°C to 69°C as compared with 43 to 50°C at 1.3 cm in the soils that were not covered (Egley, 1983). In field experiments in Israel during the summer, maximum soil temperature under plastic cover at 5 cm depth averaged to 46 to 49°C (Horowitz, 1983).

Under Italian conditions, the use of PVC and polyethylene (PE) film covers for soil solarization in summer raised soil temperatures at a depth of 5 cm to 38-40°C in open fields to 45-48°C in PE - clad structures and to 50 to 55°C in glass clad structures. At a soil depth of 20 cm, the temperatures were 31-32°C, 36-39°C and 41-42°C respectively (Garibaldi, 1987).

In solarized apple orchards in Israel, soil temperatures at 10, 30 and 50 cm were raised from 35 to 46°C, 33 to 38°C and 31 to 37°C, respectively (Sztenjnberg *et al.*, 1987). The mean maximum temperature in the vertizols of ICRISAT reached 53.9, 46.6 and 38.3°C at 5, 10 and 15 cm depths as against 43.7, 37.6 and 32.4°C in non solarized plots (Chauhan *et al.*, 1988).

Patten *et al.* (1990) reported that the mean maximum soil temperatures at the 4-inch depth in the centre of the 8-inch high bed were 113° and 105°F for solarized and non soalrized soils, respectively. A research conducted by Patten *et al.* (1991) on solarization showed that the maximum soil temperatures at 10 and 20 cm depths were 45 and 42°C in the solarized treatments compared with 41°C and 37°C in the control treatments.

A temperature greater than or equal to 55°C was easily attained in mulched soil at 5 cm depth. Lower depths of 10 and 15 cm did not attain a temperature greater than or equal to 55 or 60°C on any day during the experimental period (Kumar, 1992).

Experiments were conducted by Mugnozza and Picuno (1992) on soil mulched with polyethylene (PE) and PVC films to obtain information on thermal levels at different soil depths and to evaluate soil solarization by mulching with transparent plastic films in Southern Italy. Results showed that soil temperatures greater than 40°C were found at a depth of 20 cm under mulching compared to only 5 cm in bare soil, and that temperatures greater than 50°C were registered at 5 cm under PE mulching.

From trials carried out on this subject by Picuno and Mugnozza (1992), it was noticed that in Italian conditions, solarization in the field, made by mulching with transparent plastic sheet, doesn't necessarily lead to such high temperatures to ensure partial soil sterilization at depths of

30-40 cm. In fact, it was noticed that only in the top layers upto 10-20 cm, lethal temperatures are reached, where as for greater depths only sub-lethal temperatures are reached for many soil-borne pathogens.

Picuno and Mugnozza (1993) conducted experiments in a PVC simple sheet covered green house which was split up in two zones, mulched with PE and PVC films, and temperatures at different depths were taken. Maximum thermal levels reached under both films were 66°C, 50°C and 40°C for the depths of 5, 20 and 50 cm respectively.

Habeeburrahman (1992) reported that at all air temperatures, the soil temperature at 5 cm was significantly higher than at 10 cm. The difference reached upto 6.3°C. the frequency with which the temperature exceeded 40°C and 45°C differed at 5 cm and 10 cm depths for 10, 20 30 and 40 days duration with either 0.05 TP or 0.10 TP.

Streek *et al.* (1994) studied the effect of solarization on soil thermal regime in a plastic green house. Solarization increased soil temperature by 11.9, 10.8, 9.8 and 8.6°C over the control at 2, 5, 10 and 20 cm depths respectively. The soil temperature reached values upto 54.4 and 50.2°C at 2 and 5 cm depths respectively.

2.2 Effect of soil solarization on moisture conservation

The increasing demand of water requires intensive water conservation. A way to achieve this is by conserving the moisture in the soil using LDPE sheets. Since the soil surface is covered by the film, evaporation is prevented. The use of LDPE sheets in cropped fields, when used as a mulch is widely accepted on a global scale. But moisture conservation by soil solarization has not been studied widely and only a few works have been done on this topic. The cycling of moisture in the soil and soil moisture pattern during solarization lacks experimental evidence.

An experiment conducted by Egley (1983) on weed seed and seedling reductions by soil solarization with transparent polyethylene sheets showed that the surface soil moisture levels were elevated under the polyethylene covers.

A numerical one - dimensional model was developed by Mahrer *et al.* (1984) to study the effect of soil mulching with transparent polyethylene film upon the soil moisture and temperature regimes. The calculated moisture and temperature profiles were compared with the observed ones in experimental field plots. It was shown that soil moisture and temperature distributions are significantly influenced by the polyethylene mulch. The results indicate that the numerical model accurately predicts the soil moisture and temperature regimes in two tested soils.

Polyethylene mulch reduces water evaporation from the soil to the atmosphere and so the soil is kept wet during the mulching period. Thus water movement from the saline ground water towards the mulched soil surface will be limited (Alkayssi and Ahmed, 1989). Chakraborty and Sadhu (1992) reported that higher soil temperature (2-3°C above control), greater soil-moisture conservation (31.5-67.7%) and lower salinity level (36.7-59.8%) were observed with polyethylene mulches.

Kumar and Yaduraju (1992) while studying the effects of solarization on physico-chemical properties of soils explained the significant increase in NO_3-N based on two factors. First, under plastic film cover, soil moisture and soluble nutrients such as nitrates move upward by capillary movement. Secondly, the rate of mineralisation of soils organic nitrogen may have been stimulated by relatively more moisture present under mulching conditions during dry periods in the summer months. This clearly shows the increase in moisture content due to solarization.

Adetunji (1994) conducted an experiment to optimize water use and soil condition during dry season onion production in semi-arid Nigeria. Soil solarization with transparent polyethylene film was compared with organic mulches (ground nut shells, millet stover and saw dust) and a no-mulch control. With the exception of the saw dust mulch, mulching significantly enhanced vegetative growth and bulb yield. Solarization also conserved more moisture.

In trials conducted in Mexico by Larios *et al.* (1994), clear white and black polyetylene film mulches were used. Controls were not mulched. All mulches increased weekly measurements of soil temperature and moisture.

2.3 Effect of soil solarization on weed control

Soil solarization has been reported as a non-hazardous method for weed control by various researchers all over the world. But soil solarization has not so far been exploited on a large scale in India to attain weed control.

At Hebrew University of Jerusalem, the reduction in weed population in solarized plots over non-solarized plots was evident even about 13 months after mulching (Grinstein *et al.*, 1979). Solar heating of the soil by mulching it with transparent polyethylene during the hot season for 4 to 5 weeks resulted in effective control of most of the summer and winter annual weeds, the effect lasting for more than 5 months after PE removal. Perennial weeds which propagate from vegetative parts were only partially controlled with short SH, but mulching for 8 to 10 weeks improved control. Mulching the soil with perforated or shaded transparent PE or black PE resulted in less efficient weed control (Rubin and Benjamin, 1983).

Field experiments in Israel (Horowitz *et al.*, 1983) during the summer showed that no weeds emerged under the plastic during solarization and weed emergence was reduced after its removal. Two to four weeks of solarization produced effective control of annual weeds that was still appreciable after 1 year. The response of weed species to solarization differed.

At ICRISAT, Hyderabad, in the solarization experiments on chickpea and pigeonpea, marked decrease in weed growth was obtained especially of annuals, but perennials generally recovered (Chauhan *et al.*, 1988). In Northern Italy, solarization reduced total number of monocot weeds per square metre from 226 to 9 and that of dicot weeds from 216 to 3 (Garibaldi and Tamietti, 1989).

Soil solarization trials were carried out by Silveria *et al.* (1990) in Portugal on lettuce and onion using transparent polyethylene for 8 weeks. The number of weeds in the lettuce rows fell from 14 in the control plot to 2 in the solarized plot and in the onion experiment, the number of weed species decreased from 7 to 4. Significant reductions of the weed cover were found in both solarized plots. Elmore (1991) based on his experiments concluded that soil solarization treatment has to be applied within the correct weather, timing and application parameters to be effective. In general, winter annual weeds were most effectively controlled by solarization than summer annuals,which were not so susceptible.

Six weeks of solarization was done in Texas, with clear plastic, fumigation with methyl bromide at a rate of 400 kg/ha and an untreated control. Generally, solarization controlled weed growth satisfactorily. Solarization was considered useful under normal conditions but not where heavy infestation of soil borne pests or weeds are present (Patten *et al.*, 1991). The control of weeds and nematodes by solar heating of the soil using transparent polyethylene sheets was studied in the field (Kumar *et al.*, 1993). PE mulching for 32 days decreased the emergence from seeds of dominant weeds. Mulching for 16 days also decreased weed emergence, but to a lesser extent than the 32 day treatment.

Habeeburrahman (1992) reported that in Jowar as well as in groundnut, there was significant reduction in weed count and dry weight even upto the harvest (i.e., 120 to 130 days after the solarization with transparent polyethylene). Transparent polyethylene of 0.05mm thickness was significantly superior in reducing number and dry weight of weeds, as compared to that of 0.1mm thickness. Yaduraju and Shukla (1995) used a 100 μm thick clear polyethylene sheet to cover the soil for 30 days in July and August. The mean level of weed control was 75 per cent in July and 46 per cent in August. Solarizing the wet soil gives slightly higher level of weed control (80%) compared with the dry soil (70%).

Solarization by means of transparent polyethylene sheets for 1 to 4 weeks significantly reduced the total weed emergence of prickly sida and various grass species from natural seed populations for the growing season by 64 to 98% (Egley, 1983). Although solarization did not eliminate dormant weed seeds from the germination zone, the treatment killed non dormant seeds and greatly reduced the number of weed seedlings that otherwise would have emerged.

2.3.1 Effect of duration of solarization on weed control

In field experiments in Israel during the summer using plastic sheets, 2 to 4 weeks of solarization produced effective control of annual weed that was still appreciable after one year (Horowitz *et al.*, 1983).

Solar heating of the soil by mulching it with transparent polyethylene during the hot season for 4 to 5 weeks resulted in effective control of most of the summer and winter annual parts were only partially controlled with short SH, but mulching for 8 to 10 weeks improved control. Mulching the soil with perforated or shaded transparent PE or black PE resulted in less efficient weed control (Rubin and Benjamin, 1983).

At Lake Wood, USA, 55 days solarization with transparent polyethylene decreased germination of many weed species and the weed cover was reduced by 97 per cent (Hilde- brand, 1985). In Sudan, solarization for 30 or more days decreased weed emergence by 58 per cent, but the control of Cypress was inconsistent (Braun *et al.*, 1987).

Habeeburrahman (1992) during his experiments on soil solarization using transparent polyethylene found that among the different durations of solarization tried, 30 and 40 days was found to effect maximum reduction in weeds than the shorter durations of 10 and 20 days.

2.4 Effect of soil solarization on crop performance and yield

Soil solarization contributes significantly to the increase in yield and vegetation of many crops and therefore can be an ingredient in crop management programmes.

At Jerusalem, solarization caused reduction of weeds resulting in 52 per cent increase in yield of ground nut (Grinstein *et al.*, 1979). Katan *et al.* (1980) reported that solarization improved the plant stand and plant growth of onion and yields were increased by 109 to 125 per cent.

Rubin and Benjamin (1983) based on their studies on solar heating using transparent polyethylene reported that solarization improved plant growth and increased the yield of wheat and turnip, but not of parsley.

At ICRISAT, Hyderabad, even in wilt resistant geno type of pigeonpea there was increase in seed yield from 0.4 to 1.1 t/ha and total dry matter accumulation from 1.4 to 3.5 t/ha mainly due to weed control and benefits other than disease control by solarization. Twenty three per cent yield increase was there in chickpea also (Chauhan *et al.*, 1988).

Solarization experiments conducted in Andalusia, Spain by Melero *et al.* (1989) using plastic films showed that the total average yields of cotton were 18.1 kg and 4.2 kg for the solarized and the control plots respectively. Patten *et al.* (1990) reported that the total yield of strawberry from solarized plots were greater than from the untreated plots.

The effect of soil solarization through different LDPE film coverings on the production of healthier tomato transplants was investigated by Patel *et al.* (1991). It was found that covering the soil with LDPE clear film for 2 months during summer produced more tomato transplants. Kumar *et al.* (1993) did soil solarization experiments using transparent polyethylene (PE) sheets during the summer of 1990. The growth of soybean was improved and seed yield increased by upto 78 per cent following solarization.

In Nigeria, soil solarization was done with transparent polyethylene film and organic mulches (ground nut shells, millet stover and saw dust) and a no-mulch control. With the exception of the saw dust mulch, mulching significantly enhanced vegetative growth and bulb yield. Thus with soil solarization, the total bulb yield of onion was 80 per cent higher than with no mulch (Adetunji, 1994).

Habeeburrahman (1994) reported that, as a result of the effective weed control achieved through soil solarization, there was appreciable increase in yield of jowar and groundnut grown during succeeding kharif season. With regard to all the growth parameters and yield attributes of jowar and groundnut, the values recorded by transparent polyethylene of 0.05 mm thickness for 40 days was significantly higher than the normal practice of weed control in both the crops.

2.5 Incoming solar radiation and temperature rise in the soil

One of the major factors which affect soil temperature is solar radiation. Soil solarization is done during a period (1-2 months when solar radiation and the temperature are at the highest levels. Soil temperature is a function of the incoming solar radiation.

Use of solar energy is not a new practice in agriculture and it dates back to the ancient civilization of India when attempts have been made to use solar energy to increase soil temperature for controlling biotic agents in soil and in plant materials (Raghaven, 1964).

Mahrer and Katan (1980) found that soil temperature under plastic cover is a function of incoming radiation and thermal characteristics of the mulching material and the soil. The incoming solar radiation is a main heat source, and hence transparent covers are more efficient soil heaters than black plastic (Horowitz, 1983).

Avissar *et al.* (1986) while trying to explain the higher temperatures prevailing under old sheets found that the fine water droplets that condense on new polyethylene sheets reflect significantly more global radiation than the soil deposits and water film found on polyethylene sheets after utilization during one solarization season. The thus

171197

increased incoming radiative flux at soil surface can explain the observed higher temperatures.

Mugnozza (1993) while studying the innovatory techniques of soil solarization for environment protection, measured maximum solar radiation values ranging between 800w and 900w per square metre, where the maximum soil temperatures at 10 cm and 20 cm were 51.9°C and 44.4°C respectively when transparent polyethylene sheet was used.

2.6 Influence of soil solarization on salts movement and the hydraulic conductivity of soil

Polyethylene mulch reduces water evaporation from the soil to the atmosphere and so the soil is kept wet during the mulching period. Solarization experiments done in Iraq by covering the moistened soil with polyethylene reduced the upward movement of the saline ground water and avoided salt accumulation in the surface soil.

Soil solarization caused a considerable modification of the hydraulic conductivity of the top soil layer (0-30 cm), which tends to improve leaching of salts with irrigation water (Al-kayssi and Ahmed, 1989).

Materials and Methods

MATERIALS AND METHODS

A field study to evaluate the effect of soil solarization on moisture conservation and weed control was conducted at K.C.A.E.T., Tavanur. This chapter presents the materials used and methodology employed for experimentation, data collection and analysis of the data.

3.1 Experimental site

The experiment was conducted in the Instructional farm K.C.A.E.T., Tavanur in Malappuram district. The place is situated at $10^{\circ} 53' 33'' N$ latitude and $76^{\circ}E$ longitude.

The experimental site was well drained and has a level topography. The absence of buildings or any other obstruction around the site which would have cast shadows was a major advantage of the location, since solarization requires a site which is free from shadow and will receive maximum solar radiation. The soil of the site was mainly laterite.

3.2 Climatic conditions

Agroclimatically, the area falls within the border line of Northern zone, Central zone and kole zone of Kerala. The area receives rainfall mainly from the South-West monsoon and to a certain extent from the North-East monsoon.

3.3 Season and weather conditions

The experiment was conducted during March - September of 1996. The rainfall data recorded at the solarization period are given in Appendix 1. Solarization was done during March to May, since this was the period during which the area received maximum radiation.

3.4 Experimental procedure

The experiment was laid out in Randomized Block Design with 9 treatments and three replications.

T1 - 0.05 mm TP 30 days

T2 - 0.05 mm TP 40 days

T3 - 0.05 mm TP 50 days

T4 - 0.10 mm TP 30 days

T5 - 0.10 mm TP 40 days

T6 - 0.10 mm TP 50 days

T7 - Weed free check

T8 - Control check

T9 - Normal practice

Plot size - 3.0m X 3.0m

The layout of the experiment is given in figure 1. The methodology employed and the various components and equipments used in the experiment are explained below.

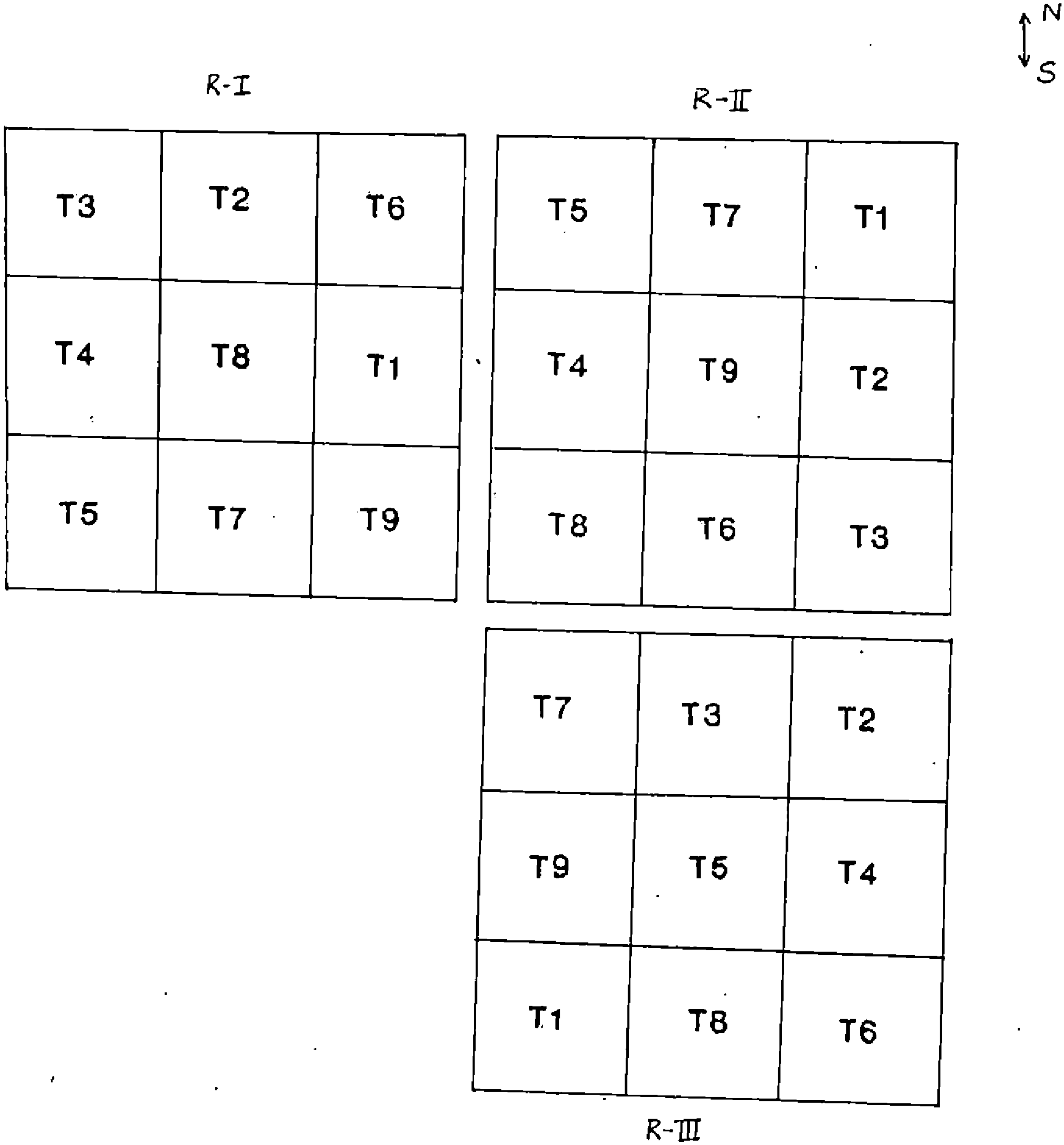

Fig.1. Layout of the experiment

3.4.1 Land preparation

The experimental plot was selected in the Instructional farm of K.C.A.E.T., Tavanur. The area was ploughed with a tractor drawn cultivator and was levelled to an approximately uniform grade. Thorough levelling is essential to minimize the air space between sheeting and also to minimise protrusions such as stubbles and stones which may otherwise tear off the polyethylene sheeting.

3.4.2 Layout of field

Plots were laid out as per plan and small fields bunds were erected around each plot. The bunds in between the plots were 0.2 m wide and in between replications were 0.3 m wide.

3.4.3 Irrigation

Moist soil either irrigated before mulching or irrigated under the polyethylene film, increases the thermal sensitivity of weed seeds as well as heat transfer in the soil. So an irrigation was given before laying the sheets.

3.4.4 Spreading of polyethylene sheets

Polyethylene film was spread over the ground in the plots without wrinkles. To make the covering air tight, the soil was placed over the four sides of the film.

The calendar of operations was as follows

Polyethylene spreading : 19-3-1996

Removal of polyethylene :

After 30 days solarization : 18-4-1996

After 40 days solarization : 29-4-1996

After 50 days solarization : 09-5-1996

Date of sowing : 25-7-1996

Start of harvest : 20-9-1996

3.4.5 Seeds and sowing

After the period of solarization, seeds of bhindi (Arka Avamika) were sown in the plots on 25 th July 1996 at a spacing of 50 cm X 60 cm. This was done to know the crop performance after solarization. Sowing was done without much disturbance to the soil.

3.4.6 Application of fertilizers

Fertilizer application and other plant protection measures were done as per the package of practice recommendations.

3.4.7 Weeding

Weed management was done as per the treatments. In the treatments involving solarization (T1 to T6) weeding was done after taking the weed count, at an interval of 35 days. In the non-solarized unweeded control (T8), no weeding was done. Weeds were removed as and when they emerged in the weed free check treatment (T7).

3.4.8 Harvesting

Harvesting was started 55 days after sowing and it was continued at 3 to 5 days interval. Three plants were fixed as observation plants in each plot and the total yield (g) from each plant was noted. The average yield per plant was then calculated.

3.5 Experimental observation

Observations on soil temperature, moisture content, intensity of solar radiation, weed count etc. were made as described below.

3.5.1 Observations on soil temperature

Soil temperature was recorded at 2 day interval at 2.30 to 3.30 pm, using a digital multi-stem thermometer with an external sensing probe. The specifications of the multi thermometer are given in Appendix 2. The soil temperature at 5 cm depth was measured by inserting the sensing probe into the hole drilled upto this depth. The multi thermometer used is shown in plate 1. Maximum air temperature during these days was also noted.

3.5.2 Observations on solar radiation

The intensity of solar radiation was measured using a solar radiation meter as shown in plate 2. The sensing probe of the meter is to be placed horizontally at the point where the solar radiation is to be measured. Solar radiation in watts per square metre can be read directly from the meter. Solar radiation above and beneath the plastic sheet in the solarized plots and at the surface in the non - solarized plots were measured from all the plots at 2 day interval, at the time of measurement of soil temperature

3.5.3 Observations on moisture content

In order to analyse the variation in soil moisture content at different depths, the gravimetric method of moisture content determination was made use of. Moisture content of soil at 5, 10 and 15 cm depth was measured at 5 day intervals from all plots.

Gravimetric method of moisture content determination

The percentage moisture content is calculated from the following expression.

Plate 1. Digital Multi-stem Thermometer

Plate 2. Solar Radiation Meter

$$\text{Moisture content (\%)} = \frac{(W2 - W3)}{(W3 - W1)} \times 100$$

where,

W1 - Weight of empty container with lid

W2 - Weight of container with lid and moist soil

W3 - Weight of container with lid and dry soil

Using the above procedure the moisture content in per cent was determined.

3.5.4 Observations on weeds

3.5.4.1 Weed count per square metre

The total number of weeds present in two quadrants of 30 cm X 30 cm in each plot was counted at 35 days interval from 5th June. The weed count per square metre was then worked out. The average of these two groups was recorded as total weed count per square metre.

3.5.4.2 Dry weight of weeds

Dry weight of weeds was recorded at 35 days interval from 5th of June. The weeds were cut at ground level in two quadrants of 30 cm X 30 cm selected at random each time. The weeds were air dried first and then dried at 70°C in oven and dry weight was recorded. These dry weights were converted to dry weights per square metre. The average of the two groups was recorded as the total weed dry weight.

3.6 Weed control efficiency (%)

The weed control efficiency (WCE) was calculated as follows

$$\text{WCE (\%)} = \frac{\text{Weed dry weight of unweeded control} - \text{Weed dry weight of treatments}}{\text{Weed dry weight of unweeded control}} \times 100$$

3.7 Data transformation

The data on weed count was subjected to $\sqrt{x+1}$ transformation and on weed dry weight to log(x+2) transformation as suggested by Gomez and Gomez (1984), before the statistical analysis.

3.8 Statistical analysis and interpretation of data

Fischers method of analysis of variance was used for the analysis and interpretation of the data obtained in these experiments. The analysis was done using the computer package 'MSTATC'. The levels of significance used for

'F' and 't' test was P=0.05. The standard error of mean values and the critical difference values were found out. The results are presented in tabular form and depicted in graphs wherever necessary.

Results and Discussion

RESULTS AND DISCUSSION

The results of the field study conducted to know the effect of soil solarization on moisture conservation, weed control etc. are presented and discussed in this chapter.

For convenience the following notations are used in the text throughout the chapter.

TP - Transparent polyethylene in mm

4.1 Effect of solarization on soil temperature

The maximum soil temperature at 5 cm depth was measured at 2 day interval during the time of solarization, and the mean values are presented in tables 1 and 2. The mean maximum soil temperature recorded at 5 cm depth in the solarized treatments were significantly higher than those in the non-solarized treatments.

Generally on all days of observation, the daily averages of soil temperatures recorded with 0.05 TP were slightly greater than with 0.10 TP, but the differences were not significant.

The average maximum soil temperature at 5 cm depth, obtained in the non-solarized plots was 49.5°C only, but in

Table 1. Influence of solarization treatments on soil temperature during first 30 days of solarization period

Treatments	First 30 days of solarization[1]									
	20-3-96	23-3-96	26-3-96	29-3-96	1-4-96	4-4-96	7-4-96	10-4 96	13-4-96	16-4-96
1. TP(0.05mm) 30 days	53.50	55.67	53.50	51.50	52.50	52.50	51.00	48.67	51.50	53.07
2 TP(0.05mm) 40 days	53.00	56.00	52.67	48.33	50.00	50.67	49.33	49.23	48.43	51.57
3. TP(0.05mm) 50 days	54.00	56.17	52.50	50.83	50.67	49.00	50.17	49.77	46.47	51.00
4. TP(0.10mm) 30 days	53.00	56.00	53.17	51.00	52.33	51.67	50.00	51.10	47.13	51.90
5. TP(0.10mm) 40 days	52.67	55.00	53.50	49.67	53.00	52.33	50.00	50.00	48.60	50.77
6. TP(0.10mm) 50 days	53.50	55.17	54.17	49.67	52.33	52.67	50.17	50.13	47.47	52.43
7. Weed free check	47.00	49.50	48.67	43.67	45.50	46.83	45.33	42.87	40.20	45.13
8. Unweeded control	46.67	49.33	49.00	42.33	45.67	47.17	44.67	42.33	40.77	45.03
9. Normal practice	46.50	49.50	49.00	43.50	45.50	47.67	45.33	42.60	41.77	45.37
S.E.m ±	0.787	1.086	0.493	0.617	1.046	0.899	1.058	1.444	1.044	0.902
C.D at 5%	2.361	3.255	1.477	1.850	3.135	2.695	3.173	4.329	3.130	2.704
Max. air temp.	39.67	41.83	37.75	38.00	39.00	38.00	37.80	37.70	36.90	37.30

TP - Transparent polyethylene

1 - Polyethylene spread in all solarized plots on 19-3-96 and polyethylene removed from T1 and T4 on 18-4-96

Table 2. Influence of solarization treatments on soil temperature from 30 to 50 days of solarization

Treatments	30 to 40 days of solarization[1]				40 to 50 days of solarization[2]		
	19-4-96	22-4-96	25-4-96	28-4-96	1-5-96	4-5-96	7-5-96
1. TP(0.05mm) 30 days	39.13	41.77	46.10	45.03	43.83	42.53	41.03
2. TP(0.05mm) 40 days	41.97	45.57	48.53	47.77	40.93	40.93	39.87
3. TP(0.05mm) 50 days	40.50	44.50	47.60	46.73	45.40	46.20	43.38
4. TP(0.10mm) 30 days	38.37	40.57	46.70	44.83	43.30	41.73	40.17
5. TP(0.10mm) 40 days	41.87	45.50	49.80	48.87	41.87	41.90	40.70
6. TP(0.10mm) 50 days	40.80	43.47	50.93	49.63	44.97	46.57	44.17
7. Weed free check	36.27	38.27	40.00	39.53	40.03	34.97	40.47
8. Unweeded control	35.73	38.47	39.70	39.63	39.83	35.33	40.87
9. Normal practice	36.00	38.73	39.50	39.60	39.97	35.17	39.87
S.E.m ±	0.556	1.155	0.864	0.923	0.714	1.143	0.474
C.D at 5%	1.667	3.464	2.591	2.768	2.141	3.426	1.420
Max: air temp.	31.25	36.70	38.10	37.10	36.80	30.70	35.40

TP-Transparent Polyethylene
1-Polytethylene removed from T2 and T5 on 29-4-96.
2-Polyethylene removed from T3 and T6 on 9-5-96.

the solarized plots it went upto 56.5°C, which was higher by 7.0°C.

4.1.1 Effect of duration of solarization on soil temperature

The effect of duration of solarization on soil temperature (table 3) is noted as the percentage number of occasions (frequency) during which the temperature exceeded 40°C and 45°C, which are the lethal limits. The frequency with which the temperature exceeded 40°C with which the temperature exceeded 40°C with 0.05 TP was 94 per cent for 30 and 40 days duration, but was 100 per cent for 50 days.

For 0.1 TP, the frequency was 94 per cent for 30 days and 100 per cent for 40 and 50 days. The frequency with which the temperature exceeded 45°C with 0.05 TP and 50 days duration was 82 per cent while that for 0.10 TP was only 76 per cent. For shorter durations of solarization, the temperature exceeded 45°C only on 65 to 70 per cent of the occasions.

For non-solarized control, the frequency exceeding 40°C was 59 to 76 per cent, while that exceeding 45°C was 35 to 41 per cent. However, with either 0.05 TP or 0.10 TP, the durations did not alter the daily maximum of soil temperature.

4.1.2 Effect of thickness of polyethylene on soil temperature

Data on the effect of thickness of polyethylene (table 4) revealed that there was no significant effect for

Table 3. Influence of solarization treatments on the frequency of soil temperature exceeding 40°C and 45°C (as % of total observations

	Treatments	Frequency (%) with temp: exceeding 40°C	45°C
1.	TP(0.05mm) 30 days	94	70
2.	TP(0.05mm) 40 days	94	76
3.	TP(0.05mm) 50 days	100	82
4.	TP(0.10mm) 30 days	94	65
5.	TP(0.10mm) 40 days	100	76
6.	TP(0.10mm) 50 days	100	76
7.	Weed free check	76	41
8.	Unweeded control	65	35
9.	Normal practice	59	41

TP - Transparent Polyethylene

Table 4. Effect of thickness of polyethylene on increase in soil temperature for first 30 days of solarization

	Soil temperature 0.05 TP	0.1 TP	S.E.m+	F-value	C.D. at 5%
20-3-96	53.50	53.06	0.605	0.269	NS
23-3-96	55.94	55.56	0.726	0.144	NS
26-3-96	53.44	53.61	0.247	0.228	NS
29-3-96	50.62	50.11	0.564	0.393	NS
1-4-96	51.39	52.50	0.683	1.324	NS
4-4-96	52.94	52.22	0.564	2.347	NS
7-4-96	50.50	50.11	0.623	0.681	NS
10-4-96	49.56	50.41	0.975	0.385	NS
13-4-96	43.50	47.74	0.431	0.553	NS
16-4-96	51.88	51.70	0.631	0.039	NS

NS - Non Significant

the thickness on soil temperature, eventhough the average values of temperatures in the plots with 0.05 TP were slightly higher than in 0.10 TP plots.

The magnitude of rise in soil temperature of solarized treatments ranged from 4.9 to 10.8°C and 4.3 to 9.8°C due to 0.05 TP and 0.1 TP respectively, over non-solarized treatments. Thus it was found that the two thicknesses of transparent polyethylene were equally effective in increasing the soil temperature.

The weekly averages of soil temperatures are presented in Appendix 3.

4.2 Observations on Solar Radiation

The intensity of solar radiation, in watts per square metre, both above and beneath the polyethylene sheet were measured at 2 day interval and are tabulated in tables 5, 6, 7 and 8. The intensity of solar radiation was much higher above the sheet surface as compared to that beneath the sheet in the solarized plots. The intensity of solar radiation just above the soil surface in the solarized plots were also measured.

From the data obtained it is seen that the intensity of solar radiation falling on the soil surface in the

Table 5. Influence of solarization on the intensity of solar radiation (watts per square metre) above the sheet surface during first 30 days of solarization period.

Treatments	First 30 days of solarization[1]									
	20-3-96	23-3-96	26-3-96	29-3-96	1-4-96	4-4-96	7-4-96	10-4 96	13-4-96	16-4-96
1.TP(0.05mm) 30 days	708	698	618	560	556	480	555	625	611	607
2 TP(0.05mm) 40 days	720	726	642	545	565	564	520	617	613	625
3.TP(0.05mm) 50 days	705	704	625	549	597	477	531	636	613	626
4.TP(0.10mm) 30 days	688	710	596	572	547	539	526	621	599	607
5.TP(0.10mm) 40 days	695	649	618	542	565	529	516	623	622	618
6.TP(0.10mm) 50 days	712	702	588	512	539	426	538	616	602	638
7.Weed free check	711	716	514	533	535	476	495	604	605	597
8.Unweeded control	695	726	516	544	545	486	502	600	605	595
9.Normal practice	698	715	554	539	549	475	502	605	608	600
S.E.m ±	9.989	17.44	18.20	19.57	17.38	51.87	13.19	10.98	11.54	9.42
C.D at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

TP - Transparent polyethylene

1 - Polyethylene spread in all solarized plots on 19-3-96 and polyethylene removed from T1 and T4 on 18-4-96

Table 6. Influence of solarization on intensity of solar radiation (watts per square metre) above the sheet surface during from 30 to 50 days of solarization

Treatments	30 to 40 days of solarization[1]				40 to 50 days of solarization[2]		
	19-4-96	22-4-96	25-4-96	28-4-96	1-5-96	4-5-96	7-5-96
1. TP(0.05mm) 30 days	153	593	560	597	629	622	610
2. TP(0.05mm) 40 days	161	645	539	640	616	587	578
3. TP(0.05mm) 50 days	169	644	512	649	642	618	632
4. TP(0.10mm) 30 days	180	623	531	626	613	607	609
5. TP(0.10mm) 40 days	194	628	550	639	608	616	607
6. TP(0.10mm) 50 days	159	622	557	641	617	610	637
7. Weed free check	164	624	560	611	596	552	605
8. Unweeded control	152	605	530	597	609	593	577
9. Normal practice	182	610	543	591	608	596	611
S.E.m ±	13.37	10.38	24.01	16.68	8.99	15.75	11.85
C.D at 5%	NS	31.12	NS	NS	NS	NS	35.82

TP - Transparent Polyethylene
1 - Polyethylene removed from T2 and T5 on 29-4-96.
2 - Polyethylene removed from T3 and T6 on 9-5-96.

Table 7. **Influence of solarization on the intensity of solar radiation (watts per square metre) below the sheet surface during first 30 days of solarization period**

Treatments	First 30 days of solarization[1]									
	20-3-96	23-3-96	26-3-96	29-3-96	1-4-96	4-4-96	7-4-96	10-4 96	13-4-96	16-4-96
1. TP(0.05mm) 30 days	595	574	552	437	486	440	447	517	517	501
2 TP(0.05mm) 40 days	561	561	496	417	477	497	452	506	522	522
3. TP(0.05mm) 50 days	539	568	550	463	477	416	467	543	512	530
4. TP(0.10mm) 30 days	576	558	517	415	451	444	445	530	517	515
5. TP(0.10mm) 40 days	547	553	475	421	434	454	434	534	496	507
6. TP(0.10mm) 50 days	582	551	527	422	439	363	447	485	516	524
7. Weed free check	711	716	514	533	535	476	495	604	605	597
8. Unweeded control	695	726	516	544	545	486	502	600	605	595
9. Normal practice	698	715	554	539	549	475	502	605	608	600
S.E.m ±	22.52	39.32	17.69	22.25	12.38	54.47	13.76	15.88	12.75	7.43
C.D at 5%	67.50	118.6	NS	66.71	37.11	NS	41.25	47.60	38.21	22.27

TP - Transparent polyethylene

1 - Polyethylene spread in all solarized plots on 19-3-96 and polyethylene removed from T1 and T4 on 18-4-96

Table 8. Influence of solarization on intensity of solar radiation (watts per square metre) below the sheet surface during from 30 to 50 days of solarization

Treatments	30 to 40 days of solarization[1]				40 to 50 days of solarization[2]		
	19-4-96	22-4-96	25-4-96	28-4-96	1-5-96	4-5-96	7-5-96
1. TP(0.05mm) 30 days	153	593	560	597	629	622	610
2. TP(0.05mm) 40 days	114	519	451	517	616	587	578
3. TP(0.05mm) 50 days	115	546	422	565	551	479	537
4. TP(0.10mm) 30 days	180	623	531	626	613	607	609
5. TP(0.10mm) 40 days	141	539	453	561	608	616	607
6. TP(0.10mm) 50 days	112	492	461	511	516	503	526
7. Weed free check	164	624	560	611	596	552	605
8. Unweeded control	152	605	530	597	609	593	577
9. Normal practice	182	610	543	591	608	596	611
S.E.m ±	11.96	12.96	20.82	16.76	9.85	15.63	13.68
C.D at 5%	35.85	38.76	62.42	50.25	29.54	46.87	41.02

TP - Transparent Polyethylene
1 - Polytethylene removed from T2 and T5 on 29-4-96.
2 - Polyethylene removed from T3 and T6 on 9-5-96.

solarized plots are much less than that in the non solarized plots.

The weekly solar radiation intensity values, both above and beneath the sheet surface were calculated and are given in Appendices 4 and 5.

The data above the sheet surface indicated that there was no significant difference between the solar radiation intensity values in the solarized and non solarized plots, except in a few cases.

The data below the sheet surface were also analysed and in that case there were significant difference in the solar radiation intensity values between the solarized and non-solarized plots.

There was no significant difference in the solar radiation intensity values(both above and beneath the sheet surface) between the two thicknesses of polyethylene or between the three durations of solarization. The maximum solar radiation intensity below the .sheet surface in the 0.05 TP came upto 629 watts per square metre and in the 0.10 TP came upto 626 watts per square metre. Similar results were obtained by Mugnozza (1993) while studying the innovatory techniques of soil solarization for environment protection.

4.3 Effect of solarization on moisture conservation

The moisture contents of the soil at 5, 10 and 15 cm depths from all the plots were determined and are given in tables 9, 10 and 11. The weekly averages of moisture content for 5, 10 and 15 cm depths are given in Appendices 6, 7 and 8. There was significant increase in the moisture content values in the solarized plots compared with the non - solarized plots at all the three depths of soil moisture determination.

The moisture content at the different depths in all the treatments for the 7 weeks are presented in figures 2 to 8. The general trend observed in the solarized plots was that the moisture content at the 10 cm depth was lower than those at 5 and 15 cm depths. But the general trend in the non-solarized plots was that the moisture content values increased with depth upto the 15 cm depth. This is the general trend observed in any non-solarized soil profile. Eventhough the moisture contents at the 10 cm depth in the solarized plots were less than that at 5 and 15 cm depths, it was much higher than the corresponding values in the non-solarized plots.

This increase in moisture content at the 5 cm depth in the solarized plots is achieved by preventing the loss due to evaporation. If sowing is to be done before the onset of monsoon, this conserved moisture can be made use of, and the

Table 9. **Influence of solarization on the soil moisture content at 5 cm depth during the solarization period**

Treatments	First 30 days of solarization						30 to 40 days of solarization		40 to 50 days of solarization	
	25-3-96	30-3-96	4-4-96	9-4-96	14-4-96	19-4-96	24-4-96	29-4-96	4-5-96	9-5-96
1. TP(0.05mm) 30 days	9.94	7.46	10.99	13.97	15.74	16.56	14.65	14.85	18.71	15.10
2 TP(0.05mm) 40 days	11.83	11.25	14.32	13.73	13.79	15.66	17.11	15.81	18.76	12.74
3. TP(0.05mm) 50 days	8.08	10.97	12.84	18.69	18.30	14.97	16.43	19.71	19.96	16.82
4. TP(0.10mm) 30 days	6.92	8.28	13.33	21.68	15.96	16.11	16.87	17.23	15.60	12.08
5. TP(0.10mm) 40 days	5.60	9.40	13.63	15.64	14.03	12.95	20.70	15.77	17.88	12.96
6. TP(0.10mm) 50 days	11.26	10.70	11.78	12.74	14.62	15.57	17.21	18.21	20.64	18.59
7. Weed free check	4.16	5.17	9.44	15.78	11.62	13.24	14.01	13.32	16.30	11.08
8. Unweeded control	4.39	3.37	10.19	17.85	11.33	13.72	14.26	12.93	16.98	9.84
9. Normal practice	4.44	4.36	9.81	13.58	11.38	12.73	13.01	12.38	15.66	10.45
S.E.m ±	1.652	1.197	2.039	2.792	2.316	2.725	1.407	1.130	1.509	1.408
C.D at 5%	4.954	3.590	NS	NS	NS	NS	4.219	3.387	NS	4.221

TP - Transparent polyethylene

Table 10. Influence of solarization on the soil moisture content at 10 cm depth during the solarization period

Treatments	First 30 days of solarization						30 to 40 days of solarization		40 to 50 days of solarization	
	25-3-96	30-3-96	4-4-96	9-4-96	14-4-96	19-4-96	24-4-96	29-4-96	4-5-96	9-5-96
1. TP(0.05mm) 30 days	6.94	7.94	15.53	13.98	16.60	15.32	14.53	17.29	19.80	16.82
2 TP(0.05mm) 40 days	11.35	10.66	14.32	15.39	13.44	15.22	21.52	18.67	15.18	13.81
3. TP(0.05mm) 50 days	8.95	11.78	14.32	16.56	19.35	18.95	18.79	17.24	21.34	17.61
4. TP(0.10mm) 30 days	7.63	8.09	12.23	16.33	15.58	15.95	16.61	19.57	15.51	13.42
5. TP(0.10mm) 40 days	6.06	9.50	14.10	13.24	13.30	18.64	18.31	16.57	17.88	13.74
6. TP(0.10mm) 50 days	8.66	11.14	12.36	16.92	15.62	16.64	14.82	18.34	20.24	17.08
7. Weed free check	4.22	3.87	10.24	15.68	12.15	14.27	14.36	13.02	17.14	11.82
8. Unweeded control	6.09	5.32	11.75	16.52	12.13	15.45	15.77	15.00	17.85	11.82
9. Normal practice	5.79	4.16	9.37	15.86	12.16	13.95	14.19	12.88	16.06	12.18
S.E.m ±	1.276	1.400	1.702	2.008	2.123	1.658	2.328	1.060	0.846	0.844
C.D at 5%	3.825	4.199	NS	NS	NS	4.956	6.979	3.177	2.535	2.529

TP - Transparent polyethylene

Table 11. Influence of solarization on the soil moisture content at 15 cm depth during the solarization period

Treatments	First 30 days of solarization						30 to 40 days of solarization		40 to 50 days of solarization	
	25-3-96	30-3-96	4-4-96	9-4-96	14-4-96	19-4-96	24-4-96	29-4-96	4-5-96	9-5-96
1. TP(0.05mm) 30 days	9.65	7.93	14.26	14.79	17.40	14.90	15.74	16.51	19.89	17.46
2 TP(0.05mm) 40 days	11.41	10.77	13.97	15.74	14.32	15.89	16.59	22.32	16.75	13.61
3. TP(0.05mm) 50 days	8.04	11.24	14.50	18.58	17.87	18.64	19.66	19.63	29.26	19.49
4. TP(0.10mm) 30 days	8.48	8.80	12.74	11.34	16.83	13.87	17.34	17.24	16.31	16.55
5. TP(0.10mm) 40 days	6.77	9.78	13.02	12.27	12.35	16.74	16.23	22.62	17.46	14.03
6. TP(0.10mm) 50 days	10.18	11.07	21.75	15.16	15.64	15.31	15.45	18.51	18.73	19.38
7. Weed free check	5.17	6.72	11.01	19.91	15.47	15.73	17.15	14.11	15.58	10.85
8. Unweeded control	5.99	5.44	13.01	16.86	12.80	14.54	14.49	16.41	17.49	10.88
9. Normal practice	6.06	5.40	13.88	13.44	12.49	14.27	15.54	14.85	14.82	10.65
S.E.m ±	1.413	1.311	3.347	2.897	2.259	1.567	2.245	2.099	1.543	0.879
C.D at 5%	NS	3.931	NS	NS	NS	NS	NS	NS	4.627	2.637

TP - Transparent polyethylene

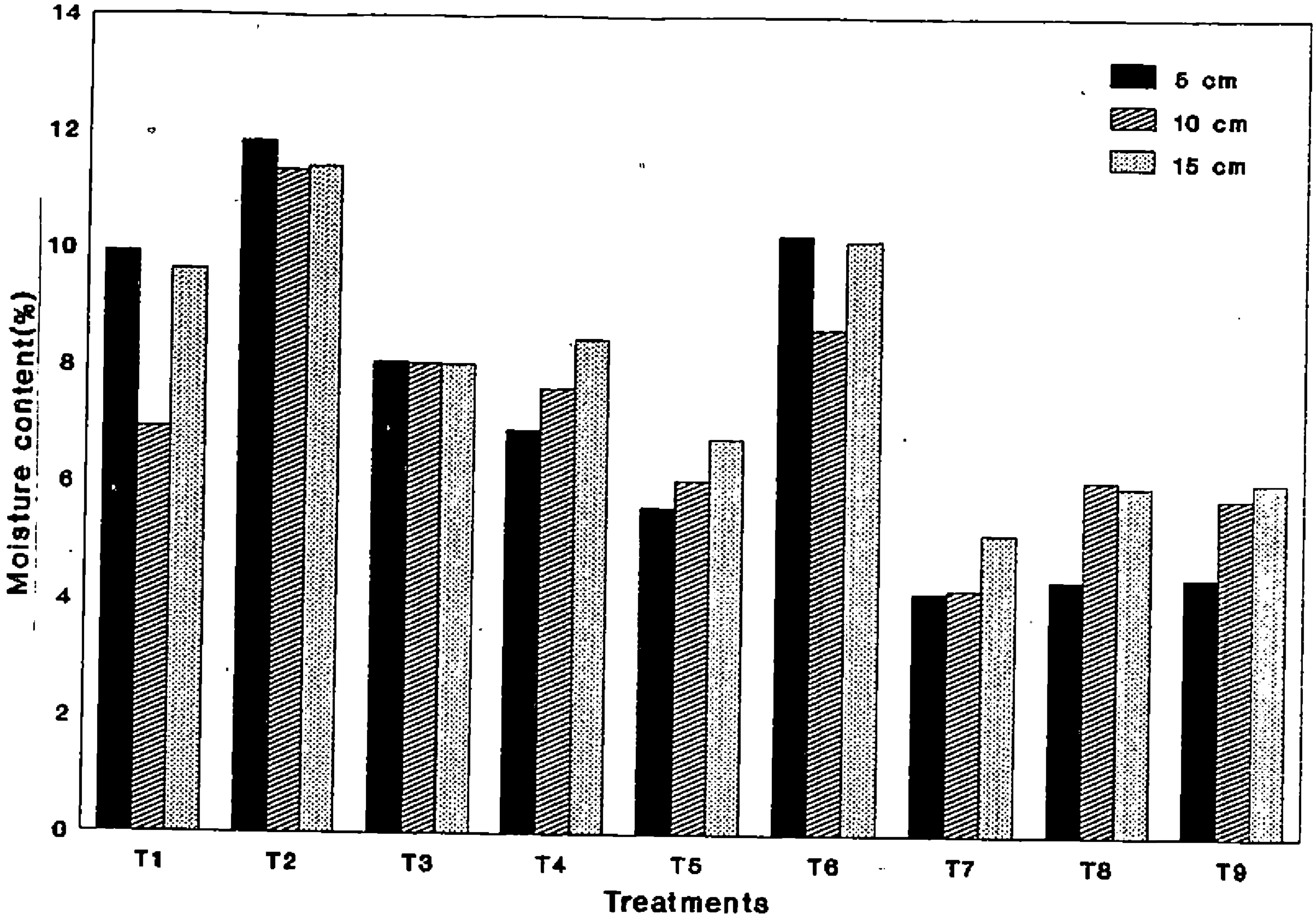

Fig.2. Effect of solarization on the moisture content at various depths during the first week of solarization

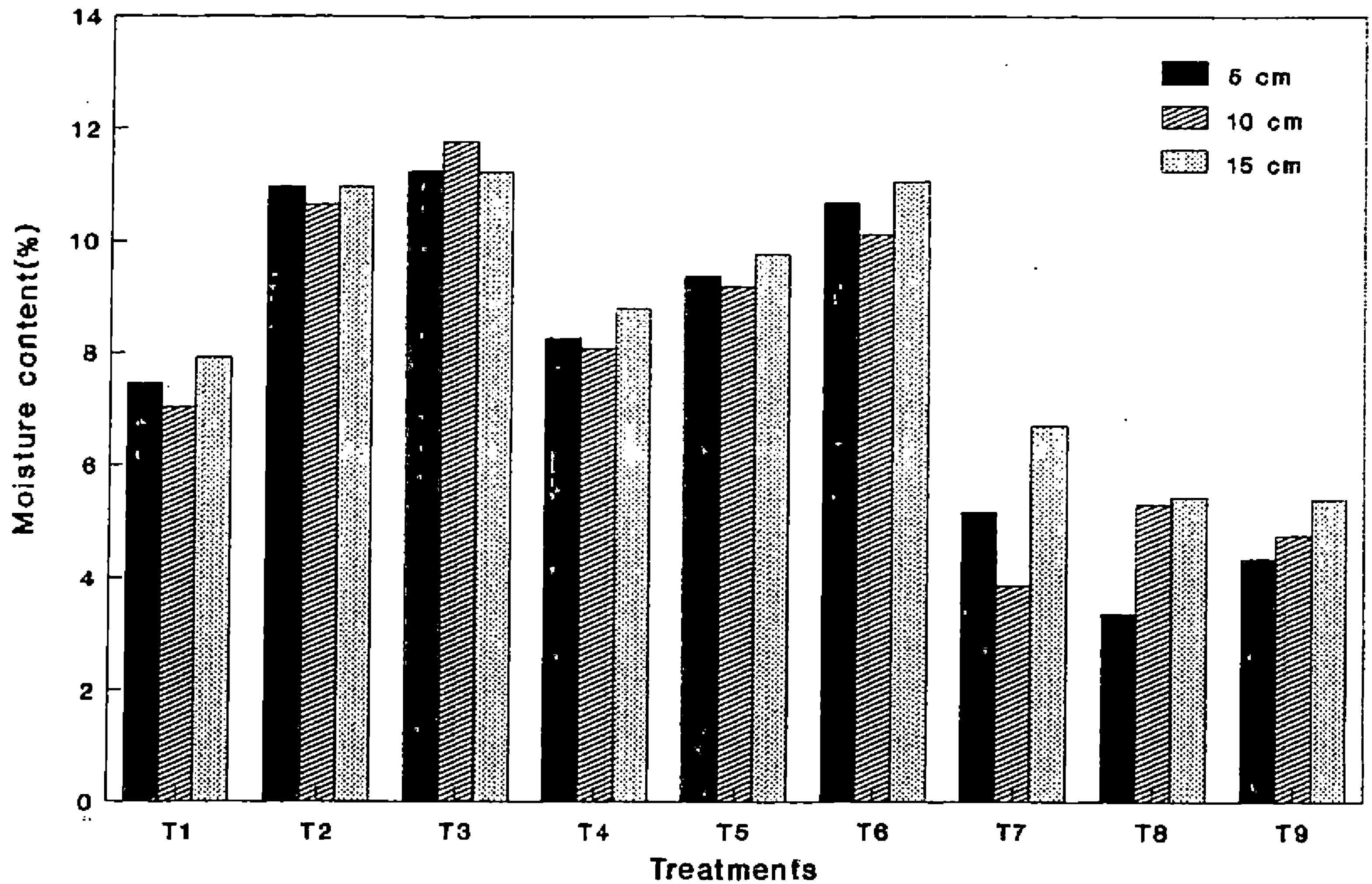

Fig.3. Effect of solarization on the moisture content at various depths during the second week of solarization

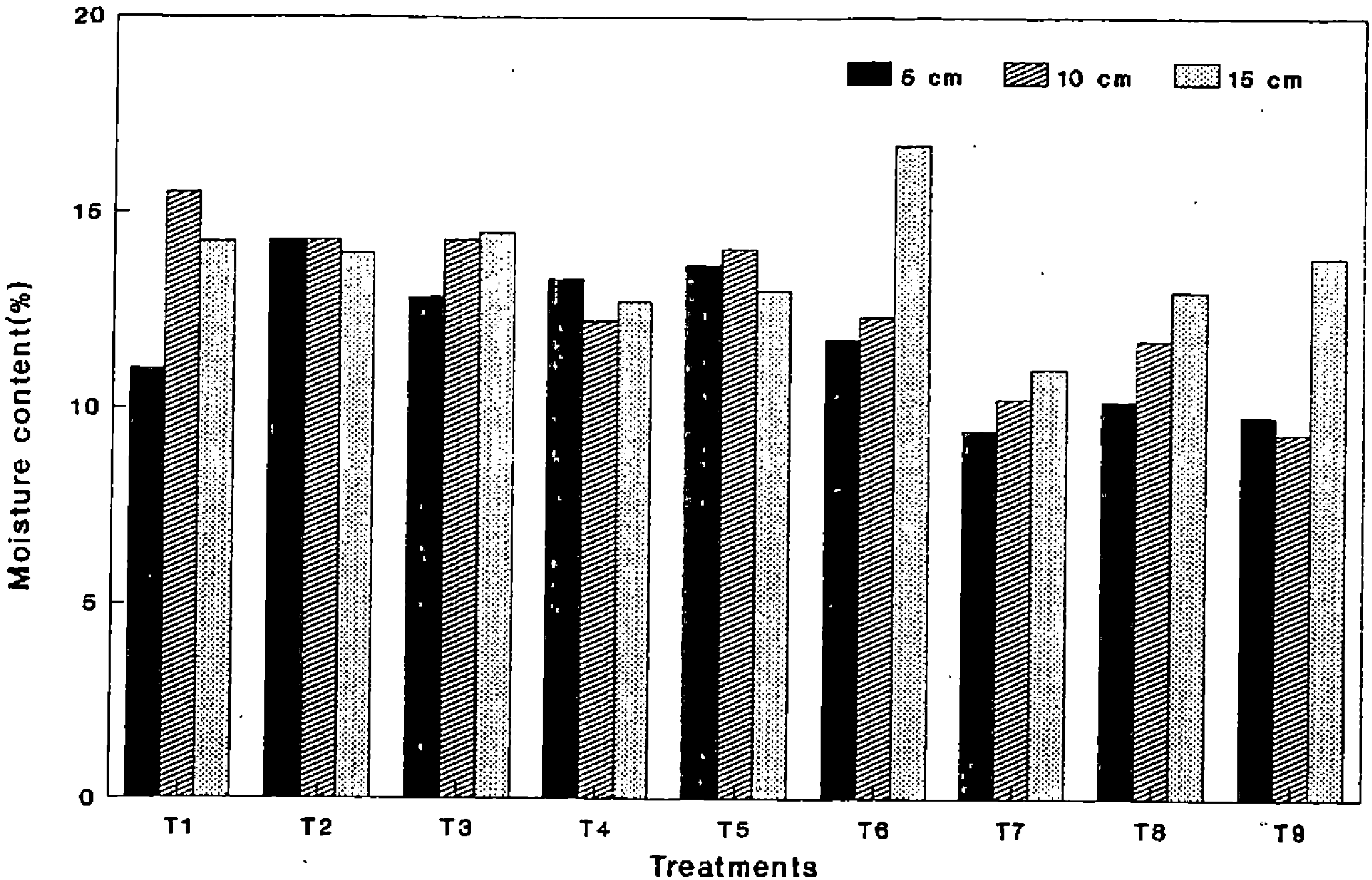

Fig.4. Effect of solarization on the moisture content at various depths during the third week of solarization

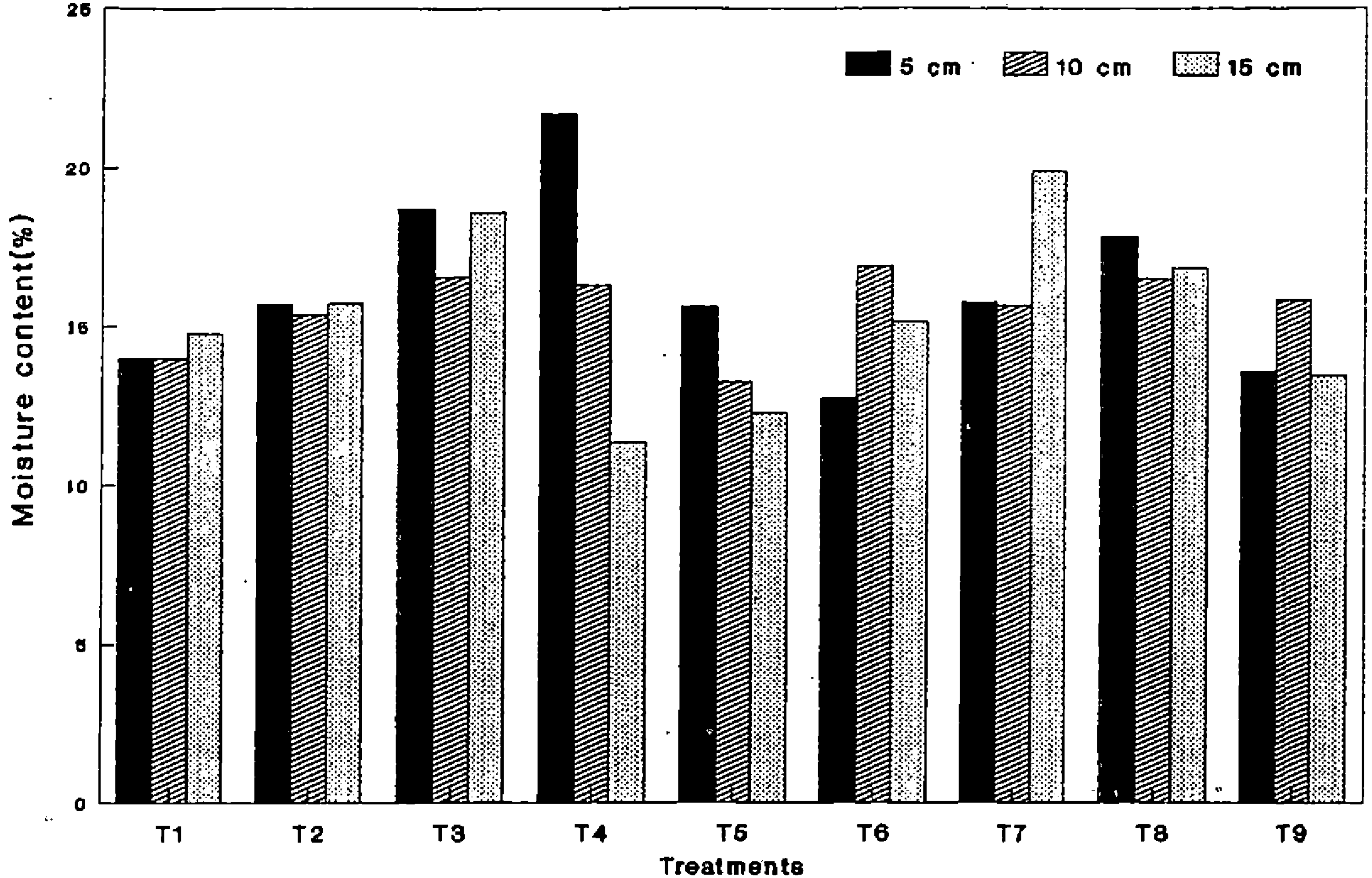

Fig.5. Effect of solarization on the moisture content at various depths during the fourth week of solarization

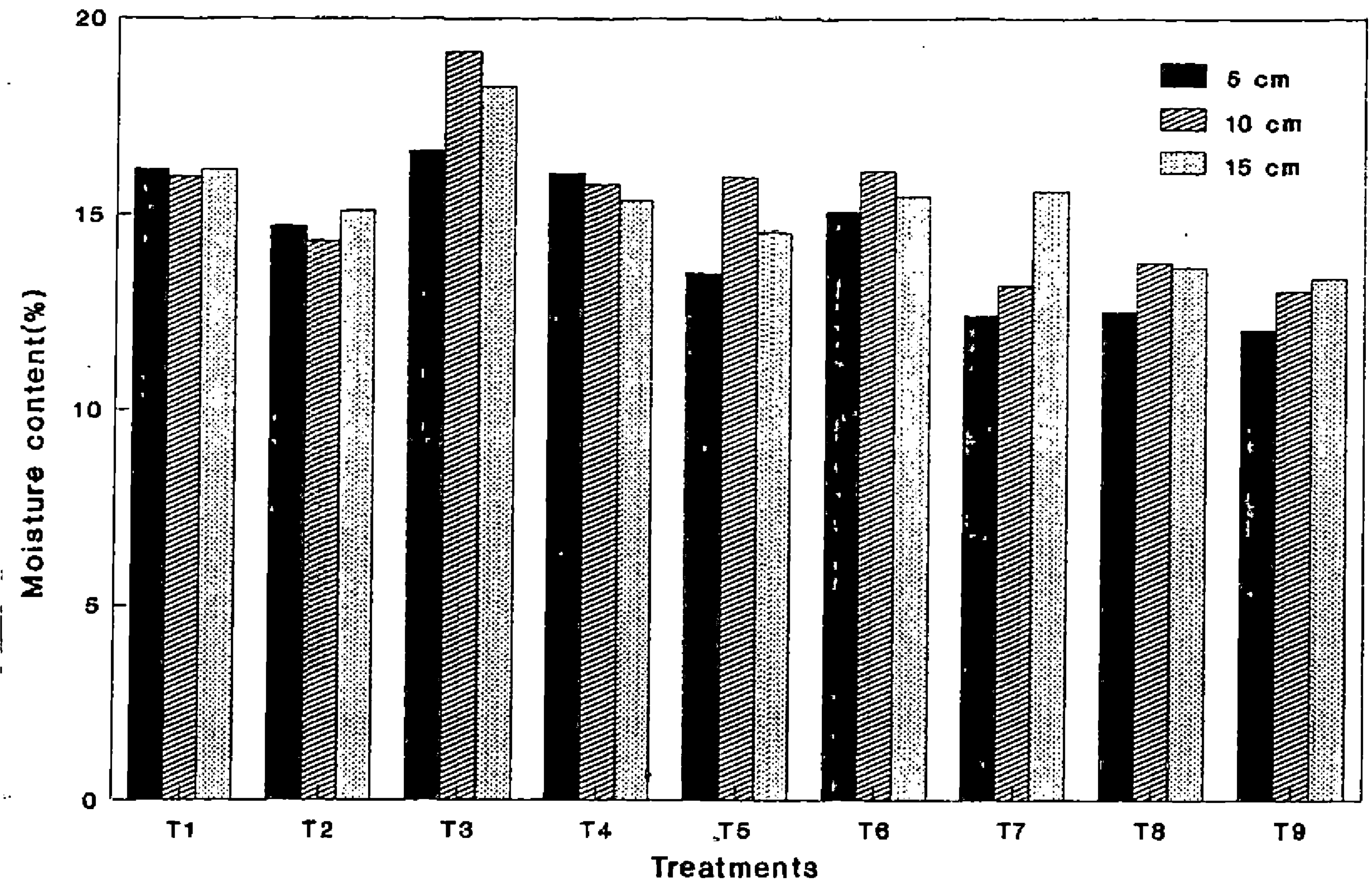

Fig.6. Effect of solarization on the moisture content at various depths during the fifth week of solarization

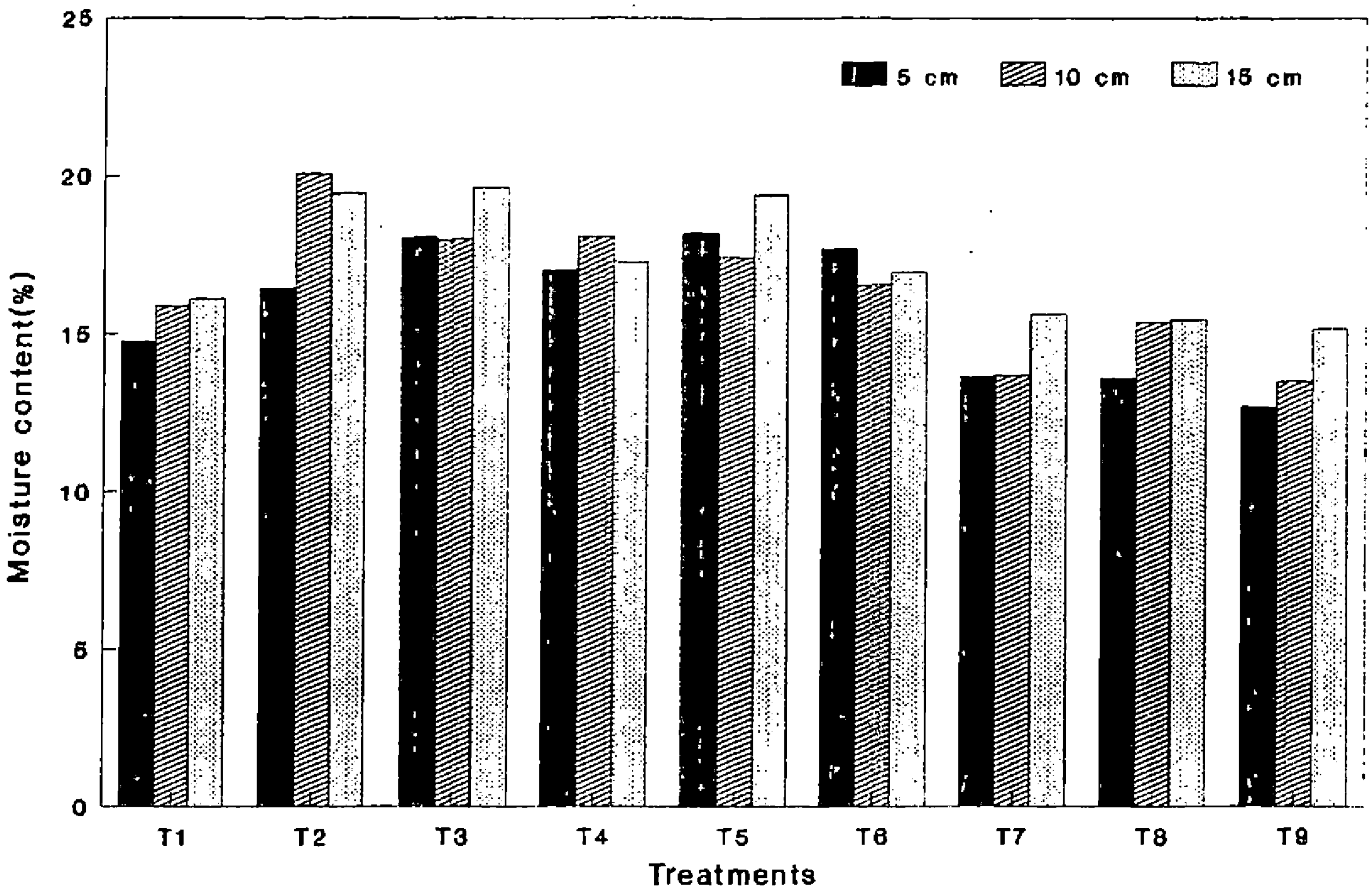

Fig.7. Effect of solarization on the moisture content at various depths during the sixth week of solarization

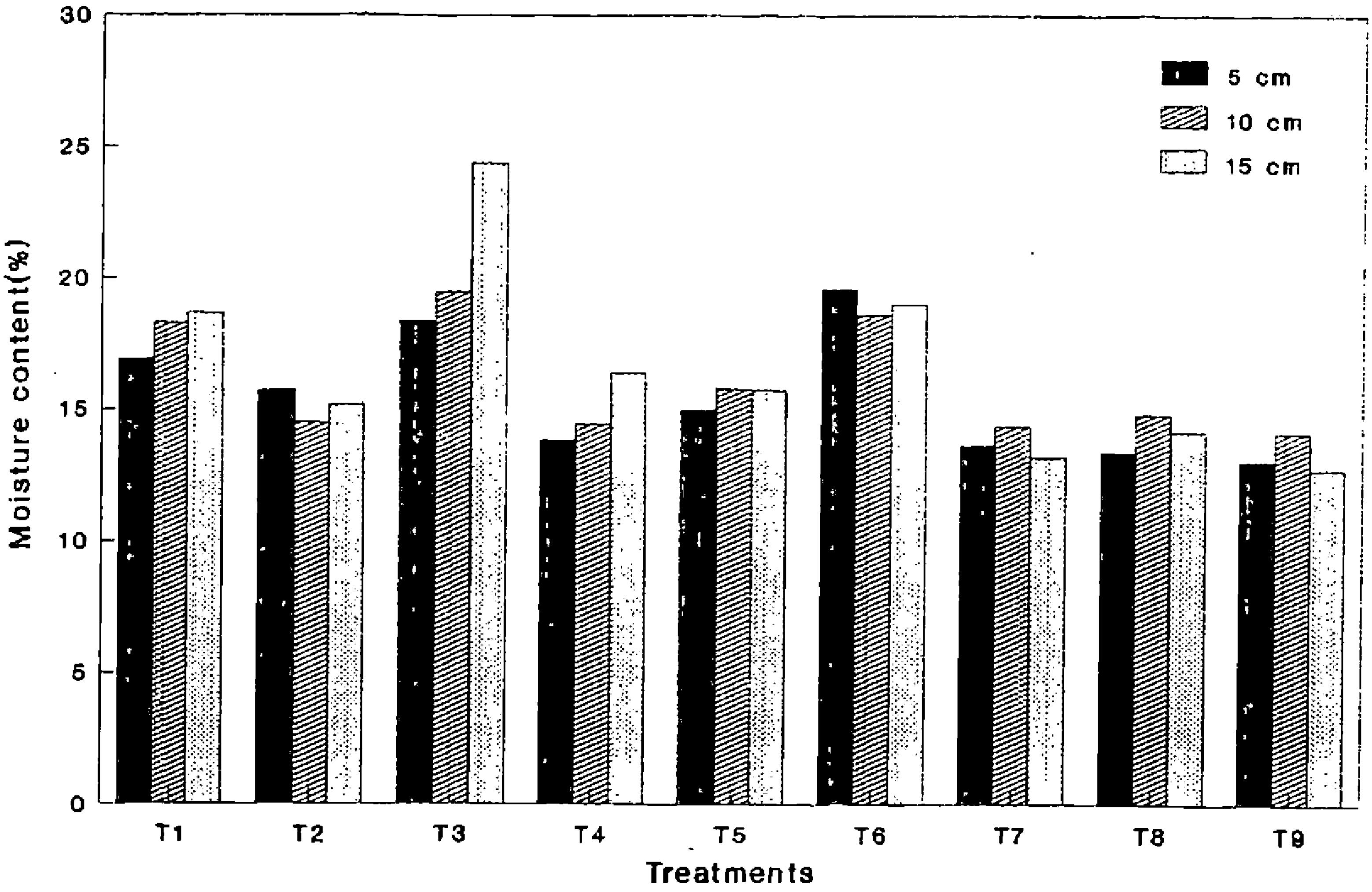

Fig.8. Effect of solarization on the moisture content at various depths during the seventh week of solarization

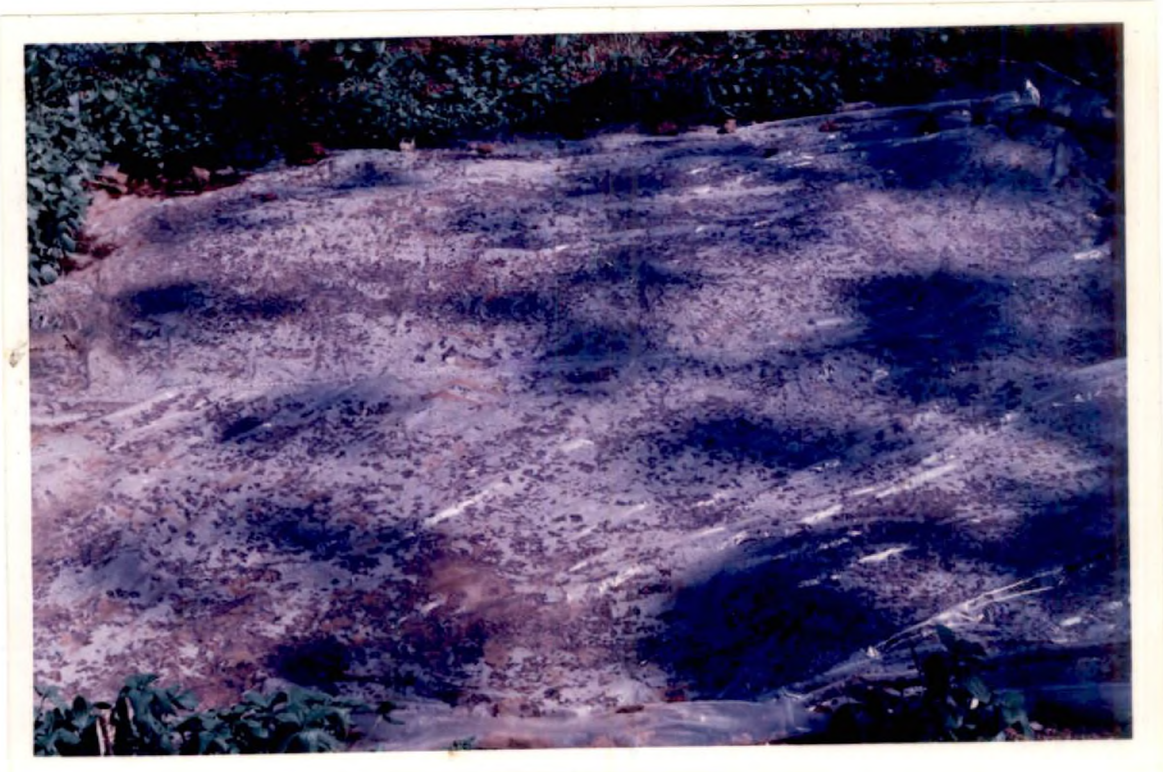

Plate 3. View of the moisture retained beneath the sheet surface.

pre sowing irrigation can be avoided. This will be a great advantage since it occurs at a period when there is peak demand of water.

Considerable moisture conservation as reported by Patra *et al.* (1993) and Gutal *et al.* (1992) occurred in mulched soils.

4.3.1 Effect of thickness of polyethylene on moisture conservation

Factorial analysis was done for the daily data on moisture content upto 30 days of solarization to study the effect of thickness of polyethylene on moisture conservation. The results are presented in table 12. It was observed that there was no significant difference in the moisture content values for 0.1 TP and 0.05 TP, eventhough there was significant difference in the moisture content values between the solarized and non-solarized plots. It may be concluded that both 0.1 TP and 0.50 TP were equally effective in conserving the soil moisture.

The averages of moisture content values during the first 30, 40 and 50 days of solarization were found out and the per cent increase in the moisture content values with respect to T8 (non-solarized unweeded control) were plotted against the different solarization treatments. This per cent increase in

Table 12. Effect of thickness of polyethylene on increase in soil moisture contents at various depths for first 30 days of solarization

	moisture content 0.05 TP	0.1 TP	S.E.m $\pm$	F value	C.D.at 5%
5cm depth					
25-3-96	9.951	7.595	1.09	2.342	NS
30-3-96	9.985	9.460	0.70	0.194	NS
04-4-96	12.718	12.914	1.44	0.017	NS
09-4-96	15.464	16.688	1.99	0.189	NS
14-4-96	15.941	14.871	1.60	0.224	NS
19-4-96	15.731	14.875	1.94	0.097	NS
10cm depth					
25-3-96	9.079	7.450	0.82	1.980	NS
30-3-96	10.127	9.578	0.87	1.200	NS
04-4-96	14.722	12.899	1.77	0.010	NS
09-4=96	15.310	15.497	1.32	0.577	NS
14-4-96	16.460	14.833	1.52	0.124	NS
19-4-96	16.497	17.077	1.17	0.559	NS
15cm depth					
25-3-96	9.700	8.478	0.94	0.852	NS
30-3-96	9.978	9.884	0.78	1.126	NS
04-4-96	14.240	15.837	2.43	0.306	NS
09-4-96	16.370	12.923	1.57	2.440	NS
14-4-96	16.477	15.307	0.93	0.400	NS

NS - Non Significant

the moisture contents for the 5, 10 and 15 cm depths are presented in figures 9, 10 and 11 respectively.

In the solarized treatments there is 37.9, 33.7 and 38.3 per cent increase in the moisture content values at 5, 10 and 15 cm depths respectively. The maximum per cent increase in moisture content at all the 3 depths occurred in the T3 (0.05 TP and 50 days duration) treatment.

Egley (1983), Mahrer *et al.* (1984) and Adentunji (1994) also observed elevated surface soil moisture levels under the polyethylene covers to a considerable extent. The soil moisture is thus significantly influenced by the polyethylene mulch.

4.4 Effect of solarization on weed control

Solarization had significant effects in lowering the weed count as well as the dry weight of the weeds in the following season.

4.4.1 Influence of solarization on weed count

The weed count data obtained from the solarization treatments after the period of solarization, from 5th June 1996 onwards at 35 days interval are presented in table 13. In general the least value noticed was for T3 (0.05 TP and

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Plate 4. Effect of solarization on weed growth.

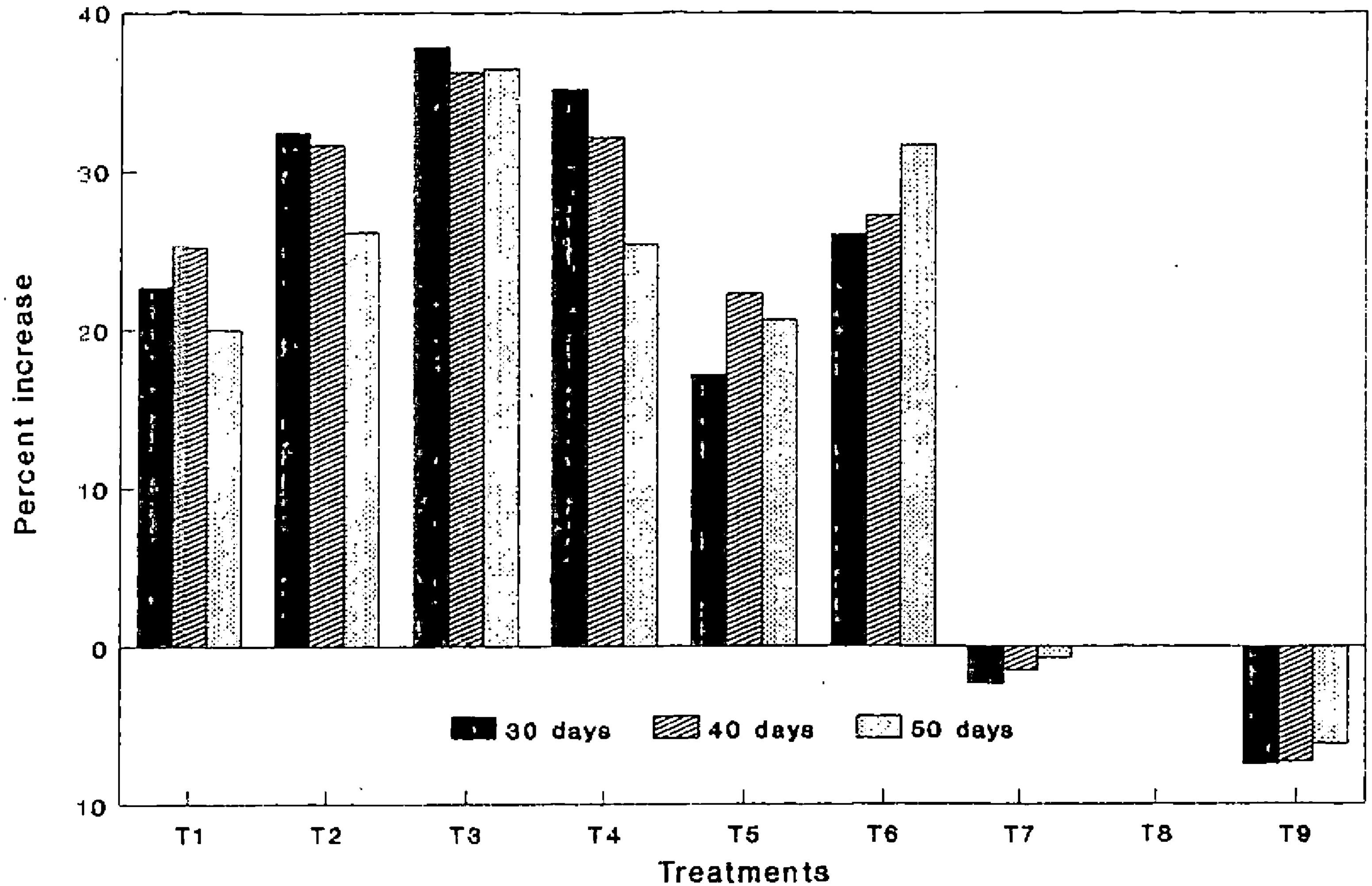

Fig.9. Per cent increase in average moisture contents for different durations at 5 cm depth due to solarization treatments

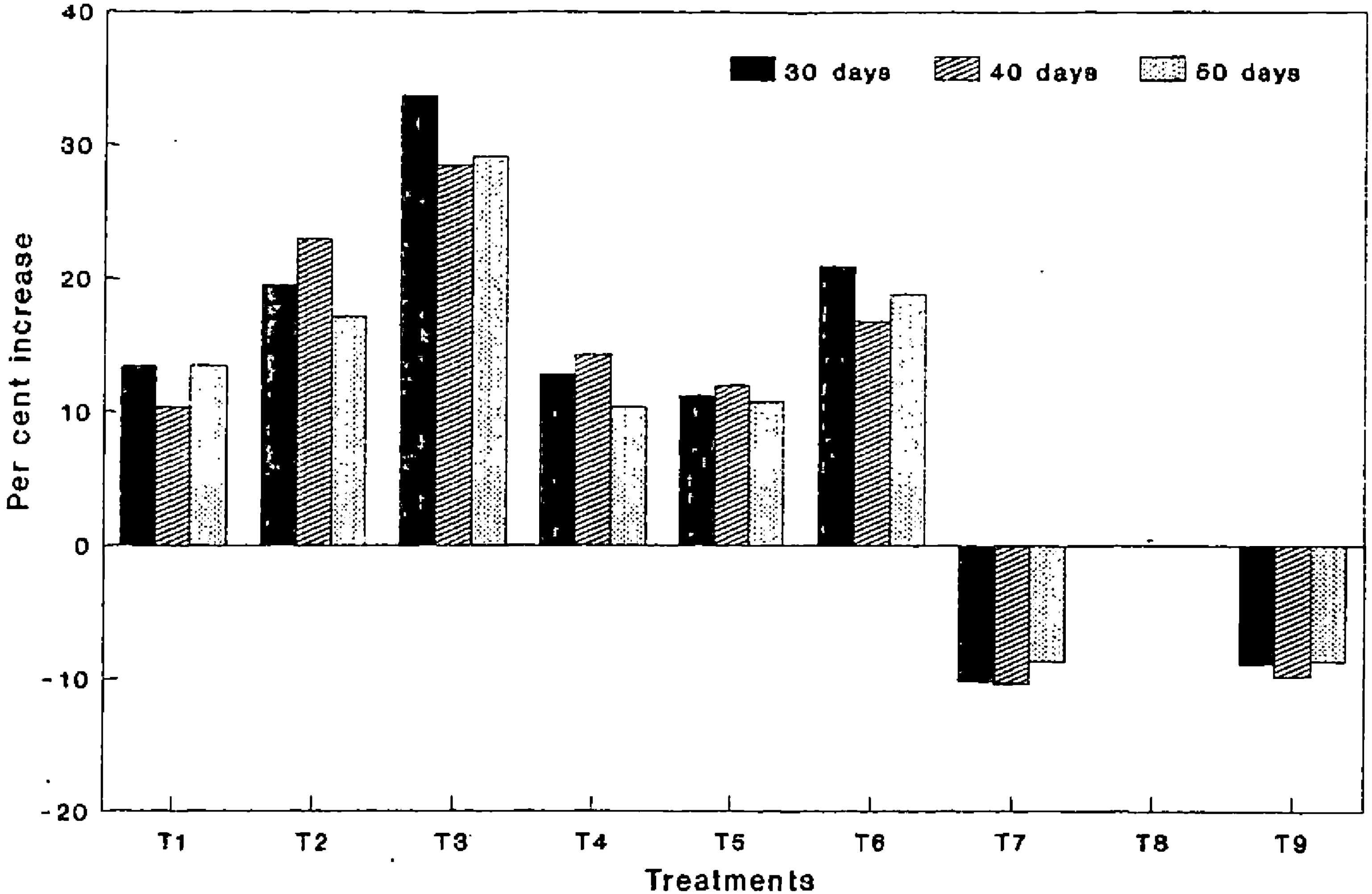

Fig.10.Per cent increase in average moisture contents for different durations at 10 cm depth due to solarization treatments

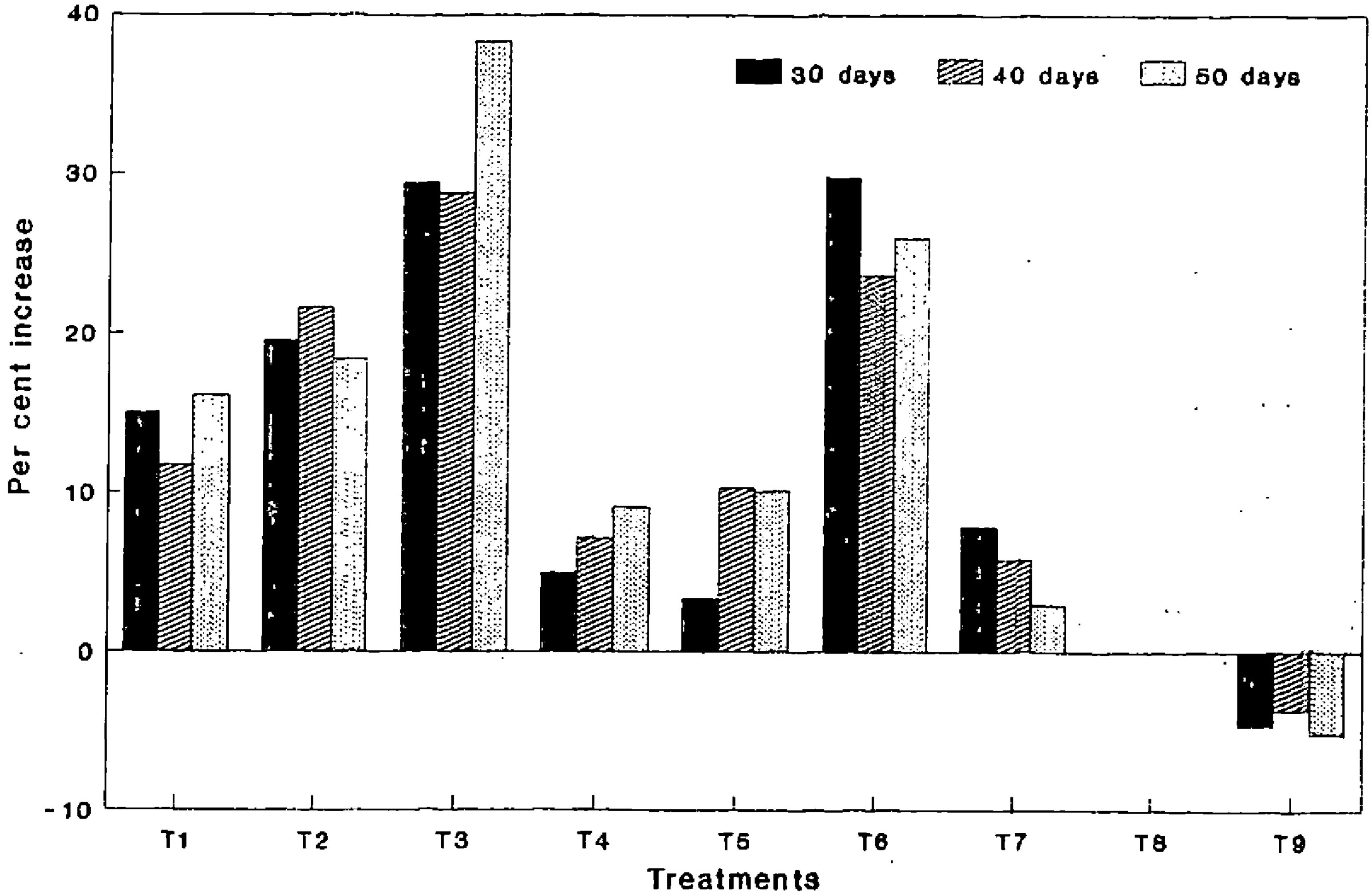

Fig.11.Per cent increase in average moisture contents for different durations at 15 cm depth due to solarization treatments

Table 13. Influence of solarization treatments on weed count after the solarization period

Treatments	Weed count per sq.m after the solarization period				
	5-6-96	10-7-96	16-8-96	20-9-96	25-10-96
1. TP(0.05mm) 30 days	4.62(20.37)	6.74(44.44)	7.99(62.96)	8.56(72.22)	8.77(75.93)
2. TP(0.05mm) 40 days	1.70(1.85)	7.0(48.15)	6.98(47.78)	7.76(59.26)	7.40(53.70)
3. TP(0.05mm) 50 days	3.98(14.81)	5.53(29.63)	5.7(31.48)	6.6(42.59)	5.86(33.33)
4. TP(0.10mm) 30 days	3.20(9.26)	7.88(61.11)	9.18(83.33)	9.67(92.59)	9.08(81.48)
5. TP(0.10mm) 40 days	1.69(1.85)	7.14(50.0)	9.58(90.74)	10.93(118.52)	8.88(77.78)
6. TP(0.10mm) 50 days	1.0(0)	5.86(33.33)	10.05(100)	10.5(109.26)	7.4(53.7)
7. Weed free check	1.0(0)	1.0(0)	1.0(0)	1.0(0)	1.0(0)
8. Unweeded control	32.07(1027.8)	28.4(805.56)	28.4(805.56)	25.08(627.78)	13.79(189.1)
9. Normal practice	32.05(1025.9)	23.8(568.52)	25.2(633.33)	28.25(797.34)	13.09(170.4)
S.E.m ±	1.540	1.877	2.541	2.183	0.794
C.D at 5%	4.618	5.628	7.618	6.544	2.381

Figures in parenthesis indicate original values

50 days). There was significant difference between the solarized and the non solarized treatments.

Among the solarized treatments, the weed count was usually highest with 0.10 TP and 30 days duration, but was significantly lower than the non solarized treatments. The low intensity of solar radiation falling in the solarized plots may be a factor which causes reduction in weed growth in these plots compared to the non solarized plots. This low intensity must have affected the germination of the weed seeds and the high soil temperature in these plots may have destroyed the emerged weeds. Similar reduction in weed count due to soil solarization has also been reported earlier by Grinstien *et al.* (1979), Katan *et al.* (1983) and Stapleton *et al.* (1989).

4.4.1.1 Effect of duration of solarization on weed count

The results of the factorial analysis conducted to study the effect of the duration of solarization on weed count are given in table 16. Out of the five observations on weed count on three days there was significant difference in the weed count values between the 3 durations. In general, the weed count decreased with decrease in the duration of solarization. Thus in most cases the weed count data was lowest in case of 50 days of solarization and highest in case of 30 days solarization. Thus the effect of duration of solarization on

Table 14. Influence of solarization treatments on the dry weight of weeds after the solarization period

Treatments	Weed dry weight (g/sq.m) after the solarization period				
	5-6-96	10-7-96	16-8-96	20-9-96	25-10-96
1. TP(0.05mm) 30 days	0.51(1.26)	0.84(4.89)	0.98(7.50)	1.44(25.20)	0.99(7.74)
2. TP(0.05mm) 40 days	0.36(0.29)	0.78(4.02)	0.86(5.26)	1.41(23.63)	0.85(5.04)
3. TP(0.05mm) 50 days	0.45(0.83)	0.66(2.61)	0.67(2.67)	1.26(16.33)	0.58(1.79)
4. TP(0.10mm) 30 days	0.71(3.15)	0.94(6.72)	1.21(14.11)	1.35(20.13)	0.98(7.55)
5. TP(0.10mm) 40 days	0.43(0.70)	0.88(5.56)	1.04(9.08)	1.41(23.85)	0.89(5.83)
6. TP(0.10mm) 50 days	0.30(0.00)	0.90(6.02)	1.06(9.43)	1.17(12.61)	0.75(3.61)
7. Weed free check	0.30(0.00)	0.30(0.00)	0.30(0.00)	0.30(0.00)	0.30(0.00)
8. Unweeded control	2.15(137.6)	1.67(44.94)	1.42(24.02)	2.02(101.4)	2.43(265.6)
9. Normal practice	2.19(153.8)	1.86(70.74)	1.63(40.48)	1.69(47.02)	1.31(18.4)
S.E.m ±	0.0876	0.1265	0.1033	0.1402	0.2978
C.D at 5%	0.2625	0.3792	0.3096	0.4204	0.8927

Figures in parenthesis indicate original values

Table 15. Effect of thickness of polyethylene on the decrease in weed count

	5-6-96	10-7-96	16-8-96	20-9-96	25-10-96
Weed count (0.05 TP)	2.811	6.337	6.784	7.616	7.263
Dry weight* (0.1 TP)	1.771	6.860	9.545	10.171	8.381
S.E. m ±	0.512	0.241	0.297	0.479	0.435
F - value	2.060	2.363	43.249	14.252	3.307
C.D. at 5%	NS	NS	1.62	2.612	NS

* - Weed count values given are the transformed values
NS - Non Significant

Table 16. Effect of duration of solarization on the decrease in weed count.

	5-6-96	10-7-96	16-8-96	20-9-96	25-10-96
Weed count (30 days)	3.527	7.260	8.463	9.092	8.851
Weed count* (40 days)	1.520	6.883	8.225	9.280	8.034
weed count (50 days)	1.827	5.653	7.806	8.309	6.582
S.E. m ±	0.627	0.294	0.364	0.586	0.532
F - value	2.968	8.145	0.838	0.772	4.663
C.D. at 5%	NS	0.928	NS	NS	1.677

* - Weed count values given are the transformed values
NS - Non Significant

the decrease in weed count can be concluded as significant. These observations are supported by that of Hildebrand (1985), Braun *et al.* (1987), Silveria *et al.* (1990) and Habeeburrahman (1992).

4.4.1.2 Effect of thickness of polyethylene on weed count

The results of the analysis conducted to find out the effect of thickness of polyethylene on weed count are presented in table 15. Significant difference in weed count between the 0.05 TP and 0.10 TP occurred in most of the cases. In all other cases except the first day of observation (i.e., 5-6-1996), the weed count was less for the 0.05 TP than with 0.10 TP, eventhough the difference between the two in some cases was not significant. The 0.05 TP was better than the 0.1 TP in reducing the weed count. The rise in temperature maxima was also in the same order. Rise in temperature to higher levels by TP 0.05 might have caused the death or damage to the weed seeds present in the soil to a greater extent, thus reducing their emergence to a minimum. Standifer *et al.* (1984), Patel *et al.* (1990) and Habeeburrahman (1992) also observed superiority of this thin TP over thick TP with respect to reduction in weed count.

4.4.2 Influence of solarization on dry weight of weeds

The observations on the dry weight of weeds were taken and are tabulated in table 14.

There was significant difference in dry weight of weeds between the solarized and the non - solarized treatments. In some trials the dry weight of weeds was higher in T9 (normal practice) than T8 (unweeded control), but in some other trials it was less. Even when it was higher, the difference was not significant.

Similar to that of weed count, TP 0.05 for 50 days appeared to be the best in reducing the weed dry weight. The explanation given in connection with weed count reduction holds good here also, as the weed dry weight is reduced mainly due to the effective reduction in germination and emergence which, in turn, occurred as a result of repeated daily heatings for a period of 50 days.

4.4.2.1 Effect of duration of solarization on dry weight of weeds

Analysis were done to find out the effect of solarization on the dry weight of weeds and the results obtained are given in table 18. Even though the dry weight of weeds decreased with increase in duration in all cases, the decrease was significant only in one case. The dry weight of weeds was lowest in case of 50 days of solarization. The reason for this has been explained earlier. Similar results were obtained by Braun *et al.* (1987) and Habeeburrahman (1992).

Table 17. Effect of thickness of polyethylene on the decrease in dry weight of weeds

	5-6-96	10-7-96	16-8-96	20-9-96	25-10-96
Dry weight (0.05 TP)	0.433	0.736	0.800	1.325	0.853
Dry weight* (0.1 TP)	0.439	0.860	1.078	1.188	1.289
S.E. m ±	0.059	0.078	0.051	0.069	0.203
F - value	0.004	1.271	14.871	2.003	2.316
C.D. at 5%	NS	NS	0.276	NS	NS

* - Transformed values of dry weight are given
NS - Non Significant

Table 18. Effect of duration of solarization on the decrease in dry weight of weeds

	5-6-96	10-7-96	16-8-96	20-9-96	25-10-96
Dry weight (30 days)	0.557	0.870	1.078	1.277	1.303
Dry weight* (40 days)	0.380	0.783	0.910	1.377	1.128
Dry weight (50 days)	0.371	0.742	0.829	1.117	0.781
S.E. m ±	0.073	0.095	0.063	0.084	0.248
F - value	2.063	0.467	4.121	2.455	1.150
C.D. at 5%	NS	NS	0.195	NS	NS

* - Transformed values of dry weight are given
NS - Non Significant

4.4.2.2 Effect of thickness of polyethylene on dry weight of weeds

The results obtained during the analysis to find out the effect of thickness of polyethylene on dry weight of weeds are presented in table 17. The dry weight of weeds was less in plots solarized with 0.05 TP than in plots solarized with 0.1 TP, but the difference was not significant except in a few cases. The higher increase in soil temperature due to the thinner polyethylene might be the reason for this decrease in dry weight of weeds with 0.05 TP. In conformity with this Habeeburrahman (1992) observed that transparent polyethylene of 0.05 mm was significantly superior in reducing the dry weight of weeds, as compared to that of 0.1mm thickness.

4.5 Observation on the yield of bhindi

The average yield of bhindi obtained per plant for the different treatments are given in table 19. Maximum average yield of 151.7 g/plant occurred from T7 (weed free check) and a minimum of 33.06 g/plant occurred from the T8 (unweeded control). Among the solarized plots, T3 (0.05 TP and 50 days) was the best with an average yield of 141.38 g/plant which was not significantly lower than the maximum yield obtained from T7. The average yield obtained from T1 (0.05 TP and 30 days), T4 (0.1 TP and 30 days) and T5 (0.10 TP and 40 days) were significantly lower than the maximum yield.

Table 19. Average yield of bhindi(g/plant) as influenced by solarization treatments

	Treatments	Yield
1.	TP(0.05mm) 30 days	111.63
2.	TP(0.05mm) 40 days	137.54
3.	TP(0.05mm) 50 days	141.38
4.	TP(0.10mm) 30 days	109.98
5.	TP(0.10mm) 40 days	123.49
6.	TP(0.10mm) 50 days	127.17
7.	Weed free check	151.78
8.	Unweeded control	33.06
9.	Normal practice	107.76
S.E.m ±		7.246
C.D at 5%		21.720

The table clearly indicates significant difference in yield between the solarized and the non solarized treatments. From the above results, it can also be concluded that the thickness of polyethylene as well as the duration of solarization had significant effects on the yield of the crop. There was significant difference in yield between T1 and T2, i.e., with 0.05 TP and different durations, T2 having a longer duration and significantly higher yield. Similar is the case between other treatments also.

The per cent increase in yield of bhindi with respect to the different treatments was calculated and is shown graphically in figure 12. The per cent increase was calculated with respect to T8 treatment (unweeded control).

The per cent increase in yield in solarized plots ranged from 232.7 per cent to 327.7 per cent. The lowest per cent increase among the solarized treatments was recorded with T4 (0.1 TP and 30 days) and highest with T3 (0.05 TP and 50 days). Similar increase in yield in the solarized plots was obtained by Patten *et al.* (1990) and Kumar *et al.* (1993).

4.5.1 Influence of weed count on the yield of bhindi

The result of the correlation analysis done to study the influence of weed count on yield of bhindi are presented in table 21. The weed count data at 20 DAS (days after sowing), 55 DAS and 90 DAS for all the nine treatments were correlated

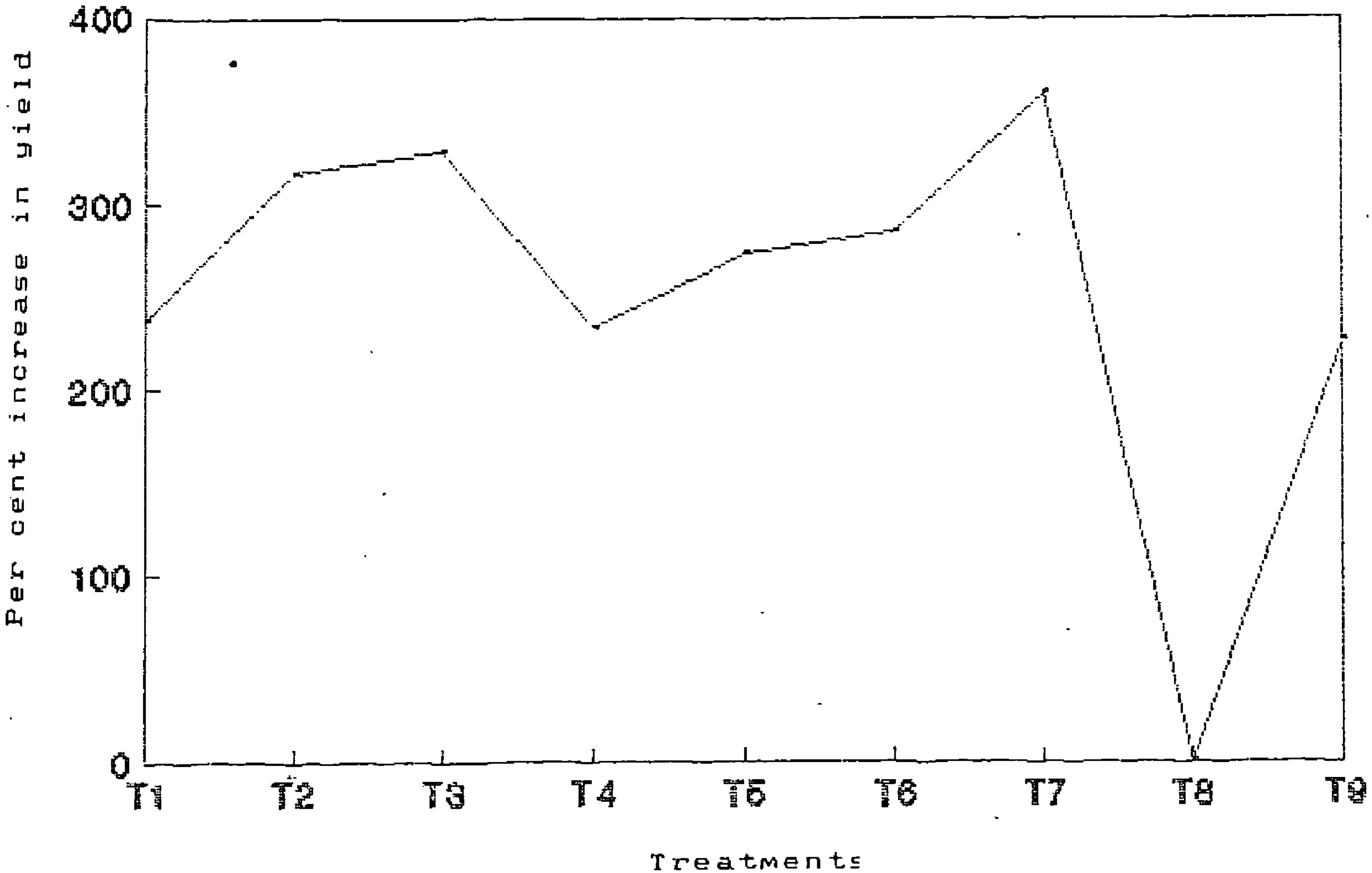

Fig.12. Influence of solarization on per cent increase in yield of bhindi.

with the corresponding total yield. There was significant negative correlation between weed count and yield of bhindi in all the three days of observation. Grinstein *et al.* (1979) also observed similar negative correlation between the yield and the weed count due to solarization treatments.

4.6 Influence of intensity of solar radiation on soil temperature

The soil temperature at 5 cm depth was found to be significantly correlated (positive) with the intensity of solar radiation above the sheet surface except in one or two cases in all the solarized plots (table 20). In the non-solarized plots also there was positive correlation but was not significant. The soil temperature was also positively correlated to the intensity of solar radiation below the sheet surface, but in most cases it was not significant.

From the results obtained during the above analysis it is evident that as the intensity of the solar radiation increases, the soil temperature also increases, which is beneficial in reducing the weed growth.

4.7 Influence of soil temperature on the soil moisture content

The results obtained during the correlation analysis between the data on weekly averages of soil temperature and

Table 20. Influence of solar radiation intensity on soil temperature[1]

	Above sheet correlation coefficient	surface proba bility	Below sheet correlation coefficient	surface proba-bility
1.TP(0.05mm) 30 days[2]	0.825	0.065	0.835	0.058
2.TP(0.05mm) 40 days	0.891	0.011	0.875	0.015
3.TP(0.05mm) 50 days	0.810	0.021	0.734	0.052
4.TP(0.10mm) 30 days	0.946	0.007	0.540	0.329
5.TP(0.10mm) 40 days	0.362	0.473	0.731	0.085
6.TP(0.10mm) 50 days	0.823	0.018	0.464	0.286
Non - solarized	0.157	0.735		

1 See Appendices 4 and 5 for the data

2 - For T1 to T6, data after removal of polyethylene are not included.

Table 21. Influence of weed count on the yield of bhindi

Weed count[1]	Correlation coefficient	Probability
20 DAS	-0.803	0.007
55 DAS	-0.762	0.014
90 DAS	-0.892	0.001

1 - Weed count datas are given in table 13

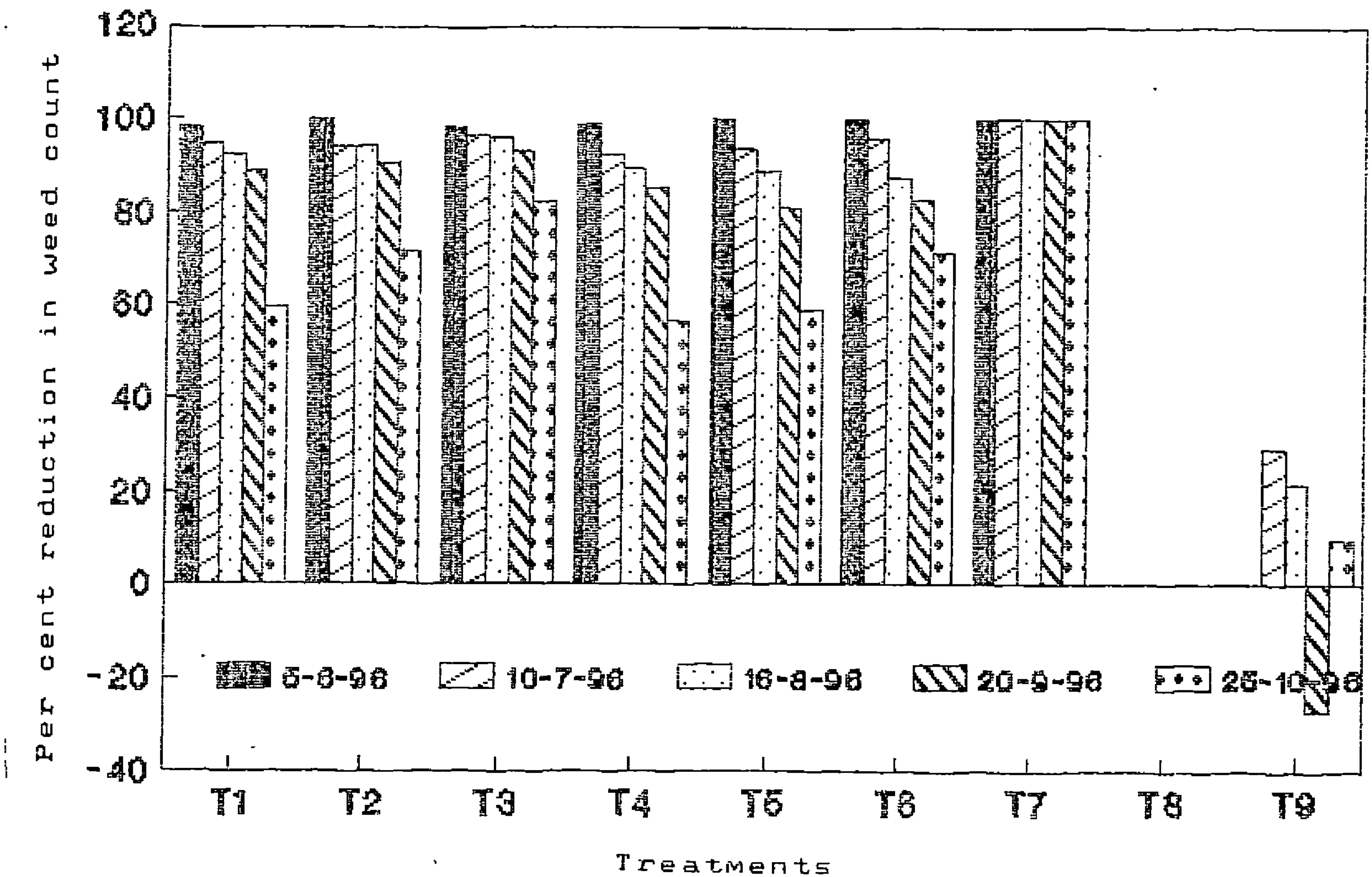

Fig.13. Per cent reduction in weed count due to solarization treatments

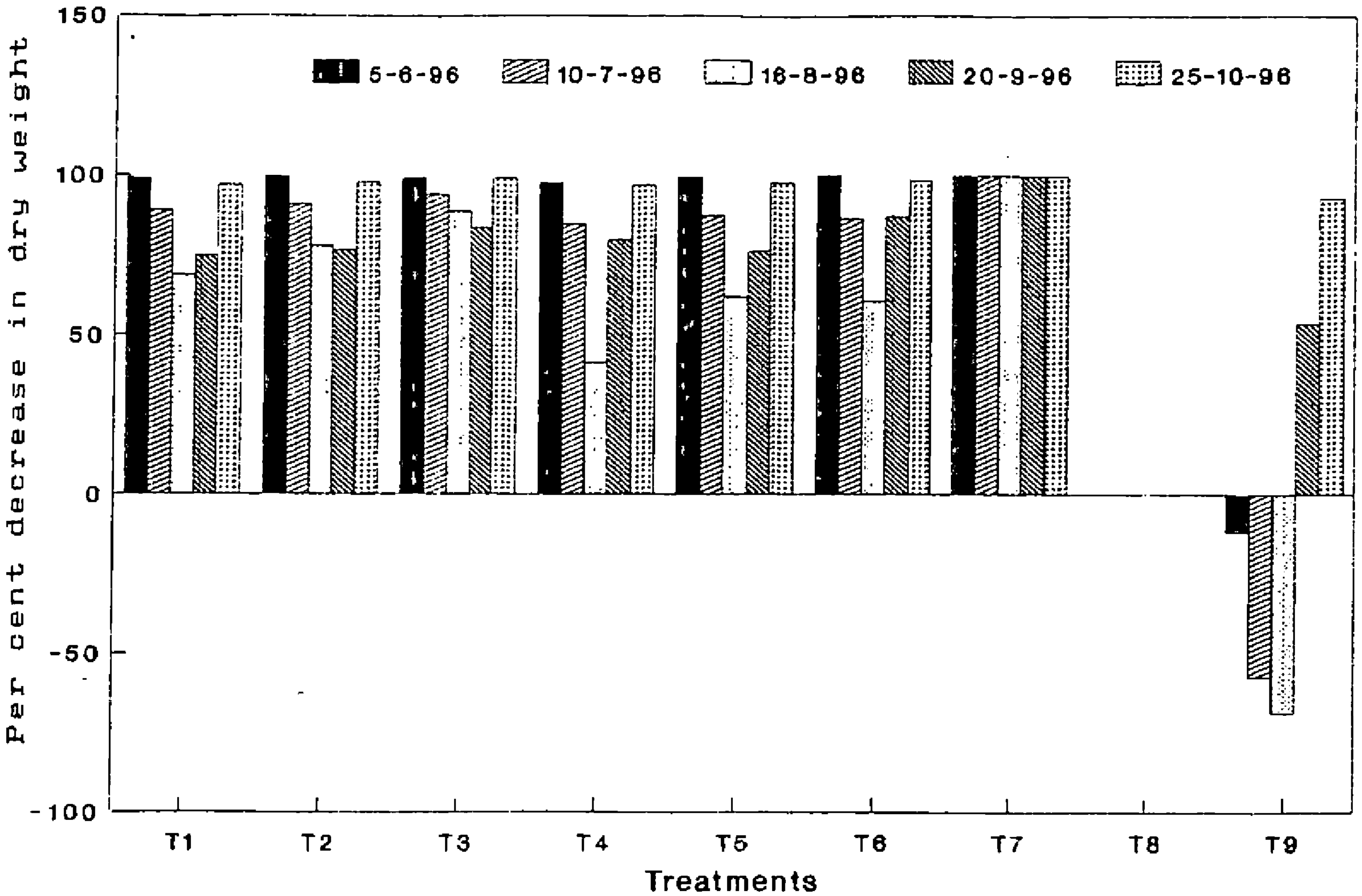

Fig.14.Per cent decrease in dry weight of weeds due to solarization treatments

Table 22. Influence of soil temperature on the soil moisture content at various depths[1]

	Moisture content at 5 cm depth		Moisture content at 10 cm depth		Moisture content at 15 cm depth	
	Correlation coefficient	Probability	Correlation coefficient	Probability	Correlation coefficient	Probability
Week 1	0.787	0.010	0.679	0.040	0.781	0.011
Week 2	0.785	0.010	0.773	0.012	0.820	0.005
Week 3	0.518	0.148	0.802	0.008	0.772	0.012
Week 4	-0.429	0.245	-0.330	0.383	0.059	0.881
Week 5	0.683	0.038	0.691	0.035	0.874	0.001
Week 6	0.828	0.005	0.797	0.008	0.850	0.003
Week 7	0.932	0.000	0.892	0.001	0.918	0.000

1 - See Appendices 6,7 and 8 for data.

the soil moisture contents at various depths are presented in table 22. It showed significant positive correlation on most of the days.

This positive correlation indicates that in all treatments having higher soil temperatures, the moisture content was also high. The negative correlation in the 4th week may be due to the rainfall that has occurred during that period. This increase in moisture content even with low soil temperatures was not because of the conservation of moisture, but because of the moisture received during the period through rainfall.

4.8 Weed control efficiency

The weed control efficiency (%) was calculated both with respect to the weed count and the dry weight of weeds. The values obtained are plotted as bar diagrams and are shown in figures 13 and 14. The weed control efficiency values were calculated with respect to the unweeded control.

The weed control efficiency (WCE) with respect to weed count and dry weight of weeds was highest with T3, 0.05 TP and 50 days (after weed free check). Among the solarized treatments, the WCE was lowest with T4 (0.05 TP and 30 days). In T9 (normal practice), the WCE became negative in some cases. However, the WCE ranged from 41.26 to 100 per cent during the observations in the solarized plots.

Summary

SUMMARY AND CONCLUSION

Soil solarization is a method of heating the surface soil by using plastic sheets like LDPE placed on moist soil to trap the solar radiation. This raises the soil temperature to levels lethal for many soil borne pathogens and weed seeds. It also conserves the moisture in the soil.

An attempt is made here to study the effect of solarization on moisture conservation and weed control. The field experiment was conducted at the Instructional farm at K.C.A.E.T., Tavanur during the summer of 1996. Two thicknesses of transparent polyethylene (0.05 mm and 0.10 mm) and 3 durations (30 days, 40 days and 50 days) were used for the study. The effect of thickness of polyethylene on soil temperature and moisture conservation was also studied. Bhindi crop was sown in the plots after the solarization period. The performance and yield of the crop was also noted. The important findings are summarized below.

The average maximum soil temperature at 5 cm depth, obtained in the non-solarized plots was 49.5°C only, but in the solarized plots it went upto 56.5°C which was higher by 7.0°C. The magnitude of rise in soil temperature of solarized treatments ranged from 4.9 to 10.8°C and 4.3 to 9.8°C due to 0.05 TP and 0.1 TP respectively, over non-solarized treatments. There was no significant difference between the effects of the two types (0.10 mm and 0.05 mm) of polyethylene.

The intensity of solar radiation reaching the soil surface was significantly different in the solarized and the non-solarized plots, but there was no significant effect for the thickness of polyethylene.

There was significant increase in the moisture content values in the solarized plots compared with the non solarized plots at 5, 10 and 15 cm below the soil surface. The general trend observed in the solarized plots was that the moisture content at the 10 cm depth was lower than those at 5 and 15 cm depths. This increase in moisture contents at the 5 cm depth in the solarized plots is achieved by preventing the loss due to evaporation. The trend in the non-solarized plots were the same as in the ordinary soil profiles. In most cases the moisture content values in the 0.05 TP were slightly higher than in the 0.1 TP solarized plots, but was not significant. In the solarized treatments there was 37.9, 33.7 and 38.3 per cent increase in the moisture content values in the 5, 10 and 15 cm depths respectively.

Solarization had significant effects in lowering the weed count as well as the dry weight of the weeds for around 5 months after the period of solarization. Maximum weed control was attained with 0.05 TP and 50 days duration. In general, the weed count and dry weight of weeds decreased with increase in the duration of solarization and decrease in thickness of polyethylene, but was significant only in few cases.

There was significant difference in yield of bhindi between the solarized and the non-solarized treatments. The thickness of polyethylene and the duration of solarization had significant effects on the yield. This increase in yield of bhindi due to the effective solarization treatments can be attributed to the drastic reduction in weed count and dry weight on account of solarization.

The present study suggests solarization as a measure for moisture conservation during the peak summer and as a very effective method for weed control.

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Appendices

Appendix I

Rainfall received during the solarization period

Date	Rainfall(cm)
28-3-96	6.20
07-4-96	4.90
10-4-96	0.60
17-4-96	0.90
18-4-96	0.60

Appendix II

Specifications of multi-stem thermometer

Measurement range	:	-50 c to 150°C
Accuracy	:	+ 2°C
Resolution	:	1
Display size	:	41x15mm
Sensing probe	:	stainless steel
Sensing probe length	:	105 mm
Probe cord length	:	800 mm
Battery	:	1x1.5V, size 'AAA'
Battery life	:	1 year approx.
Unit size	:	100(L)x64(W)x21MM(H)
Unit weight	:	87g

Appendix III

Weekly averages of soil temperatures for the solarization treatments

	Treatments	week 1	week 2	week 3	week 4	week 5	week 6[1]	week 7[2]
1.	TP(0.05mm) 30 days	54.59	53.34	52.84	50.39	53.07	44.30	42.46
2.	TP(0.05mm) 40 days	54.50	50.50	51.67	49.00	51.57	46.02	40.58
3.	TP(0.05mm) 50 days	55.09	52.50	50.84	48.81	51.00	45.09	48.77
4.	TP(0.10mm) 30 days	54.75	52.09	52.00	49.41	51.90	41.88	41.73
5.	TP(0.10mm) 40 days	53.84	51.59	52.67	49.53	50.77	45.72	41.49
6.	TP(0.10mm) 50 days	54.34	51.92	52.50	49.26	52.43	45.07	45.24
7.	Weed free check	48.25	46.17	46.17	42.80	45.13	38.18	38.49
8.	Unweeded control	48.00	45.67	46.42	42.59	45.03	37.97	38.68
9.	Normal practice	48.00	46.25	46.59	43.23	45.37	38.08	38.34

1 - Polyethylene removed from T1 and T4
2 - Polyethylene removed from T2 and T5 also.

Appendix IV

Weekly averages of solar radiation intensity (watts per square metre) above the sheet surface

	Treatments	week 1	week 2	week 3	week 4	week 5	week 6[1]	week 7[2]
1.	TP(0.05mm) 30 days	703.0	589.0	518.0	597.0	607.0	583.3	620.3
2.	TP(0.05mm) 40 days	723.0	593.5	564.5	583.3	625.0	608.0	593.7
3.	TP(0.05mm) 50 days	704.5	587.0	537.0	593.3	626.0	601.7	630.7
4.	TP(0.10mm) 30 days	699.0	584.0	543.0	582.0	607.0	593.3	609.7
5.	TP(0.10mm) 40 days	672.0	580.0	547.0	587.0	618.0	605.7	610.3
6.	TP(0.10mm) 50 days	707.0	550.0	482.5	585.3	638.0	606.7	621.3
7.	Weed free check	713.5	523.4	505.5	568.0	597.0	598.3	584.3
8.	Unweeded control	710.5	530.0	515.5	569.0	595.0	577.3	593.0
9.	Normal practice	706.5	546.5	512.0	571.7	600.0	581.3	605.0

1 - Polyethylene removed from T1 and T4

2 - Polyethylene removed from T2 and T5 also.

Appendix V

Weekly averages of solar radiation intensity (watts per square metre) below the sheet surface

	Treatments	week 1	week 2	week 3	week 4	week 5	week 6[1]	week 7[2]
1.	TP(0.05mm) 30 days	584.4	494.5	463.0	493.7	501.7	583.3	620.3
2.	TP(0.05mm) 40 days	561.0	456.5	458.5	493.3	522.0	361.3	593.7
3.	TP(0.05mm) 50 days	553.5	506.5	446.5	507.3	530.0	361.0	531.7
4.	TP(0.10mm) 30 days	567.0	466.0	447.5	497.3	515.0	593.3	609.7
5.	TP(0.10mm) 40 days	550.0	448.0	444.0	488.0	507.0	377.7	610.3
6.	TP(0.10mm) 50 days	566.5	474.5	401.0	482.7	524.0	355.0	510.0
7.	Weed free check	713.5	523.5	505.5	568.0	597.0	598.3	584.3
8.	Unweeded control	710.5	530.0	515.5	569.0	595.0	577.3	593.0
9.	Normal practice	706.5	546.5	512.0	571.7	600.0	581.3	605.0

1 - Polyethylene removed from T1 and T4

2 - Polyethylene removed from T2 and T5 also.

Appendix VI

Weekly averages of soil moisture content at 5 cm depth for the solarization treatments

	Treatments	week 1	week 2	week 3	week 4	week 5	week 6[1]	week 7[2]
1.	TP(0.05mm) 30 days	9.94	7.46	10.99	13.97	16.15	14.75	16.91
2.	TP(0.05mm) 40 days	11.83	10.97	14.32	15.73	14.73	16.46	15.75
3.	TP(0.05mm) 50 days	8.08	11.25	12.84	18.69	16.64	18.07	18.39
4.	TP(0.10mm) 30 days	6.92	8.28	13.33	21.68	16.04	17.05	13.84
5.	TP(0.10mm) 40 days	5.61	9.40	13.68	15.64	13.49	18.24	14.98
6.	TP(0.10mm) 50 days	10.26	10.71	11.78	12.74	15.09	17.71	19.62
7.	Weed free check	4.16	5.17	9.44	15.78	12.43	13.67	13.69
8.	Unweeded control	4.39	3.37	10.19	17.85	12.52	13.59	13.41
9.	Normal practice	4.44	4.36	9.81	13.58	12.06	12.69	13.05

1 - Polyethylene removed from T1 and T4

2 - Polyethylene removed from T2 and T5 also.

Appendix VII

Weekly averages of soil moisture content at 10 cm depth for the solarization treatments

	Treatments	week 1	week 2	week 3	week 4	week 5	week 6[1]	week 7[2]
1.	TP(0.05mm) 30 days	6.94	7.04	15.53	13.98	15.96	15.91	18.31
2.	TP(0.05mm) 40 days	11.35	10.66	14.32	15.39	14.33	20.10	14.50
3.	TP(0.05mm) 50 days	8.05	11.78	14.32	16.56	19.15	18.02	19.48
4.	TP(0.10mm) 30 days	7.63	8.09	12.23	16.33	15.77	18.09	14.47
5.	TP(0.10mm) 40 days	6.06	9.20	14.10	13.24	15.97	17.44	15.81
6.	TP(0.10mm) 50 days	8.66	10.14	12.36	16.92	16.13	16.58	18.66
7.	Weed free check	4.22	3.87	10.24	15.68	13.21	13.69	14.40
8.	Unweeded control	6.09	5.32	11.75	16.52	13.79	15.39	14.84
9.	Normal practice	5.79	4.76	9.37	15.86	13.06	13.54	14.12

1 - Polyethylene removed from T1 and T4

2 - Polyethylene removed from T2 and T5 also.

Appendix VIII

Weekly averages of soil moisture content at 15 cm depth for the solarization treatments

	Treatments	week 1	week 2	week 3	week 4	week 5	week6[1]	week7[2]
1.	TP(0.05mm) 30 days	9.65	7.93	14.26	14.79	16.15	16.13	18.68
2.	TP(0.05mm) 40 days	11.41	10.97	13.97	15.74	15.11	19.46	15.18
3.	TP(0.05mm) 50 days	8.04	11.24	14.50	18.58	18.26	19.65	24.38
4.	TP(0.10mm) 30 days	8.48	8.80	12.74	11.34	15.35	17.29	16.43
5.	TP(0.10mm) 40 days	6.77	9.78	13.02	12.27	14.55	19.43	15.75
6.	TP(0.10mm) 50 days	10.18	11.07	16.75	15.16	15.48	16.98	19.06
7.	Weed free check	5.17	6.72	11.01	19.91	15.60	15.63	13.22
8.	Unweeded control	5.99	5.44	13.01	16.86	13.67	15.45	14.19
9.	Normal practice	6.06	5.40	13.88	13.44	13.38	15.20	12.74

1 - Polyethylene removed from T1 and T4

2 - Polyethylene removed from T2 and T5 also.

EFFECT OF SOIL SOLARIZATION USING LDPE-MULCH ON MOISTURE CONSERVATION AND SOIL TEMPERATURE VARIATION

By

ANU VARUGHESE

ABSTRACT OF THE THESIS

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Conservation Engineering
KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
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ABSTRACT

Soil solarization is based on mulching the soil surface with transparent polyethylene sheets which capture the solar radiation and thus heat the soil to a level lethal for various pests. Solarization is useful in the control of weeds and also helps in moisture conservation. To some extent this can satisfy the demand of water for pre sowing irrigation during the summer months by conserving the moisture in the soil. In the experiment two types of polyethylene sheets (0.10 mm and 0.05 mm) were used and three durations of solarization, i.e., 30 days, 40 days and 50 days were tried. A crop (bhindi) was sown in the area after the solarization period to know the effect of solarization on its performance.

The average maximum soil temperature at 5 cm depth obtained in the non-solarized plots was 49.5°C only, but in solarized plots it went upto 56.5°C. The magnitude of rise in soil temperature of solarized treatments was higher due to 0.05 TP than 0.10 TP. The intensity of solar radiation reaching the soil surface was significantly higher in the non-solarized plots than in the solarized plots. There was significant increase in the moisture content values in the solarized plots compared to the non solarized plots at 5, 10 and 15 cm depth below the soil surface. The moisture content values in 0.05 TP solarized plots were slightly higher than

in 0.10 TP solarized plots, but was not significant. In the solarized treatments, there was 37.9, 33.7 and 38.3 per cent increase in the moisture content values at 5, 10 and 15 cm depths respectively. Solarization also had significant effect in lowering the weed count as well as the dry weight of the weeds for around 5 months after the period of solarization. The yield of bhindi was significantly higher in the solarized treatments than in the non-solarized treatments. This increase in the yield of bhindi may be due to the drastic reduction in weed count and dry weight on account of solarization.