STUDIES ON MICROCLIMATE OF SUMMER GROUNDNUT (*Arachis hypogaea* L.) UNDER DIFFERENT IRRIGATION SCHEDULES AND MULCHES

by

BHARAT BANSIDHARRAO JADHAV
Univ. En. No. 98230

A thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI, 413 722 DIST. - AHMEDNAGAR.
MAHARASHTRA, (INDIA)

in partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL METEOROLOGY

DEPARTMENT OF AGRICULTURAL METEOROLOGY
MAHATMA PHULE KRISHI VIDYAPEETH
COLLEGE OF AGRICULTURE,PUNE 411 005
MAHARASHTRA

2000

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** DEDICATION * *

This research manuscript is

affectionately dedicated to my Late grandfather

and my beloved Aai and Baba

--- Bharat

CANDIDATE'S DECLARATION

I hereby declare that this thesis or a part there of has not been submitted by me or any other person to any other universities or institute for a degree or diploma.

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CERTIFICATE

This is to certify that the thesis entitled "**Studies on microclimate of summer groundnut (*Arachis hypogaea* (L.)) under different irrigation schedules and mulches**" submitted to Mahatma Phule Agricultural University, Rahuri, for the award of the degree of **master of science (Agriculture) in AGRICULTURAL METEOROLOGY** is a record of bonafide research work carried out by **Shri. Bharat B. Jadhav**, under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help sent during the course of this investigation has been fully acknowledged.

Place : Pune
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CERTIFICATE

This is to certify that the thesis entitled, "**Studies on microclimate of summer groundnut (*Arachis hypogaea* L.) under different irrigation schedules and mulches**", submitted to the faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Ahmednagar (Maharashtra) in partial fulfilment of the requirements for the degree of master of science (Agriculture) in AGRICULTURAL METEOROLOGY, embodies the results of a piece of bonafide research work caried out by **Shri Bharat B. Jadhav,** and under the guidance and supervision of **Dr. A. S. Jadhav**, Professor of Agronomy and Associate Dean and Principal, College of Agriculture, Pune -5 and that no part of the thesis has been submitted for any other degree or diploma or publication in any other form.

Place : Pune
Date: 30/ 01/ 2001

(A. S. Jadhav)

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Place: Pune (B.B. Jadhav)

Date : Jan. 24, 2001

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LIST OF PLATES

LIST OF ABBREVIATIONS

@	: at the rate of
BSH	: Bright sunshine hour
Blue	: 425-490 nm
$^{\circ}C$	: Degree Celcius
cms^{-1}	: Centimeter per second
CPE	: Cumulative pan evaporation
DAS	: Days after sowing
EC	: Electrical Conductivity
ET	: Evapotranspiration
Epan	: Pan evaporation
et al.	: and others
Fig.	: Figure
FC	: Field capacity
gm	: gram (s)
Green	: 490-560 nm
ha	: hectare(s)
i.e.	: that is
kg	: Kilogram(s)
LAI	: Leaf area index
mg	: Milligram(s)
mm	: Millimetre
ms^{-1}	: Metre per second
Mha	: Million hectare
$\mu gcm^{-2} s^{-1}$	: Micro gram per centimetre per second
μ	: micron
nm	: nanometer
no.	: number
NIR	: Near infrared (750-850 nm)
%	: Percentage
PAR	: Photosynthetically Active Radiation
$q\ ha^{-1}$	: Quintal per hectare

LIST OF ABBREVATIONS (Cond..)

Red	:	640-740 nm
RH-I	:	Relative humidity at 07.30 h
RH-II	:	Relative humidity at 14.30 h
scm^{-1}	:	Second per centimetre
t	:	tonne(s)
Tc	:	Canopy temeperature
ΔTc	:	Canopy-air temeperature differential
Tmax	:	Maximum temperature
Tmin	:	Manimum temperature
viz.	:	Valedictory (namely)
WUE	:	Water use efficiency

ABSTRACT

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"STUDIES ON MICROCLIMATE OF SUMMER GROUNDNUT (*Arachis hypogaea* (L.)) UNDER DIFFERENT IRRIGATION SCHEDULES AND MULCHES"

By
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A candidate for the degree
of
MASTER OF SCIENCE (AGRICULTURE)
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Post Graduate Institute
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2000

Research Guide : **Dr. A. S. Jadhav**
Department : **Agricultural Meteorology**

The field investigation entitled "Studies on microclimate of summer groundnut (*Arachis hypogaea* (L.)) under different irrigation schedules and mulches" was carried out during summer season of the year 2000. The experiment was laid out in split plot design with 3 replications. The main plot treatments comprised of 4 irrigation schedules *viz.*, 75, 100, 125 mm CPE and irrigation at 10 days interval and sub plots treatments comprised of 3 mulches *viz.*, no mulch, straw mulch and polythene mulch. The gross plot and net plot size was 6.00 m x 4.80 m and 5.10 m x 4.20 m, respectively. The crop was dibbled on February 2, 2000.

The micrometeorological observations were recorded on soil moisture, soil temperature, canopy temperature, spectral characteristics, stomatal conductance, resistance and transpiration of summer groundnut. The

observations were recorded just before the schedule of irrigation and 48 h after irrigation. The diurnal pattern of stomatal conductance and transpiration was recorded at the initiation of branching, 50% flowering , pod development and at harvest stage. The biometric observations were recorded from 28 days onwards at an interval of 14 days.

The seasonal soil temperature, canopy temperature and canopy–air temperature differential values were comparatively more under schedule of irrigation at 125 mm CPE followed by irrigation scheduled at 100 mm CPE . However, transpiration rate was decreased with increase in CPE values (irrigation interval), whereas, stomatal resistance showed reverse trend.

The reflectance in blue, green, red and near infrared waveband was significantly lower under irrigation scheduled at 75 mm CPE than 100 and 125 mm CPE, particularly during advanced crop growth phases indicating more absorption of energy.

In general, stomatal conductance and transpiration rate on the abaxial leaf surfaces exceeded that of adaxial leaf surfaces. Diurnal pattern of stomatal conductance and transpiration rate indicated that the values were low in the early morning and the maximum at about 12 h and decreased in the afternoon. These values were least under 125 mm CPE.

The important growth and yield contributing characters were significantly more under irrigation scheduled at 75 mm CPE and 10 days interval than 100 and 125 mm CPE. However, irrigation scheduled of 75 mm CPE and 100 mm CPE and 10 days interval found to be at par with each other, but significantly higher values of dry pod, creeper yields and harvest index as compared to scheduling of irrigation at 125 mm CPE. The number of irrigation turns under 75 and 100 mm CPE and that of 10 days interval were 9, 7 and 9, respectively. But no significant difference were noticed in pod and creeper yields in these irrigation schedules indicating that summer groundnut be irrigated at 100 mm CPE for economizing the water use.

The evapotranspiration values under different irrigation schedules ranged between 400.33 and 630.30 mm and water use efficiency between 3.02 and 4.13 $kgmm^{-1}ha^{-1}$.

The values of the seasonal soil temperature, canopy temperature and canopy–air temperature differential were comparatively more under polythene mulch than no mulch and straw mulch.

The stomatal conductance and transpiration rate of both abaxial and adaxial surfaces were more under polythene mulch than no mulch and straw mulch. However, reverse trend was observed for stomatal diffusive resistance.

The reflectance in blue, green, red and near infrared wavebands was significantly lower under polythene mulch than no mulch and straw mulch indicating absorption of more energy under polythene mulch.

The important growth and yield contributing characters were significantly more under polythene mulch followed by straw and no mulch resulting in significant increase in pod and creeper yields under polythene mulch followed by straw mulch and no mulch.

The total evapotranspiration under different mulches varied from 492.44 to 565.33 mm. The water use efficiency was the highest under polythene mulch (5.12 $kgmm^{-1}ha^{-1}$) followed by straw mulch and no mulch indicating that the water is most economically utilized under polythene mulch.

It would be therefore advisable to use polythene mulch with irrigation schedule of 100 mm CPE to summer groundnut for maximizing the pod yield and economizing water use.

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INTRODUCTION

1. INTRODUCTION

Groundnut (*Arachis hypogaea* (L.)) is widely grown crop. Groundnut is important component of mixed/intercropping and sequencial cropping of small farmers of dryland tropics. It is a cash crop. It is legume and enriches soil by fixing atmospheric nitrogen to the extent of 30 kg ha^{-1}.

The productivity of *Kharif* groundnut is 10.0 q ha^{-1} and that of summer groundnut is 15-20 q ha^{-1} at national level. In Maharashtra state during 1998-99, the area under *kharif* groundnut was 4077 '00' ha and productivity was 1164 kg ha^{-1} and that of summer groundnut was 1348 '00' ha and productivity was 1430 kg ha^{-1} (Anonymous, 1999). It means the productivity of summer groundnut was higher than the *kharif* groundnut.

Among various factors responsible for low productivity of groundnut in Maharashtra state, improper scheduling of irrigation is measure one. In order, to increase the groundnut yield, it is necessary to apply proper quantity of irrigation water at appropriate time. This can be achieved by proper scheduling of irrigation.

The approach viz.., irrigation based on critical growth stages of plant (Chauhan *et al.*,1970.) and irrigation based on soil moisture deficit (Singh and Dastane, 1971) have been extensively used for irrigation scheduling. Recently, the evaporative demand gained importance as the main factor in determining the water requirement of a crop. The concept of cumulative pan evaporation was therefore utilized for scheduling irrigation in present investigation.

Irrigation is responsible for modifying the microclimate. The status of water in plants, soil water potential, rooting density, and distribution as well as other plant charcterstics represent an integration of atmospheric demand. (Krammer, 1969) When relative water content decrease below 80%, groundnut crop showed adaptation of drought status by reducing stomatal conductance (Bhagasari, *et al.,* 1976). Diffusive resistance in the stressed plant was 30-35 scm $^{-1}$ while in the watered plants it varied from 0.5-2.5 scm^{-1}. Reduced photosynthesis due to drought stress in groundnut was attributes to stomatal closure (Bhagasari *et al.,*1976).

Leaf temperature is in principal, a good indicator of plant water stress, The measurement on individual leaf surface has some disadvantages as compare to other point measurement. Recent advances in infrared thermometry of obviate that disadvantages by offering possibilities of rapidly surveying large number of plants and integrating the plant temperature over entire field or characteristic section of the field. Accurate hand held infrared thermometer is used for measurement of canopy temperature. Tanner (1963), Monteith (1962), were among the first scientists who suggested the use of infrared thermometer for irrigation scheduling.

An ideal irrigation scheduling technique should be use the plant as the indicator of water stress since plant respond is both arial and soil environments (Throsell *et al.,*1987). Infrared thermometer is portable, has quick response time and high accuracy. It can also gives difference between temperature of that surface and air temperature direct by simply pressing the trigger.

Hatfield (1979), Idsol *et al.* (1981), Jackson *et al.* (1977) have pointed out that canopy- air temperature can be used as an indicator of crop water stress. Canopy and air temperature difference is directly related to the amount of water supplied to a crop. Crops with an adequate supply of water maintain canopy temperature below the air temperature. Those lacking in soil water supply express their canopy temperature above than the air temperature. A plant with adequate soil moisture transpire water profusely, keeping its leaves cooler than the surrounding air. When soil moisture is insufficient, plant is experiencing moisture stress, The leaves transpire less and become warmer. The infrared thermometer provides an unique means of measuring the degree of stress, directly in field. With these known stress factors, we can schedule the irrigations. Maintenance of the field at known level of stress helps to optimize the crop yields and reduce irrigation costs. Thus, the canopy temperature and canopy-air temperature differential can be a good indicator of soil moisture status.

Reflectance characteristics of agronomic crop are of major importance in energy exchange of surface. The canopy reflectance or albedo is defined as the ratio of solar radiation reflected from the canopy to the incident radiation in the same waveband. Photosynthetically active radiation (PAR) controls the potential rate of dry matter accumulation. The albedo of cropped surface is greater than the albedo of the bare soil, hence rapid increase in albedo is associated with period of rapid growth, i.e. increasing leaf area index (Kalma and Badham, 1972). Leaf area index (LAI) of 3.5 to 4.0 was found to provide the highest light use efficiency. The LAI beyond 4.0 was not linearly associated with higher pod yield. Attaining this optimum LAI of 4.0 in later stages of growth (Pod filling and pod development) than in early stages of growth gives better pod yield in groundnut. This particular behaviour of the groundnut crop has wider implications in breeding as well as crop management (Annonymous, 1995).

In plant, leaves functions as an optical organs and their spectral properties are attuned to environment in which they live. The efficiency of absorption of PAR partly determines the efficiency of photosynthesis of plant. The PAR is absorbed more efficiently than NIR and centering around 660 and 730 nm, determine the course of plant development (Lee and Patel, 1987).

Evapo-transpiration from vegetative surface is a complex process influenced by such meteorological factors as net radiation, humidity, wind speed and physiological factors such as leaf water potential and stomatal conductance of the plant. Therefore, in order to fully understand difference in crop growth and to develop production system for yield maximization, it is necessary to know the amount of transpiration from crop. Transpiration can be estimated from measurement of stomatal conductance and leaf area index (Wallance *et al.,*1990). Stomatal conductance has long been recognised as a key variable that influence leaf- gas exchange through regulation of water vapour and carbon di-oxide diffussion (Wallance *et al.,* 1990).

Application of surface mulches reduces water requirement of crops substaintially through the control of evaporation without reduction in yield (Bhan, 1976). Mulches acts as an insulating material for soil temperature, as well as evaporation. Many types of mulches have been used in agriculture such as farm waste, straw mulch, sugarcane trash, weeds, plastic mulch, polythene mulches etc. for reducing water requirement of crop. These mulches also modifies the microclimate.

Microclimate is the climate near the ground, that is, the climate in which plants and animals live. It differs from the macroclimate, which prevails above the first few metres over the ground. Primarily in the rate at which changes occurs with elevation and with time. Microclimate is modified by the different methods such as irrigation, fertilizer application, by slope and aspects, artificial heating of soil and by using mulches. Mulches or Mulching is the creation or application of any material to cover soil that constitutes a barrier to the transfer of heat or vapour (Rosenberg *et al.,* 1974).

A polythene (PE) film mulching technique was developed in the 1970's to accelerate initial growth, flowerings, fruit setting and to extend the growing period in Korea. The technique resulted in "white revolution" in groundnut production, when grain yield qaudrupted. For the national average productivity, the grain yield was only 410 $kgha^{-1}$ in 1960's, but it increased to 1900 kg ha^{-1} and the best groundnut growers produced 4000 kg ha^{-1} in 1991 by using polythene film mulching, and sowing high-yielding cultivars (Park, 1996).

Polythene mulch was introduced to China from Japan in the year 1978. At present area under PMG in china is 3,70,000 ha (10.2 per cent of the total area under groundnut).In India, use of plastic film mulch for groundnut is still at a conceptual stage. Transparent and black polythene sheets (50 micron) on groundnut in 1992 and 1993 in winter increased soil temperature by 6 -7 °C, and as the consequence 70% germination within two weeks after planting as against 22% in control. However, there was very little impact of this on yield as sheets were removed after obtaining 100% germination within three weeks (Subrahmaniyan *et al.,* 1999).

Taking a clue from the use of ultrathin (6-8 microns) polythene film mulch for revolutionizing groundnut yield in China, a research has been planed and undertaken on use of polythene film for groundnut. (Anonymous,1999a).

The film of 8-10 microns was tested in medium black cotton soil of Maharashtra involving a innovative groundnut farmer, Gunde from Kolhapur district (Anonymous, 1999a). Large scale field trials conducted for 2 consective summers by following the raised bed and furrow planting (ICRISAT method) resulted in 5.0 -7.0 tones of dry pod yield ha^{-1} as against 2.6 tones from normal planting as control. The net monetary return on a rupee spent was Rs. 2.26 within a span of 4 months. The reason for such a steady increase in yield have been attributed to (i) initial increase of soil temperature, (ii) better retention of soil moisture, (iii) increased efficiency of soil micro-organism, (iv) improved microclimate, (v) reduced crop weed competition and (vi) reduced incidence of sucking pests.

Over and above use of polythene film mulch has cut down water requirement of irrigated summer groundnut by about 40% and slowed down process of salinity build up by arresting soil evaporation (Anonymous,1998).

With this back ground in view, the present investigation was undertaken to know the microclimate of summer groundnut under different irrigation schedules and mulches with following objectives:

(1) To study the microclimate of summer groundnut under different irrigation schedule.

(2) To study the microclimate of summer groundnut under different mulches.

(3) To study the effect of irrigation schedule and mulches on yield and ET of summer groundnut.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The present investigation "Studies on microclimate of summer groundnut under different irrigation schedules and mulches" was carried out in the summer season of the year 2000. The literature reviewed is presented below under appropriate sub heads.

2.1 Irrigation:

Hukkeri and Panday (1977) reported that like grain legume, oilseeds are also efficient in water use and hence, requires less water for their growth. These crops are mostly grown as rainfed but their yield could be boosted substentially if grown under irrigated condition, especially in the arid and semi-arid areas on lighter type of soils.

2.1.1 Effect of soil moisture on growth of groundnut crop :

The scheduling of irrigation at 25 per cent deplection of ASM on loamy sand soil in rabi season increased number of flowers resulting in more yield (Lenka and Misra, 1973).

On vertisol soils of Parbhani, Birajdar (1973) observed that during the summer season the mean plant height, dry matter accumulation, number of nodules and number of developed pods per plant in groundnut var., SB-11 increased due to irrigation scheduled at 50, 75 and 100 mm CPE over those of 125 mm CPE. The maximum response per mm of water was recorded from irrigation scheduled after 75 mm CPE.

Kumthekar (1974) stated that the plant height, spread, number of branches per plant were increased with the increase in ASM from 25 per cent ASM to 0.7 water use factor.

Birajdar and Ingle (1974) on medium black soils during the summer season at Parbhani observed that the irrigation scheduled corresponding to 100 mm CPE (equivalent to 8 irrigations to groundnut) was optimum.

Khupse (1975) on clay loam soil of Parbhani during the summer season, observed the effect of irrigations at 50, 75, 100 and 125 mm CPE. He pointed out that the treatments, 50, 75 and 100 mm CPE were at par with each other and yielded significantly superior over 125 mm CPE.

Joshi (1978) observed that irrigation at 8 day's interval increase the growth characters namely height, spread and number of branches per plant.

Shinde (1980) did not observe any significant effect of irrigations on leaf area at Parbhani during summer season.

Nodulation of roots of groundnut was increased significantly with increasing in irrigation frequencies. Irrigation after every 13 days increased the number of nodules per plant twice (37nodules plant^{-1}) than that of 18 days irrigation frequency(18 nodules plant^{-1}). There was no significant variation in number of nodules per plant in the treatments of 18, 10 and 8 days interval of irrigations (Rasve *et. al.*, 1983).

In general, the plant height increased with increasing availability of soil moisture (Desai *et al.*, 1985).

Thanzuala (1987) at Parbhani recorded the maximum leaf area at 0.75 and 1.0 IW/CPE ratios as compared to 0.5 IW/CPE ratio.

The reduction in plant height was directly proportional to the quantity of stress imposed and the reduction was more drastic between ET/PE ratios of 0.6 and 0.2 (Madhusadhan Rao *et al.*, 1988).

Total dry matter accumulation plant^{-1} in terms of leaf, stem and pod DM plant^{-1} was found significantly superior for irrigation schedule at weekly interval, while other irrigation schedules remaine more or less at par. (Babalad and kulkarni 1988).

Rao and Bhatt,(1988) found that the percent dry matter distribution for vegetative growth was higher for irrigation treatment of continuous stress (ET/PE =0.6) while per cent dry matter distribution for reproductive growth was higher for irrigation treatment of ET/PE ratio 1.0.

Scheduling irrigation through successive increasing ratios of IW/CPE from 0.40 to 1.0 improved various growth parameters *viz.*, Plant height, branches plant^{-1}, leaf area index, nodules plant^{-1}, chlorophyll content and CGR significantly and consequently overall crop growth in terms of dry matter accumulation (Patel *et al.*,1995).

Irrigation schedule at IW/CPE ratio of 1.0 produced significantly higher plant height over irrigation schedule at IW/CPE ratios of 0.7 and 0.4 (41.9cm) and (42.1cm), respectively during summer season (Tiwari *et al.*,1997).

2.1.2. Effect of mulch on growth :

Sang *et al.* (1987), Hu Wenguang *et al.*(1995) and Duan Shufen *et al.* (1998) in China reported that the polythene mulch improves groundnut crop growth and nodulation development significantly. The dry root mass of groundnut was 12.23 to 128.7 % higher over control during the various phases of crop growth. The nitrogen fixing activate was 3.28 to 148.8 % higher over non mulched groundnut. Plant height at 3 leaves stages was 3.25 to 4.02 cm tall, which was 45.28 to 77.8 % taller over control. However, the difference in height reduced gradually. The chlorophyll content of the leaves was 1.30 $mg g^{-1}$ under polythene mulch while it was only 0.6 $mg\ g^{-1}$ under control. Groundnut under polythene mulch emerges, blooms, set pods and matures about 8 days earlier than no mulched groundnut.

Dayal (1989) in a trial with groundnut, mulching with 5t wheat straw ha^{-1} increased the number and weight of pods $plant^{-1}$ by 16 and 23%, respectively.

Dayal and Ghosh (1995) conducted a field experiment in Rabi-summer season of the year 1994 with six mulches, namely (i) wheat straw (WS) @ 5 tons ha^{-1}, (ii) white polythene (WP), (iii) Black polythene (BP), (iv) WP + WS, (v) BP + WS, and (vi) control (No mulch). Four duration of polythene mulch *viz.*, (i) up to germination, (ii) up to flowering, (iii) up to pod development and (iv) up to maturity were maintained. The significant findings were, early and the maximum germination (85%) recorded in the plot where BP + WS was applied. The flowering was began at 41, 35 and 42 days after sowing in wheat straw, polythene and control treatment, respectively.

In korea, Park Chang Hwan (1995) reported that emergence of groundnut in polythene film mulched plot was 11-15 days earlier than non mulched plot. Young seedling growth was accelerated by a factor of two to six and flowering by 17-18 days earlier.

Sandhu *et al.* (1996) conducted a field experiment on clay soil at Junagadh, India (1992-93 and 1993-94), revealed that mulching with wheat straw increase plant height, seed weight $plant^{-1}$, 1000 seed weight, nutrient uptake and water use efficiency of mustard. Residual effect of wheat straw mulch treatment increased plants height, filled pods $plant^{-1}$ and pods of succeeding groundnut crop (*Arachis hypogaea*).

2.1.3. Effect of soil moisture on yield :

Birajdar (1973) on vertisol soil of Parbhani during the summer season reported that the pod yield of groundnut increase from 13.87 qha^{-1} with irrigation scheduled after 125 mm CPE to 18.50 qha^{-1} with 75 mm CPE. The haulm yield increased progressively with the increasing frequency of irrigation.

Joshi (1978) found on medium black soil at Rahuri that the irrigation treatment of 8 days interval produced significantly higher yield of pods, creepers, kernels and oil per hectare than that of irrigation at 12 days interval.

At Akola, Dahatonde (1978) observed that the groundnut grown in summer gave the highest pod yield with irrigation scheduled at 75 mm CPE over 100, 125 and 150 mm CPE.

Shelke (1979) found that in summer groundnut at Parbhani, the dry pod yield increased significantly when the irrigations scheduled after 40 and 80 mm over 120 mm CPE. Higher consumptive use of water was recorded with lower CPE treatments (40 and 80 mm). However, The WUE was higher with irrigation scheduled after 80 mm fallowed by 120 mm and 40 mm CPE. Most of the yield contributing characters were favorably affected by the irrigation scheduled at 80 mm CPE.

Shelling percentage was improved significantly with increase in total amount of water applied up to 540 mm at 10 days irrigation interval while shelling percentage was at par at 8 and 13 days of irrigation levels. (Rasve *et al*,1983).

In groundnut, shelling percentage to an extent of 73.5 was reported by Desai *et al.* (1985) for irrigation levels of IW/CPE ratios of 0.70 and 0.90 which was significantly superior over IW/CPE ratios of 0.5.

Patil (1985) found that the irrigation treatment of 50 mm CPE level produced 13, 45 and 55 per cent more pod yield than that of 100 and 150 mm CPE and irrigation as per canal supply, respectively. However, 100 mm CPE level was optimum and gave the highest additional profit than rest of irrigation treatments.

In general, there is reduction in number of pods, test weight and shelling percentage with stress treatments beyond 0.6 IW/CPE ratio (Madhusudhan Rao *et al*,1988).

Jadhav *et al.*(1989) obeserved that the dry pod yield increased significantly with 1.0 IW/CPE ratio (80 mm CPE) and irrigation applied at 10 days interval as compared to scheduling of irrigation at 0.6 IW/CPE ratio. Further, it was noticed that irrigation schedule at 1.0 IW/CPE ratio also gave significantly more dry pod yield over 0.8 IW/CPE ratio (100 mm CPE).

Total number of pods and two seed filled pods were maximum in treatment of irrigation scheduled at 50 per cent DASM and 75 mm CPE and one seed filled pods were also significantly higher due to this treatment because of receiving more number of irrigation and providing moisture stress free condition to the crop (Pawar *et al.*, 1993).

Tiwari and Dhakar (1997) reported 61.64 per cent and 61.82 percent of shelling under IW/CPE ratio of 1.0 during summer season which was at par with IW/CPE ratio of 0.70 but significantly superior over IW/CPE ratio of 0.4 in both the seasons.

2.1.4. Effect of mulch on Yield :

Dayal (1989) in a trial with groundnut cv. Girnar 1 with 10 (recommended) or 7 irrigations, mulching with 5 t wheat straw ha^{-1} gave average pod yield of 2.22 tha^{-1} compared with 1.80 tha^{-1} without mulch. Mulch +10 irrigations gave the highest yield of 2.64 tha^{-1}.

Dayal *et al.* (1991) conducted an experiment consisting of 3 levels of mulch; (1)no mulch; (2) soil mulch; (3) wheat straw mulch. In wheat straw mulch, the number and weight of pods $plant^{-1}$ increased by 22.5 and 26.7%, respectively, which ultimately resulted in 23.4 % higher pod yield over soil mulch and no mulch.

Dayal and Ghosh (1995) conducted a field experiment in rabi – summer season of the year 1994 with six mulches namely (1) wheat straw (WS) @ 5 tha^{-1} (2) white polythene (WP), (3) Black polythene (BP), (4) WP + WS, (5) BP + WS and (6) control (no mulch). Four durations of polythene mulch *viz.*, (i) up to germination (ii) up to flowering (iii) up to pod development and (iv) up to maturity were maintained. The significant findings are combinations of wheat straw with black polythene recorded the maximum pod yield (18.04 qha^{-1}) which was 63% higher than the control. The superiority of the treatments with respect to pod yield was in the order of BP + WS >WP +WS > WS. Duration of polythene mulch also significantly affected pod yield. The maximum yield was recorded when polythene mulch was kept upto pod development stage (15.9 qha^{-1}). Retention of polythene mulch up to maturity of the crop caused reduction in pod yield.

Hu Wenguang *et al.* (1995) and Daun Shufen *et al.* (1998) reported that under China conditions because of the good vegetative growth under polythene film mulch groundnut, more reproductive buds differentiated and bloomed early. Total 16.8 more number of flowers and 64.2 more effective flowers per plant than non mulched groundnut were reported. The increase in well filled pods over non mulched groundnut was 21.15%. Results from 2,20,000ha of polythene film mulched groundnut in five provinces of China revealed that average 4.19 tha^{-1} yield was recorded due to polythene film mulching over control (2.14 tha^{-1}). On farm trials in 16 provinces shows that the pod yield under polythene film mulch groundnut was 3.75 to 4.5 t ha^{-1} with the maximum of 10.5 t ha^{-1}. These yields were 20 to 50% higher than those of non mulched groundnut. The result of 131 trials on polythene film mulching conducted on soil of varying levels of fertility revealed that the polythene mulched groundnut recorded significantly more pod yield.

Sandhu *et al.* (1996) conducted a field experiment on clayey soil at Junagadh, India (1992-93 and 1993-94), with a irrigation at 0.8 IW/CPE ratio and residual effect of wheat straw mulch treatments. They observed increase in filled pods $plant^{-1}$ and pod and haulm yields of suceeding groundnut crop.

A polythene film mulching technique (PMG) developed in the 1970'^s in Korea resulted in "White Revolution". The groundnut productivity increased four times i.e. from 410 $kgha^{-1}$ to 1900 $kgha^{-1}$ and the best groundnut growers produced 4000 $kgha^{-1}$ in the year 1991 (Park *et al.*, 1996).

In India, use of plastic film mulch for groundnut is still at a conceptual stage. The film of 8-10 micron was tested in medium black cotton soil of Maharashtra involving a innovative groundnut farmer shri Gunde and large field trials were conducted for 2 consecutive summer season by fallowing raised bed and furrows method of planting (ICRISAT method) resulted in 5.0

to7.0 tone dry pod yield ha^{-1} as against 2.6 tone from normal planting as control (Anonymous, 2000).

An experiment conducted at Digraj showed the maximum and significantly higher dry pod yield (4.1 tha^{-1}) under PMG as compared to NMG. (Annonymous, 1999a).

An experiment conducted at Dapoli and Thane conditions revealed that there was significant increase in the yield and quality of groundnut under PMG (Chavan, 1999 and Nalawade, 1999). The reasons for such a steady increase in yield have been attributed to (i) initial increase in soil temperature, (ii) better retention of soil moisture, (iii) increase efficiency of soil micro organisms (iv) improve micro climate (v) reduce crop weed competition, and (vi) reduce incidence of sucking pests.

Table: Pilot trial on polythene mulch groundnut (PMG) During Rabi-summer season of the year 1996-97 (pod yield $kgha^{-1}$) at progressive farmer's (Gunde) field.

Variety	Pod Yield ($kgha^{-1}$)	
	Fresh	Dry
ICGS-11	8400	7010
TAG – 24	6500	5400
TG-26	11390	9458
Control(without Mulch)	3180	2640

(Annonymous, 1999a)

2.1.5. Soil Temperature in Groundnut :

Soil temperature is an important factor and its effects are more critical on the germination of the seed, emergence of the seedling and early plant growth. When the temperature of the soil is below 18°C, emergence of seedling of groundnut is less (Mixon *et al.*, 1969). The embryo is killed at soil temperature above 54°C (Dickens and Khalsa, 1967).

Different genotypes respond differently to temperature. The rate of growth of the groundnut plant increases with the rise in temperature from 20°C to 30°C (Fortanier,1957 and De Beer, 1963). The optimum temperature for vegetative growth is between 27°C and 30°C depending on the cultivar. (Fortanier, 1957; Bolhuis and Groot, 1971 and De Beer 1963). The lower critical temperature for growth is 13.3°C (Mills, 1964).

Temperature has an important role in determining the rate of flowering (Nicholaides *et al.,* 1969). It is the major factor influencing the length of the period between initiation and opening of first flower. Reproductive growth is maximum between 24°C and 27°C, constant temperature above 33°C affects pollen viability (De Beer,1963), Temperature below 20°C affects flowering and the ratio of fertilized flower (Chang,1974).

The rate of peg initiation increased when temperature rise from 19°C to 23°C (Williams *et al.*, 1975). Soil temperature influence not only on pod growth rate but also the duration of growth. The maximum rate of growth of pods is between the range of temperature of 30°C and 34°C (Dreyer, 1980). They observed smaller kernels at higher temperatures. Temperature, therefore, greatly influences not only the growth duration but also the growth pattern of the plant.

2.1.6. Effect of mulch on soil temperature :

Hanks *et al.* (1961) used the wheat straw mulch at the rate of 4 tone $acre^{-1}$ and found that the average soil temperature at all the depths were lower for mulched soil than bare soil. They also compared between wheat straw and clear plastic mulch and observed the temperature differences of 19°F at 1cm, 15°F at 4 cm, 11°F at 16 cm and 6°F at 15 cm depth. Thus there was decrease in the differences of temperature with increase in depth.

Hank *et al.* (1961) used different types of mulches including straw mulch and reported that evaporation losses were more in the unmulched plots than mulched plots.

Burrows and Larson, (1962) used the straw mulch at the rate of 8 tone acre^{-1} and found that the average soil temperature under mulch was lower than bare soil, because less heat energy reaches the soil due to greater reflection of solar radiation. The difference between mulched and unmulched soil temperature was the greatest at the maximum temperature, least at the minimum temperature and intermediate at 24 h average temperature.

Adams, (1965) studied the effect of straw mulch (2 inch thick) and found that soil temperature was lower under straw mulched soil. Wiegand *et al.,* (1968) reported that the mean daily maximum and minimum soil temperatures at 10 cm depth were both in order of sand mulch, bare soil, cotton, tur mulch, bermuda grass sod. Simillar types of results were obtained by Brengle and Whitfield (1969). Soil temperatures were lower by 0.5 - 0.6°C on an average under straw mulch used at the rate of 5,040 kgha^{-1} than mulched plot. (Unger, 1978).

Sowers and Wetterlen (1988) observed that mean soil temperatures at 1600 hrs during June-July under straw mulch and bare soil are as follows

Table : Soil temperatures under straw mulch and fallow from June-August at Madison ,U.S.A.

Month	1984 Bare (°C)	1984 Straw (°C)	1985 Bare (°C)	1985 Straw (°C)
June	33.9	27.7	32.9	24.7
July	33.2	29.0	32.8	26.8
August	33.9	28.3	32.0	27.6

Brar and Khera (1988) used straw mulch at two rates of 6 tone ha^{-1} and 12 ton ha^{-1} and reported that the soil temperatures were lower under both the mulches at 2.30 p.m. But higher than Bare soil by 1.0 - 2.9°C in the morning at 8:30 am.

Devi Dayal (1991) pointed out that the rabi - summer groundnut crop is affected by lower soil temperature during the initial growth phases whereas higher temperature affect pod filling during pod development phase. Experiment conducted during two rabi-summer seasons indicated that wheat straw mulch at the rate of 5 tha^{-1}, can overcome the temperature fluctuations during the various phases of groundnut crop. An experiment consisted of 3 levels of mulch : (1) no mulch, (2) soil mulch, (3) wheat straw mulch. The pooled results indicated that the soil temperatures were raised by 2 - 3°C during seedling emergence and early vegetative growth in the wheat mulch treatment. This resulted in earlier flowering (by 5 days) in the mulch-treated crop. During the pod development phase, however, the soil temperatures were found low by 3 - 5°C in the wheat straw mulched plot.

PMG (Polythene mulching in groundnut) increased soil temperature, increase in the temperature is usually higher into 5 cm layer. Higher total accumulated temperature under PMG shortens the crop period and increase the pod yield. Moreover, during hot season PMG protect the soil from direct heating and optimize temperature from middle growing phase of groundnut (Hu Waneguag, 1995).

Studies conducted in Korea by Park (1996) revealed that soil surface temperature under PMG were 2.8 to 9.4°C higher at 10 a.m.and 0.4 to 7.3 °C higher at 14 p.m. as compared to non mulched groundnut (NMG).

An experiment conducted at ICRISAT - Asia centre (AP) releaved that PMG increased the soil temperatures at 13 hr by 0.7 to 3 °C (Annonymous.1999a).

Changes in soil temperature, moisture under PMG and NMG during late growing phases of groundnut is shown below in tabulation form

Factor	Trea-	Time (Hours)							
	Ment	0600	0800	1000	1200	1400	1600	1800	2000
Temp	PMG	25.5	22.3	25.5	25.5	26.5	23.9	22.0	19.2
(°C)	NMG	17.0	22.0	24.2	25.0	25.4	24.2	22.2	20.0
Moist-	PMG	19	82	72	68	71	89	77	84
ure(%)	NMG	93	83	75	74	72	92	92	94

Source : Liaoning Agricultural Bureau, China (1981).

2.1.7. Transpiration rate in groundnut crop :

Porometer Technique :

Azam-Ali (1983) in the experiment on millet crop measured stomatal resistance using a porometer. He stated that the changes in the mean measured rates of transpiration were strongly correlated with the change of green leaf area during the growing season of the crop.

Vos (1986) studied water relations and stomatal conductance during transient water stress of potato cultivars using a LI-COR 1600 steady state porometer. The relative stomatal conductance of stress treatments declined rapidly when soil water became limiting.

Wallace *et al.*(1990) measured the stomatal conductance of the leaves and panicles of a sparse dryland millet crop using diffusion porometer and infra-red gas analyser, respectively. Leaf conductance were found to be high upto 1.2 cms^{-1}. These data were combined with the leaf area index to calculate canopy conductance.

Rao and Bhatt (1991) imposed moisture stress in four tomato cultivars by with holding water for 8 days stomatal conductance and transpiration were measured with a LI-COR 1600 steady state porometer in both irrigated and water stressed plants during 10.30 to 12.00 a.m. Stomatal conductance was significantly higher in irrigated plants than in water stressed plants.

2.1.8. Effect of various parameters on stomatal conductance, Resistance and Transpiration :

Stomatal conductance, resistance and transpiration as effected by soil moisture avalibility:

Pallas (1973) measured transpiration of soil grown, growth- chamber culture cotton (*Gossypium hirsutum* L.), soybean (*Gossipum max* merr.) and bermuda grass (*Cynodon dactylon* L.) plant during 14 h photoperiods; a diurnal trends in transpiration was evidanced by the dicots. The sinusoidal nature of the curves suggest endogenous rhythmic changes in diffusive resistance and / or biochemical activities.

Bodlaender *et al.* (1986) studied the effect of drought on potato and concluded that water shortage diminished transpiration. Similarly, Vos (1986) who also worked on the water relations of potato agreed that relative stomatal conductance of stressed treatment was rapid when soil moisture was limiting.

Yera *et al.,* (1986) measured stomatal conductance of normally oriented and inverted leaves of faba bean (*Vicia faba* L.) as light levels (PPFDs) were increased over uniform population of leaves of plants grown in an environmental chamber. Adaxial stomata of inverted leaves reached the maximum water vapour conductance at a life level of 60 µmoles $m^{-2}s^{-1}$, the same light level at which abaxial stomata of normally oriented leaves reached the maximum conductance. Abaxial stomata of inverted leaves reached the maximum water vapour conductance at light level of 500 µmoles $m^{-2}s^{-1}$, the same light level at which abaxial stomata of normally oriented leaves reached the maximum conductance. Regardless of whether leaves were normally oriented or inverted, when light levels were increased to values high enough that upper leaf surfaces reached the maximum conductance (about 500 µmoles$m^{-2}s^{-1}$), light levels incident on lower shaded leaf surface were just sufficient (about 60 µmoles $m^{-2}s^{-1}$) for stomata of those surfaces to reach the maximum conductance.

Xu et al., (1987) reported that the stomata of Ginseng leaves opened at 0530 h and closed at 2030 h but did not close at mid day.

Schoh *et al.* (1987) studied watering effects on the stomatal resistance and transpiration of eggplants in a green house and concluded that the stomatal resistances of both sides of the leaves were little higher for dry treatments than for the watered one.

Measurements of stomatal conductance of Oak canopy (*Quercus robur* L.) in the Netherlands by Dolman and van den Burg (1988) showed diurnal changes in conductance to be dependent on solar radiation and vapour pressure deficit. In general, stomatal conductance is low in the early morning, rises quickly to the maximum value and decrease in the afternoon.

Vurlev *et al.* (1988) using maize made investigations to describe changes in evapotranspiration on reduction of soil water content showing that evapotranspiration is not reduced as soil water content fall to a critical value (about 75-80 % of field capacity) but then reduced to zero.

Lu (1988) found that when the soil water potential in the root zone of wheat crop decreased, the stomatal resistance on the abaxial side of the leaves increased faster and to a greater extent than on the adaxial side.

Roa and Bhatt (1988) imposed water stress on bell paper (*Capsicum annum.* L.) grown in a controlled environment. Both transpiration rate and relative water content declined with slight changes in leaf water potential. Stomatal resistance increased with increasing water stress.

However, Rubino *et al.* (1989) in their experiment on tomato demostrated that transpiration rate and stomatal resistance were not sensitive to the changes in soil water content. When the soil water of the rooting layer varied between field capacity and the wilting point, the abaxial stomatal resistance values during the hottest part of the day fluctuated around 1.5 scm^{-1}, stomatal resistance was greater at soil water contents below wilting point.

In a study involving potato cultivars reaction of water deficit, Sukumaran *et al.* (1989) showed a reduction of 61 - 86% of stomatal conductance in the leaves of the stressed plants.

The results of an experiment on wheat conducted by Lu (1989) indicated that adaxial and abaxial stomatal apartures have different sensitivities of water stress. Resistance of abaxial stomata increased substaintially with decreasing soil water content. The increase of stomatal resistance was large on the abaxial surface than that on the adaxial surface under stress conditions.

Measurements of net radiation and wind speed at two heights of canopy and the canopy conductance were used by Bell and Ma (1990) to determine factors driving transpiration in both rainfed and irrigated soybean crops. It was found that if wind speed less than 2 ms^{-1}, the rate of transpiration determined predominantly by net radiation with little variation caused by differing canopy conductance.

Bhatnagar and Kundu (1990) studied evapotranspiration demand of wheat (*Triticum aestivum.* L.), barley (*Hardeum vulgare.* L.), lentil (*Lens culicaries* Medikus) and pea (*Pisum sativum.* L.) using Neutron soil moisture probe. The water use efficiencies of the four crops ranged between 3.25 – 8.10 $kgha^{-1}$ mm, being the highest for wheat and the lowest for pea.

Whitfield (1990) investigated changes in evaporation rates in both an irrigated and rainfed wheat crop on a diurnal and daily basis by making measurement during the growth phases between ear emergence and physiological maturity. Canopy conductance decreased rapidly in rainfed treatments during grain filling phases and its mid-day values became progressively smaller than the mornings values as stress progressed. Evaporation was adversely affected by the increase in evaporative demand during the day.

Subramanian and Maheshwari (1990) subjected potted groundnut plants to stress at the flowering stage. Leaf water potential and transpiration rate decreased progressively with increasing duration of water stress, indicating that plants under mild stress were postponing tissue dehydration stomatal conductance decreased almost steadily during the stress period indicating that stomatal conductance was more sensitive than the water loss during the initial stress period. Results suggested that plants adapt to water stress by slowing down tissue dehydration.

Deng (1991) reported that the leaf water potential of rice, maize and groundnut was the highest at dawn, decreased rapidly during the morning to the minimum at 1300-1400 h and then increased slowly until the highest level was again reached at dawn.

Kumar and Tripathi (1991) conducted a field trial on wheat growing without irrigation as well as providing five irrigations each of 6 cm in addition to the rainfall. Rainfed wheat had consistently lower leaf water potential and transpiration rate than irrigated wheat. The differences increased as drought intensified, the maximum difference occurred at 1400 h and the value was 9 bar and 7.6 $\mu gcm^{-2}s^{-1}$ for leaf water potential and transpiration rate, respectively.

Laker *et al.*(1991) studied effects of soil water stress on stomatal diffusion conductance and leaf water potential in maize. On sufficiently watered plots; during the early morning and mid-day stomatal conductance correlated with early morning temperature, photosynthesis photon flux density (PPFD) and vapour saturation deficits. In stressed plots, stomatal conductance did not respond to environmental conditions and was probably determined by soil root conductane. During the early morning, leaf water potential for unstressed plots was always higher than in the stressed plots. Late afternoon stomatal conductance was low and did not differ between unstressed and stressed plots. The afternoon reductions in stomatal conductance facilitated recovery in leaf water status which is beneficial to the plants.

Bishnoi *et al.* (1994) showed differences in the behaviour of pre-down leaf water potential, stomatal resistance and transpiration rate with soil moisture availibility in wheat crop.

Scarlet (1996) showed that stomatal diffusive resistance comparatively higher resistance on the adaxial than on the abaxial leaf surface, and it was noticed that the diurnal pattern of the resistance on both the leaf surface were higher at 0600h, declined towards noon and again increased at 1800h. They also showed that the transpiration rates remains comparatively higher on abaxial leaf surface except at 0600 h. The canopy conductance showed a decreasing trend with the increase in the CPE values during all the three crop growth stages with the exception of 30 mm CPE irrigation schedule during the fruiting stage in brinjal.

2.1.9. Canopy temperature and canopy minus air temperature differential :

Blad and Rosenberg (1976) found that alfalfa was 5-7°C cooler than air during mid and late afternoon. On the other hand irrigated corn was always warmer than alfalfa and usually warmer than air.

Frank *et al.* (1977) observed that the canopy temperatures were consistantly higher for the dry land as compared with irrigated treatments. Under dryland, seasonal average temperatures showed that sheltered treatments were significantly warmer than exposed treatments by an average of 1.6°C. In irrigated treatments exposed canopy was warmer than shaded.

Sandhu and Harton (1978) carried out an experiment on oat. They found that the difference between stressed and non stressed canopy temperatures ranged from 3.5 to 4.5°C.

Soil water stress if severe, partial closure of the stomates occur which causes a repartitioning of incident energy, offen resulting in increased temperature. The effect of soil water stress on air temperature with a soybean canopy was studied by Reicosky *et al.*, (1980) and the increased air temperature related to decreased ET and plants water stress. The data showed that as soil water stress became more severe, canopy air temperature with non-irrigated soybeans increased above those within the irrigated soybean canopy. The above canopy minus within canopy temperature difference between the irrigated and non irrigated plots increased during peak radiation with little difference at night. When the plants wilt symptoms indicated severe stress, ET decreased 40-47% canopy air temperature increase.

Jackson (1981) affirmed canopy minus air temperature difference (Tc-Ta) of 5 °C as the upper limit for wheat crop for irrigation. In different treatments they found 2 to 9°C temperature difference.

Gardner *et al.* (1981a) showed that the average mid day difference in canopy temperature between stressed and non stressed areas was as large as 7°C. In fully irrigated plots, the standard deviation of mid-day canopy temperature was about 0.3 °C but in non-irrigated areas it reached upto 4.2°C. It is concluded that a standard deviation of temperature in a plot exceeding 0.3°C signals that some plants are experiencing water stress. This behavior can indicate the need for irrigation.

Singh and Kanemasu (1983) concluded that average afternoon canopy temperature of irrigated pearl millet was 33.1°C and that of non-irrigated was 37.2°C. The average afternoon canopy minus air temperature difference in some irrigated genotype goes up to -4.0°C while canopy minus air temperature difference in non irrigated genotype ranged from -0.3 to +1.5°C.

Gupta and Sastry (1986) observed that canopy temperature of fully watered wheat ranged from 12.3°C to 24.8°C and that of air temperature from 21.1 to 30.3°C respectively. While canopy minus air temperature difference was always negative and ranged from 4.35 to 7.05°C.

Blad *et al.* (1988) concluded that temperature difference between rainfed and fully irrigated plots were of the order of 3 - 8°C. This suggested that the rainfed plots probably suffered moderate to serve water stress. The canopy temperature viewed from the nadir showed even greater temperature difference of 10-15°C due to the contribution of emitted radiation from the hot, dry soils of the rainfed treatment.

Ranjan and Sandhu (1987), in a field study of summer mung bean to assess canopy temperature as an index of water stress showed that the unmulched crop had lower leaf xylem water potential, higher leaf diffusion resistance and higher canopy temperature than the mulched crop.

Throssell *et al.* (1987) studied the canopy air temperature differential (ΔT) of blue grass in response to water stress and showed that the well watered blue grass turf had lower values of ΔT than slightly stressed turf, which had lower values of ΔT than moderately stressed bluegrass turf. The relationship of lower values of ΔT with increased amounts of water applied has been shown for many crops including wheat and southern pea. The higher values of ΔT measured on the moderately stressed plots are due to greater depletion of available water by the bluegrass plants because of the layer internal between irrigations.

Alok kumar and Tripathi (1990) recorded the maximum value of canopy temperature during 1330–1440 h. They also noticed that unirrigated wheat had consistently higher canopy temperature than irrigated one. With intensification of drought, difference between irrigated and unirrigated wheat became large, and the maximum difference were noticed around 1400h. The canopy temperature difference of irrigated and unirrigated wheat was 3.8° C.

2.1.10. Effect of crop Temperature on Yield:

Gardner *et al.* (1981a) concluded that, decrease in optimum grain yield due to moisture stress, when expressed as a per cent of non-stressed crop yield, can be estimated with remotely sensed canopy temperature data if a non-stressed area is available for comparison. Summation of the mid-day difference in daily temperature during the pollination and grain filling stage was used successfully to predict grain yield with an accuracy of ± 10.

Clawson and Blad (1982) observed that if a plot is irrigated when canopy- temperature minus air temperature difference (as related to well watered plot) reached 1°C, a saving of 41 per cent of the overall amount of water was achieved with a yield reduction of only 20 per cent.

Singh and Kanemasu (1983) studied the leaf and canopy temperature of pearl millet genotypes under irrigated and unirrigated conditions and observed that in the irrigated treatments grain yields were negatively and significantly correlated with average afternoon canopy temperature (r = -0.81) and average afternoon canopy minus air temperature differential (r = -0.78), where as, grain yield ratio (non-irrigated grain yield to irrigated grain yield) was positively and significantly correlated with average afternoon canopy temperature (r = 0.64) and canopy minus air temperature difference (r = 0.75). Similarly, total yield ratio (non irrigated total yield to irrigated total yield) was significantly correlated with average canopy minus air temperature differential (r = 0.70). Plant temperature were significantly correlated with grain yield and grain yield ratio, especially in the non stressed treatments. So canopy temperature and canopy minus air temperature as observed in non stressed environment could be successfully used in a criteria for screening of the millet genotype for their grain yield and yield stability.

Alok kumar and Tripathi (1991) conducted field trial at Pantnagar, wheat (RR –21) was grown without irrigation or given 5 irrigation. They found that rainfed wheat had consistently higher day time canopy temperature than irrigated wheat. These differences increased as drought intensified, and the maximum difference occurre at 1400h and canopy temperature was higher by 3.8° C.

Kadam and Magar (1994) observed the average canopy temperature measure in the stress plot during a particular time period was ± 1°C higher than the average canopy temperature of well watered plot.

Selvaraju (1994) found that canopy temperature increases progressively with increasing soil moisture stress at all stages of the crop growth.

Alok kumar and Tripathi. (1994) determined canopy temperature (Tc) and canopy minus air temperature (Tc–Ta) by using a Telatemp infrared thermometer (model AG – 42). They noted that the differences between stressed minus well irrigated wheat during 1300–1400 hr. exceed 1.45° C in general and 1.2° C on clear days.

2.1.11. Effect of spectral reflectance on groundnut crop:

The spectral reflectance pattern is important to the radiative balance of the crop and may be used as discriminating feature for remote sensing applications. Reflectance characterestics of agronomic crops are of major importance in energy exchange of surfaces.

The diurnal variation of the crop albedo under clear sky conditions is strongly dependent on the solar elevation, during earlier and later hours of the day. The crop albedo is more and attains it minimum value at the solar noon. The lowar albedo at small solar zenith angles (noon hours) is because of trapping of radiation beneath the canopy due to large energy received when the sun is high. The effect is less pronounced at large zenith angles (morning and evening hours). Since the direct solar radiation cannot penetrate to such an extent (Fritschen,1967; Ramkrishna Rao and Varade,1980; Srinivas Murthy and Subbarao,1980; Rajhans,et al,1995 and Shendage 1996).

Kalma and Badham (1972) measured the seasonal albedo and the values for the pasture legume stylo to be 0.19, for a mixed stand of two annual grass species 0.22, and for bare soil 0.21. Albedos of dry soil varied between

0.20 and 0.22. Wetting of the surface has low albedo upto 0.14. At plant establishment, the maximum albedos for Tounsville style and grasses were 0.25 and 0.28, respectively the while minimum values were 0.13 and 0.15, respectively.

Suits (1972) observed that the spectral reflectance of vegetative cover governs the nature of spectra in spectral range from ultraviolet to near infrared. The spectral reflectance of canopy depends more upon the angle of illumination and azimuthal angle than just upon the structure and biological content of canopy. The variation in the directional reflectance of the canopy with azimuthal angle become prominent when canopy is illuminated by the sun at large angle from zenith.

Kanemasu and Arkin (1974) observed that plant leaves are effective filter and have absorption band of 400-700 nm. Leaves absorb strongly in the visible waveband but weakly in the near infra red waveband. Canopy albedo depends upon leaf area, leaf angle and plant spacing in addition to solar elevation and soil reflectance.

Colwell (1974) studied the cause and effect relationship in producing vegetation canopy reflectance. He suggested that all the factors *viz*., leaf area, leaf orientation, hemispherical reflectance and transmittance of supporting structures, solar zenith angle can be very important in influencing canopy reflectance and in certain situation of the leaves.

The spectral information of green red and infrared is utilised for assessing the status of vegetative canopy and consequential crop phenology. The green/red ratio closely follows and development and appear to be more desirable than near infrared reflectance (Kanemasu, 1974).

Leamer et al . (1978), studied the reflectance in the wavelength interval of 0.45 to 2.50 nm with the help of ground based spectro radiometer on nine cloud free days between planting and maturity of wheat planted on a sandy clay loam soil. They found that seedling rate affected the rate of ground cover, but not the spectral reflectance on either winter or spring wheat after about 25 % of the area covered by vegetation. All reflectance curves recorded after four week of emergence had the characteristics shape of vegetated surface. The proportion of ground covered by plants was more important than development stage of the plant in determining spectral responses, except at the end of the season when the plant senesced and lost pigmentation. Throughout the season, soil was much less reflective than green vegetation at 0.75, 0.50 and 1.10 nm and much more reflective at 1.65 and 2.20 nm, making these wavelength valuable for distinguishing vegetation from soil background and for assessing vegetation cover/density.

A plant in full sun light has its top 4 to 5 leaves exposed to direct solar radiation were as other leaves are wholly and partially shaded and are exposed to various intensities of direct and diffused light. Leamer and Noriega (1981) conducted that reflactance from crop canopy is made up of integration reflectance from various components of the canopy.

The crop coefficient can be estimated from bi-directional reflectance in red, near infrared and far infrared wavelength region (Heilman *et al.*, 1982).

Rapid increase in albedo was associated with periods of rapid growth. Sever water stress decreased vegetative surfaces and thus albedo through reduction in effective crop cover, maturing of inflorescence and gradual senenscence (Andre and Vishwanathan, 1983 and Hatfield *et al.*, 1978.)

The properties of red and infrared reflectance were studied with respect to green vegetation. The red reflectance exhibits non-linear inverse relationship between integrated spectral reflectance and green biomass while near infra-red components exhibits a non-linear direct relationship. The relationship between red reflectance and green biomass results from strong spectral absorption of incident radiation by the chlorophyll. The red reflectance is inversely proportional to amount of chlorophyll present in plant canopy. The chlorophyll are slightly absorptive in green region while much more absorptive in blue and red regions. Reflectance in green and infrared are positively correlated with green biomass. Reflectance curves of all vegetative surfaces are low through visible wavelengths (Tucker, 1979; Leamer *et al.*, 1978 and Alrichs and Bauer, 1983).

In early stages of crop, the reflectance in red region is more but it is less in near infrared due to lack of vegetation cover. As the crop growth occures the reflectance in red decrease and in near infrared increases. The decrease in red reflectance is due to increase chlorophyll content. As the crop matures red reflectance increases due to decrease in the red absorbing chlorophyll pigments. Thus, increase in spectral ratio is indicative of increase in vegetative cover with time and decrease is due to crop attaining its maturity phase (Ayyanger *et al.*, 1980 and Weigand and Richardson, 1984).

Millard *et al.*, (1990) estimated light interception and biomass of the potato (*Solanum tuberosum* L.) from reflection in the red and near infrared spectral bands. Calculations of cumulative light interception, assuming a 1:1 relationship between light interception and ground cover showed a curvilinear relationship with cumulative NIR/R (sum NIR/R) with N application which has increase slope of the line.

Janet Franklin *et al* (1994) observed the proportion of the ground covered by vegetation and the interception of photosynthetically active radiation (PAR) by vegetation of two variable related to evapotranspiration and primary production, respectively.

Rajhans *et al.*, (1995a) observed that the spectral reflectance of sorghum were very low in blue and red wavebands but consistently higher in NIR waveband. Also NIR/R reflectance ratio was significantly higher than blue / red and green / red reflectance ratios. The vegetation index (VI), a normalised parameter is a better indicator of crop conditions. The green reflectance was higher in narrow rows during earlier part of the crop growth and subsequently higher in wider rows.

Rajhans *et al* (1995b) found that the patterns of spectral response of leaves in PAR (400-700 nm) range replicated in blue (424- 476 nm), green (494–546 nm) and red (624-676 nm) wavebands. The leaf number four from top in sorghum was found to be physiologically the most active leaf during vegetative and reproductive phases. The absorptance in all wavebands were fairly uniform at both the growth stages because the leaf was fully grown. Leaf age resulted in higher reflectance and lower transmittance at 50% flowering than corresponding values at panicle initiation. Absorptance was observed in order of blue > red > green wavebands. Such information become useful tool in determining relative concentrations of amino acid and soluble sugar and starch in a leaf.

Shendage (1996), while working at Pune on spectral characteristics of Gram studied the profile of spectral properties of individual leaf at pod initiation stage. It was found that at pod initiation stage absortance was more, reflectance was less and transmittance was also more. The transmittance decreased with increase in leaf area.

Shendage (1996) worked on spectral characteristics of Gram . He observed that the albedo increases upto maturity stage. In early stages albedo was more in normal row spacing and in later stage albedo was more in closer row spacing. The spectral reflectance in blue and red wavebands exhibited negative relationship with LAI while green and NIR reflectance exhibited positive relationship with LAI.

MATERIAL AND METHODS

3. MATERIALS AND METHODS

The present investigation "Studies on microclimate of summer groundnut under different irrigation schedules and mulches" was carried out to schedule the irrigations based on CPE values with sub treatments of different mulches on summer groundnut crop by laying out a field experiment during summer season of the year 2000. The details of material used and methods adopted in the present investigations are given in this chapter under the following heads

3.1. **Details of an Experimental material :**

3.1.1. **Experimental site :**

The experiment was laid on Survey No.53 A/1/1 of the Plot No. E: 7-8 of E Division of Agricultural college Farm, Pune–5, during summer season of the year 2000 (Plate 1.).

3.1.2. **Soils:**

Topography of an experimental field was uniform and levelled. The experimental soil was vertisol in nature with uniform in depth upto 90 cm. It was well drained.

Field capacity of the soil was determined by the field method. Permanent wilting point was determined by using sunflower techanique. Bulk density of soil was determined by core-sample method. Mechanical analysis of the soil was done by using the International Pipette method. (Piper, 1966). The textural class of the soil was decided by using the Textural Triangle method. The composition, soil moisture constants and physio-chemical properties of the experimental soil are presented in Table 1.

Table 1. Composition, Soil moisture constants and Physio-chemical properties of an experimental soil.

Sr.No	Soil property	Observation
A	**Soil moisture constants :**	
1	Field capacity	32.80%
2	Permanent wilting point	18.39%
3	Bulk density	1.27 gcc^{-1}
B	**Physical Properties:**	
1	Sand	19.42%
2	Silt	25.40%
3	Clay	55.18%
4	Textural class	Clay
C	**Chemical properties:**	
1	PH	8.09
2	EC (mm hos cm^{-1})	0.18
3	Organic carbon	0.42%
4	Calcium carbonate equivalent	10.83%
5	Available N ($kgha^{-1}$)	240.00
6	Available P (kg ha^{-1})	14.00
7	Available K (kg ha^{-1})	359.00
8	Available sulpher (μgg^{-1})	4.00

3.1.3. Climatic conditions and Location:

General:

Pune comes under the plain zone (Transitional belt) and is situated on an elevation of 557.7 m above the mean sea level, 18°22′ North Latitude and 73°51′ East Longitude. The average annual rainfall of this place is 714.7 mm, which is receives mostly from the South-West mansoon, commencing from around middle of June. Of the total annual precipitation, about 75 per cent is received during the period between June and September, while remaining quantity is received mostly in the month of October and November. Very scanty but occasionaly rains are received during summer season and hence, assured irrigation facilities are needed for growing of summer crop.

At Pune, the maximum temperature is observed during April and May which ranges between 34 to 40°C. The lowest minimum temperature is observed during December and January which varies from 6 to 10°C.

3.1.4. Cropping history of an experimental field:

The cropping history of an experimental field for the previous 3 year is presented in Table 2.

Table 2. Cropping history of an experimental plot.

Year	Season	Crop grown
1997-98	Kharif	Sugarcane (suru)
	Rabi	Sugarcane (suru)
	Summer	Sugarcane (suru)
1998-99	Kharif	Sugarcane(ratoon)
	Rabi	Sugarcane(ratoon)
	Summer	Sugarcane(ratoon)
1999-2000	Kharif	Sorghum
	Rabi	Fallow
	Summer	Groundnut. (Present investigation.)

3.1.5. Seed selection and sowing:

The seeds of variety TG-26 was used for sowing. The seeds were sown by dibbling at 30 cm x 10 cm distance on February 2, 2000.

3.1.6. Fertilizer application:

The crop was fertilized with the dose of 25 kg N ha^{-1} and 50kg P_2O_5 ha^{-1}.

3.1.7. Seed treatment:

The seeds were treated with Rhizobium culture @ 250 g per 10kg of seed and Thirum culture @ 30 gha^{-1} before sowing.

3.1. 8. Plant protection :

Monocrotophos was sprayed for controlling leaf eating catterpiller and sulphur dust was applied @ 20 kgha^{-1} for controlling ticka disease.

3.2. Method:

3.2.1. Experimental details:

The experiment was laid out in a split plot design with three replications. Main plot treatments comprised of irrigation scheduling *viz*., 75, 100,125 mm CPE and irrigation at 10 days interval, and sub plot treatments comprised of mulches i.e. 7 micron Polythene film mulch, sugarcane trash mulch and no mulch. The details of the treatments along with the symbols used are given below

A. Irrigation CPE(mm)	**Symbol**
75	I_1
100	I_2
125	I_3
Irrigation at 10 days interval	I_4
B. Mulches	
No mulch	M_0
Sugarcane trash	M_1
Polythene film	M_2

3.2.2. The other details of the experiment are as follows:

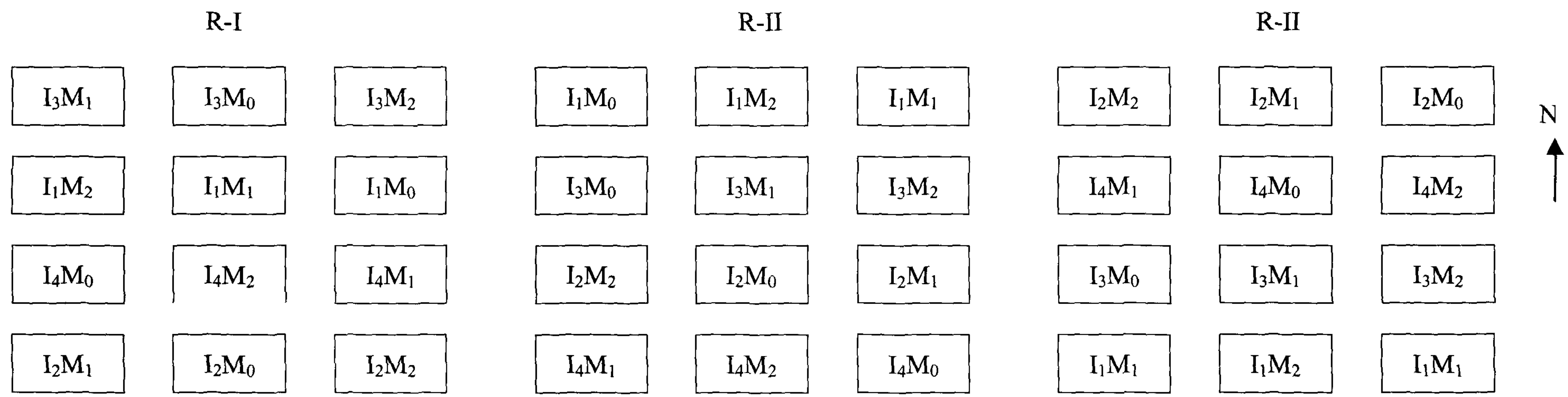
a) Total number of plots: 36.

b) Plot size: Gross: 6.00 m × 4.80 m.

Net: 5.10 m × 4.20 m.

c) Method of sowing: Dibbling.

d) Date of sowing: Feb 2, 2000.



TREATMENT DETAILS

1. Groundnut variety- TG-26
2. Design- Split Plot
3. Number of replications-3
4. Gross plot size- 6.00 m X 4.80 m
5. Net plot size - 5.10 m X 4.20 m
6. Sowing date- Feb.2, 2000

1. Main plot – Irrigation Scheduling

1. 75 mm CPE	I_1
2. 100 mm CPE	I_2
3. 125 mm CPE	I_3
4. Irrigation at 10 days interval	I_4

2. Sub plot -Mulches

1. No mulch	M_0
2. Sugarcane Trash	M_1
3. Polythene film	M_2

Fig.1 PLAN OF LAYOUT

3.3 Field operations:

The details of various cultural operations carried out in the experimental plot during summer season of the year 2000 are presented in Table 3.

Table 3. Schedule of field operation carried out during summer season of the year 2000.

Sr.No	Name of operation	Frequency	Date of operation.
A	**Preparatory tillage operations**		
1	Ploughing	1	3/01/2000
2	Harrowing	1	7/01/2000
3	Weed & Stubble collection	1	11/01/2000
4	Experimental Layout	1	13/01/2000
5	Pre-sowing irrigation	1	21/01/2000
B	**Seed and sowing**		
1	Seed treatment with Rhizobium and Thirum.	1	2/02/2000
2	Application of Fertilizers	1	2/02/2000
3	Sowing	1	2/02/2000
C	**Plant protection**		
1	Spraying of monocrotophos	1	29/2/2000
2	Application of sulphur dust @ 20 $kgha^{-1}$	1	12/3/2000
D	**Post sowing operations**		
1	Spreading of Polythene film	1	2/02/2000
2	Installation of Neutron probe	1	2/02/2000
3	Installation of soil thermometers / thermocouple	1	2/02/2000
4	Common irrigation	3	2/02/2000 08/02/2000 14/02/2000
5	Gap filling	1	11/02/2000
6	Weeding	3	28/02/2000 21/03/2000 19/04/2000
7	Irrigations	As per treatment	--
8	Harvesting	1	5/06/2000

3.3.1. Gap filling:

Gap filling was done 10 days after sowing i.e. on dated 11/02/2000.

3.3.2. Weeding:

The weeding was done 3 times on 28/2/2000, 21/03/2000 and 19/04/2000.

3.3.3. Scheduling of irrigations:

Irrigations were given as per CPE values. The details of the irrigation given are shown in Table 4.

Table 4. Irrigation schedules as per treatments.

CPE Value (mm)	Number of Irrigation	Days after sowing	Date of Irrigation
75 mm	1	28	29/02/2000
	2	40	12/03/2000
	3	50	22/03/2000
	4	61	02/04/2000
	5	69	10/04/2000
	6	79	20/04/2000
	7	87	28/04/2000
	8	95	6/05/2000
	9	105	16/05/2000
100 mm	1	32	4/03/2000
	2	46	18/03/2000
	3	61	2/04/2000
	4	73	14/04/2000
	5	86	27/04/2000
	6	98	8/05/2000
	7	110	22/05/2000
125mm	1	36	8/03/2000
	2	54	26/03/2000
	3	69	10/o4/2000
	4	86	27/04/2000
	5	101	12/05/2000
10 DI	1	28	24/02/2000
	2	38	4/03/2000
	3	48	14/03/2000
	4	58	24/03/2000
	5	68	3/04/2000
	6	78	13/04/2000
	7	88	23/04/2000
	8	98	3/05/2000
	9	108	13/05/2000

3.4. Micrometeorological Studies:

3.4.1 Determination of soil moisture:

The soil moisture for 0-30 cm layer was determined by Gravimetric soil sampling method. The soil moisture from 30-90 cm depth was measured

Table 5. Details of Micrometeorological observations.

Sr. No.	Micrometeorological studies.	Time of Observation. (DAS)	Sample size
1	Soil moisture	Treatmentwise just before irrigation and 48h after irrigation.	Net plot area.
2	Canopy temperature	Treatmentwise just before irrigation and 48h after irrigation.	Whole spot observed by Infrared thermometer
3	Soil temperature	Once in a day at 1430 h.	Net plot area.
4	Stomatal conductance, resistance and transpiration.	Treatmentwise just before irrigation and 48h after irrigation.	5 plants from net plot area.
5	Spectral charecterestics	Treatmentwise just before irrigation and 48h after irrigation.	Whole spot observed by sensor of spectroradiometer
6	Diurnal mesurement of stomatal conductance and transpiration.	At branching, 50% flowering, pod development stage and at harvest	5 plants from net plot area.

with the help of neutron probe at an interval of 15cm depth. The soil moisture was recorded before irrigation and 48 h after irrigation and when rain occurred. The count per second were converted into volume of soil moisture content by using the following formula

$$ø = 0.958 \frac{R}{RW} - 0.12 \times 100$$

Where,

ø = Per cent soil moisture content,

R = Count rate obtained in the soil at the time of observation (counts per second), and

RW = count rate in pure water (counts per second).

3.4.2 Soil temperature:

Mercury in glass type of soil thermometers were installed at 5 and 15 cm depths of soil in 12 plots in one of the replication. The soil temperatures were recorded once in a day at 1430 hr. This is as per norms of IMD.

3.4.3 Canopy temperature :

Canopy temperatures were measured with the help of infrared thermometer. The angle of infrared thermometer for the measurement of canopy temperature was adjusted and observations were recorded at least 20 feet away from the plot. Five random observations were taken and the average values were recorded. The time of observations was between 1330-1430h.

3.4.4. Stomtal conductance, resistance and transpiration :

The stomatal conductance, resistance and transpiration were measured with the help of steady state porometer. These measurement were made in situ without destructing the plant.

Transpiration ($\mu g cm^{-2} s^{-1}$) of sample was determined by following equation:

$$E = (\int c - \int a) F/A .$$

Where,

$\int c$ = water vapour dencity in cuvette (μg^{-3})

$\int a$ = density of dry air in cuvette ($\mu g\ cm^{-3}$)

A = area of sample.

F = Flow rate.

$F = \{(T/273.15)+1\} * (101.3/p) *M$

Where,

T = cuvette temperature (°C),

p = absolute atmospheric pressure (kpa)

M = mass flow rate of dry air into the cuvette (cm^3/s)

Stomatal resistance was determined from the equation.

$Rs = [(\rho 1 - \rho c) / E] – Rb$

$= [(A/F) * (\rho 1- \rho c / (\rho c- \rho a))] - Rb$

where,

ρ_1 = water vapour density in ($\mu g\ cm^{-3}$)

Rb = Boundry layer resistance. The value of the instrument used in calculation is 0.15 scm^{-1} for Rb.

Stomatal conductance was determined with following formula

$Cs = 1/Rs$ (cms^{-1})

3.4.5 Spectral characteristic:

Spectral characteristics of crop were recorded by taking measurements with the help of spectroradiometer. By the sensor of the instrument whole area of the net plot was covered for the measurement. Measurements were taken just before the irrigation.

3.5. Biometric and other observations :

The details of the biometric observations recorded are given in Table 6

3.5.1. Plant height:

The various biometric observations were recorded from each net plot. For this purpose, five plants were selected randomly from the net plot. Plant height was measured with full scape measuring scale. All Biometric observations are recorded at an interval of 14 days from 28 days after sowing.

Table 6. Details of Biometric and other observations.

Sr. No.	Particulars	Frequency	Time of Observation. (DAS)	Sample size
A.	**Biometric observation :**			
1.	Plant height	7	28, 42, 56, 70, 84, 98, 112, At harvest	5 plants
2.	Number of branches	7	28, 42, 56, 70, 84, 98, 112, At harvest	5 plants
3.	Leaf area per plant	7	28, 42, 56, 70, 84, 98, 112, At harvest	5 plants
4.	Dry matter per plant	7	28, 42, 56, 70, 84, 98, 112, At harvest	5 plants
5.	Days to 50% flowering	1	One	All plants from net plot area
6.	Days to maturity	1	One	5 plants from net plot area
7.	Number and weight of nodules per plant	3	At branching, flowering & at harvesting.	5 plants from net plot area
B.	**Post harvest studies:**			
1.	Number of pods/plant	1	At harvest	5 plants
2.	Weight of pods/plant	1	At harvest	5 plants
3.	100 kernel weight	1	At harvest	All plants from net plot
4.	Pod yield	1	At harvest	All plants from net plot
5.	Creeper yield	1	At harvest	All plants From net plot

3.5.2. Number of branches:

The number of branches were recorded by selecting five plants randomly from net plot. The number of branches are recorded at the interval of 14 days from 28 day after sowing.

3.5.3. Leaf area per plant:

The leaves of five plants selected for the dry matter study from the respective net plot were used for leaf area measurement. The leaf area per plant of functional leaves was recorded during the growth period, The observations were taken at an interval of 14 days from 28 days after sowing. The leaf area meter was used for leaf area measurement.

3.5.4. Dry matter per plant:

For dry matter studies, five plants were selected. These plants were separated into branches, leaves and roots and kept in the oven for drying at 60° ± 2°C temperature.

3.5.5. Days to 50% flowering:

The days to 50% flowering were recorded by general eye observations in each treatment of all replications.

3.5.6. Days to maturity:

The days of maturity were recorded by selecting five plants randomly from each plot, and number of matured pods were observed at the physiological maturity stage of the crop.

3.5.7. Number and weight of nodules per plant:

The number of nodules and their weight are recorded from five plants at the different phases i.e. at the initiation of branching, flowering and harvesting.

3.6. Post Harvest Studies :

3.6.1 Number of pods per plant:

The number of pods per plants were recorded by selecting five plants randomly from net plot at the harvest .

3.6.2. Weight of pods per plant:

The weight of pods per plants were recorded at harvest by selecting the five plants randomly from net plot.

3.6.3 100 Kernel weight:

The number of kernels were recorded from the net plot produce and 100 kernels weight was recorded.

3.6.4. Pod yield:

Pods were separated from the plants after uprooting them from each treatments net plot. Pods were cleaned by removing the soil sticking to the pod. The yields of dry pods were recorded and calculated in kilogram per hectare.

3.6.5. Creeper yield :

After harvesting, pods were separated from creepers. The creepers from each net plot were air dried completely. After complete drying for two weeks, creeper weight per net plot was recorded and converted it on hectare basis.

3.6.6. Harvest Index:

The percentages of economic yield compared with the above ground biomass is called as harvest index (Salisbury and Ross, 1986). The harvest index was calculated by using the following formula

$$\text{Harvest Index} = \frac{\text{Pod yield}}{\text{Biological yield}} \times 100$$

3.7 Details of Instruments used :

3.7.1. Neutron probe:

Neutron probe was used for the measurement of soil moisture. The details of this instrument are as fallows

Probe:

DIDCOT soil moisture probe type IH III was used to monitor the soil moisture. The soil moisture probe is illustrated in Plate 2.

Major components of the system are the probe, probe carrier, rate scaler and connecting cable.

Probe carrier :

It is made up of PVC pipe which holds the probe inside and the rate scaler at the top. It has a socket at its base through which it is fitted on the access tube so that the probe may be lowered directly from the carrier into the tube.

Rate Scaler :

It is a short computing unit attached through hinges to the upper end of the carrier. It can be detached when not in use. The rate scaler is connected to the cable by a socket provided at its base. Rate scaler performs and display calculation. It also stores software and data. The liquid crystal display means count rate at the conclusion of present counting time, in counts per second.

Connecting Cable :

It connects the rate scaler to the probe. It being 5m long, allows soil moisture monitoring up to the depth of 4m. While the probe is lowered in the access tube, the moving cable operates depth counter and the clamping of cable holds probe which operates with an input supply of 13 V acting through the cable and 11 V pulses are returned to the rate scaler through the same cable.

Probe :

It consist of stainless, steel cylinder of the size of 38 mm in diameter and 750 mm in length. The cylinder is marked with a line at mid-plane of source.

Probe contains Americium Beryllium (Am-Bc), a fast neutron source. The Boron Trifluoride (BF_3) is positioned at the mid point of sensitive tube.

Working Principles :

When the probe is lowered in the access tube at a desired depth, fast neutron source Am-Be emits fast neutrons in the soil. The sphere of influence of neutron is of 30 cm diameter. The neutrons collide with the hydrogen atoms present in the soil water and get scattered. The slowed neutrons are known as thermal neutrons. The cloud of thermal neutron is generated within the soil around the probe. The density of cloud is largely a function of water content of the soil. The density of cloud of thermal neutron is sensed by BF3 in the probe. The electrical pulse produced by BF3 is amplified and transmitted to the rate scaler through the cable. The rate scaler displays the pulses in terms of counts per second. The counts per second are subsequently converted into percent soil water with the help of given equation. The parameters of two equations are different for different types of soils.

3.7.2. Soil Thermometer :

Mercury in glass type thermometer was used for recording soil temperature. Two soil thermometers of 5 and 15 cm depths were installed in each plot. These soil thermometers had a bend of 120° just above the bulb and bulb rested horizontally in the soil at the desired depths. The stem of the soil thermometer was inclined at 120° from the ground to facilitate the reading of the scale. The thermometers were mounted on triangular stand fixed on the ground. The stands were made of M.S. flat 2.5 cm wide and 3mm thick. The sloping side of the stand was inclined at an angle of 60° the ground so as to support the thermometer at the accurate inclination. The stem of the thermometer was held in position by clipping the spring clips the thermometer stem and the sloping side of the stand. The check distance from the soil surface to the one fixed point on the stem was frequently measured to see whether the instrument had the observations of the same depth. Soil thermometer is illustrated in Plate 3.

3.7.3. Infrared thermometer :

The infrared thermometer is used for measuring the canopy and plant temperatures (Plate 4). The easy handling during operation and speed of measurement are the advantageous over more labourious methods such as direct thermocouple placement on the leaves. Thus, the use of infrared thermometer as a research tool to measure crop or plant temperature is becoming increasingly popular, Telatemp model AG 42 was used for measurement of canopy temperature in this experiment, This instrument operates with the help of four 1.2 volt Ni-Cd rechargable cells.

Working principles:

The energy flux of an object is a function of its temperature. The infrared thermometer senses longwave radiation emitted by the object and converts this value to a temperature scale according to Stefan's Boltzman law.

$$E = \epsilon \acute{o} T^4$$

Where,

E - energy flux.

ϵ - emissivity of the body,

ó – Stefan-Boltzman constant (5.67×10^{-8} Wm^{-2} k^4),

T - temperature of the body in $^{\circ}K$

Measuring temperature :

The instrument was fully charged before taking the temperature observations. When it was held by grip, the instrument will promptly "Come to life" as evidenced by the action of digital display.

Point the instrument at the object whose temperature is to be measured and the display will immediately indicate the temperature. The temperature difference between the target and ambient air, can be measured merely by pressing the trigger on the front of hard grip. The instrument will immidiately display the differential temperature. The telatemp model AG 42 has an acceptance angle of 4 and "see" a one foot spot at a twenty foot distance.

Use of emissivity switch :

The emissivity switch is provision for the relative radiation efficiency various which according to the types of targets. For most organic type targets, a setting of emissivity between 0.95 to 0.99 will yield acceptable results.

3.7.4. LI-1600 Steady State Porometer:

The steady state porometer is used for measurement of stomatal conductance and has wide range of application in the plant science (Plate 5). The need for frequent calibration is eliminated by utilizing the steady state technique. A ventilation radiation shield maintain the cuvette temperature within 3°C of ambient temperature. Leaf temperature is measured using the thermocouple in contact with the leaf. The measurements can be made without detaching the leaf. Thus, measurement is rapid and minimize potential modification of stomata. Observations are recorded in 10 seconds. The facilities are available with instrument for the following measurements.

i) Stomatal conductance ($cm\ s^{-1}$)

ii) Leaf temperature (°C)

iii) Rate of transpiration ($\mu g\ cm^{-2} s^{-1}$)

iv) Photosynthetically Active Radiation (PAR) (μEm^{-2})

Theory of operations :

The wire of thermocouple inside the cuvette comes in contact with the leaf. After setting a knob on "RH %" on console it directly gives RH % inside the cuvette.

Operation :

1. The aperture area and atmospheric pressure are initially set and entered into the porometer.

2. After the cuvette is acclimated to ambient condition, the null adjust valve is used to bring the flow rate within the dynamic range of the internal automatic flow controller. The amount of adjustment is dependent on the resistance of the sample, This process can be eliminated on subsequent measurements under *similar conditions.*
3. The sample is clamped into its place on the sensor head. Immediately the humidity setting switch (HUMSET) is pressed to store the cuvette RH into the memory as the null point humidity (typically ambient). The humidity other than ambient can also be used as the null point. The procedure need not to be used for subsequent measurements.
4. The null adjust indicator is seen. If the indicator has been stabilized within the range of the meter, the cuvette has reached equilibrium within 1% of the set null balance humidity, now the reading can be taken. The hold switch can then be used to hold the parameters in memory of the display. If indicator is not within the range of meter and several seconds have elapsed, the null adjust valve should be turned in direction indicated on the meter. This is repeated until the indicator stabilizes within the meter range.

3.7.5. LI 1800 Spectro-rodiometer:

Spectroradiometer LI-1800 is a completely self contained battery operated microprocessor controlled system for rapid acquisation of spectral data of radiation. It measures spectral concentration of radient energy by first dispersing the radiation with the diffraction grating monochromator and then measuring energy in each narrow wave band of resulting spectrum with a silicon detector (Plate 6). The major components are explained below

The major components are as follow

1. Consine receptor :

The standard cosine receptor is translucent collector which samples the radient flux according to cosine of the angle of incidence and will accept radiation from all the angles of hemisphere. This allows spectroradiometer to measure flux densities per unit area.

2. Filter wheel :

The light entering the LI-1800 through standard cosine receptor or 1800-10 fibre optic is directed through a filter wheel before entering in monochromator Filter wheel contains six order sorting filter which eliminates second order harmonics. During each scan LI-1800's internal micro-computer automatically rotates filter wheel to select appropriate filter for spectral region being scanned. The use of six filters also enchances stray light rejection by filtering out light rejection i.e. not in same spectral region as that being spectral region as that being measured. In addition to filter there is black target on filter wheel which serves as a black reference.

3. Monochromator :

The dispersing element in spectroradiometer is a holographic grating. Monochromator is driven by precision stepping motor under control of internal microcomputer. It disperes the radiation transmitted through filter wheel into narrow wavebands and passes each of them to the detector. Essential components of monocromator include entrance slit, grating and exit slit. As the radiation from entrance slit strikes grating it is different towards the exit slit. The net result of this diffraction is that different wavelengths are projected at slightly different angles towards exit slit. Entrance and exit slit are usually of the same size.

4. Detector :

The detector is a silicon photodiode. After emerging from monochromator the radient energy is received by detector which produces a current proportional to the amount of radiation. This signal is then amplified, converted into voltage and passed through an analog to digital converter and is made available to internal microcomputer.

5. Internal microcomputer :

The heart of LI-1800 spectroradiometer is its internal microcomputer which controls scanning, collection, reduction and storage of data. After each scan LI-1800 analyses and stores standard memory is 32K bytes which is expandable to 64K bytes.

6. Optical accessories :

For more specialized application the cosine receptor can be removed and replaced with 1800-10 fibre optic probe. It transmits radiations received from optical receptors 1800-11 remote cosine receptor, and 1800-12 external integration sphere.

7. Remote cosine receptor :

Remote cosine receptor is an optical accessory used with 1800-10, fiber optic probe for measuring the canopy reflectance i.e. albedo of crop. The probe uses quartez fiber optic cable which connects cosine receptor to optical input part of LI-1800. The remote cosine receptor is fitted on a wooden platform which can be inverted to face the canopy to measure the albedo of the summer groundnut crop.

8. 1800-12 External integrating sphere :

It is an accessory for measuring the spectral properties i.e., absorptance, reflectance and transmittance of an individual leaf of the plant. The major components are :

1. Extranel integration sphere.
2. Regulated power supply.
3. Rechargeable battery.
4. Illuminator.

Quart 2 fiber optic probe.

The sphere is designed for use with portable spectro-radiometer and quartz fibre optic probe. The purpose of an integrating sphere is the collection of all radiations that are reflected from or transmitted through a surface, so that it can be measured .These are four ports for these measurements *viz.* sample port for placing leaf, lamp port-A for transmittance, lamp post-B for reference and lamp port-C for reflectance. The colour coding on integrating sphere is used as configuration for recording different observations i.e. yellow alignment for transmittance, red for reflectance and white dot alignment for the reference measurement. The material used for reference measurement is Baso 4.

Specifications :

LI-1800 Spectro radiometer :

Wave length range	: 300-850 nm
Standard band width (1/2 mm slit)	: 4 nm

Optional band width (1mm slit)	: 8 nm
Wavelength Accuracy	: ±1.5 nm
Liner dispersion	: 8 nm/mm
Grating	: 1200 groves/mm
Automatic filter wheel	: 6 filters
Wave length drive internal	; 1, 2, 5, 10 nm
Battery charging	: It has non operation charging circuitry built in battery is charged for 12-14 h during the AC operation.

1800-12 Integrating Sphere :

Wave length range	: 330-850 nm
Sphere coating	: Barium sulphate.
Sample ports	: 145 cm diameter
Entrance ports (3)	: One each for reference, reflectance, transmittance.
Out put port	: 0.64 cm diameter designed for use with fibre optic probe and spectro radiometer.
Reference sample disk	: Uses Pressed $Baso_4$
Illuminator	: --
Spot diameter	: 0.14 cm
Stray light	: < 0.5 %
Lamp	: 6V, 10 watt glass halogen lamp.

Size : 5 cm Dia. × 20 cm L.

3.8. Statistical analysis:

The statistical analysis of the data was done by standard method of analysis of variance (ANOVA) and tested by F test The standard error was worked out for each components shown in Table 7.

Table 7. Analysis of variance for split plot experimental design.

Sources	D.F.	Meansquare	'F' calculated
Replication	(r-1)		
Main plot treatment	(m-1)		
Error (a)	(m-1)(r-1)		
Sub-plot treatment	(n-1)		
Error (b)	m(n-1)(r-1)		
Interaction Main X sub-plot treatment	(m-1)(n-1)		
Total	(mnr-1)		

Where the results were found significant the critical differences were worked out at 5% level of significance.

Suitable graphical illustrations of the mean data are also given at the appropriate places.

The statistical analysis was carried out on the computer at the Centre of Advance Studies in Agriculture Meteorology (CASAM), College of Agriculture, Pune-5, with the help of programme for analysis of split plot design with spread sheet of MS Excell.

Plate 1. Experimental site

Plate 2. Neutron Probe

Plate 3. Soil themometer / thermocouple

Plate 4. Infrared thermometer

Plate . View showing growth of summer groundnut under different mulches.

Plate . Growth of summer groundnut under polythene mulch.

Plate 5. Steady State Porometer

Plate 6. Spectro radiometer

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

The results of the field experiment entitled "Studies on microclimate of summer groundnut under different irrigation schedules and mulches" are discussed below

4.1. Weather conditions during the experimental period :

In order to get an idea of the weather conditions that prevailed during the period of the present investigations, the data on weather parameters recorded in the Agro-meteorological observatory situated at the Agricultural College Farm, Pune-5 are presented in Table 8 and depicted graphically in Fig.2.

4.1.1. Air temperature :

The data depicted in Fig.2. shows that the maximum and minimum air temperatures ranged between 25.8 to 41.2 °C and 8.7 to 27.8°C , respectively.

The maximum temperatures were higher in April. A decreasing trend was observed from mid-May, thereafter, the maximum temperatures decreased and attained lower values in the month of June.

The minimum temperatures also showed a somewhat similar trend, as that of maximum temperatures but the decreasing trend in minimum temperature continued upto end of May, it again increased in the month of June.

4.1.2. Relative humidity :

The data depicted in the Fig.2. shows that the morning relative humidity (RH-I) ranged between 35 and 99 per cent and the afternoon relative humidity (RH-II) ranged between 10 and 90 per cent. The RH-I was constantly high until it began to decline in the month of April. The RH-II on the otherhand showed a lot of fluctuations.

4.1.3 Wind Speed:

The wind velocity ranged between 1.2 to 15.4 kmph during the crop growth period.

4.1.4 Rainfall :

There was no rainfall during the crop growth period.

4.1.5 Pan evaporation :

The pan evaporation was high during the pod development period in the month of May and low during the month of February. The pan evaporation ranged between 4 to 12.6 mm.

4.1.6 Bright Sunshine hours :

During the crop growth period, the bright sunshine hours ranged between 0.7 to 11.3 h.

Table 8. Weather conditions during the period of research work for summer groundnut in the year 2000.

MW No.	Date	Tmax (°C)	Tmin (°C)	Epan (mm)	Rain-fall (mm)	WS (km ph)	Humi-dity(%) I	II	BSS (h)
5	1/2/20000	33.4	10.9	4	0	3.4	87	24	9.6
	2/2/2000	30.8	10.3	5.1	0	6.6	95	24	9.8
	3/2/2000	30.5	12.1	4.2	0	6	99	32	9.5
	4/2/2000	31.7	12.1	4.4	0	4.7	98	24	9.4
6	5/2/2000	32.9	11.4	5.4	0	6	93	36	9.7
	6/2/2000	28.4	11.2	4	0	7	99	40	9
	7/2/2000	28.7	13.5	3.8	0	4.6	98	36	9.3
	8/2/2000	29.3	10.7	4.5	0	4.7	95	27	8.6
	9/2/2000	29.6	9.7	4.4	0	2.9	97	28	9.7
	10/2/2000	29.6	11.7	4.3	0	3.7	97	30	9.5
	11/2/2000	30.9	9.6	4.9	0	6.2	84	35	9.9
7	12/2/2000	28.4	9	5.8	0	6.7	84	37	9.9
	13/2/2000	27.4	10	4.4	0	3.4	89	30	9.9
	14/2/2000	29.1	12.1	5.6	0	2.9	73	37	8.9
	15/2/2000	29.5	15.6	4.7	0	3.3	74	33	9.4
	16/2/2000	32.5	15.8	3.1	0	4.8	87	25	7.4
	17/2/2000	33	12.4	5.9	0	4.7	80	18	8.4
	18/2/2000	31.6	8.7	6.1	0	4.4	82	17	10.3
8	19/2/2000	31.4	9.6	4.7	0	3	84	19	10
	20/2/2000	32.5	10.6	4.6	0	6.6	85	29	10
	21/2/2000	27.6	11.5	5.1	0	8.3	89	28	10.3
	22/2/2000	29.4	12.7	4.8	0	4.7	96	29	10.1
	23/2/2000	31.8	14.2	5.4	0	5	84	26	9.8
	24/2/2000	32.3	14.9	5.2	0	4.5	87	42	9.8
	25/2/2000	31.3	16.2	5.4	0	3.1	82	43	8.3
9	26/2/2000	30.5	14.4	4	0	4.1	93	32	7.3
	27/2/2000	31.5	12.4	5.3	0	3.2	73	35	9.9
	28/2/2000	31.5	133.2	4.7	0	4	80	27	10
	29/2/2000	32	13.3	6.3	0	4.9	81	19	10.2
	1/3/2000	32.7	10.8	7.1	0	4.6	67	16	10.2
	2/3/2000	34.7	11.8	6.2	0	2.5	73	16	10.2
	3/3/2000	35.3	13.1	6.1	0	3.5	71	15	9.7
	4/3/2000	35.3	12.5	6.7	0	5.4	68	14	9.9
10	5/3/2000	33.8	11.1	7.5	0	6.4	75	11	10.2
	6/3/2000	33.8	11.7	7	0	5.3	95	15	10.3
	7/3/2000	33.7	15.9	6.4	0	9.7	85	36	9.8
	8/3/2000	30.2	13.2	6.1	0	9.1	91	18	10.4
	9/3/2000	30.8	10.8	6.2	0	5.2	71	18	10.3
	10/3/2000	34.9	12.8	6.8	0	5.3	81	14	10.3

	11/3/2000	35.7	12.6	7.7	0	4.6	77	13	10.1
11	12/3/2000	36.3	11.7	6.5	0	5.3	69	10	10.6
	13/3/2000	34.4	11.1	8.4	0	8.6	58	27	10.4
	14/3/2000	32.1	11.4	7.8	0	10.6	70	19	10.3
	15/3/2000	33.5	10.3	6.4	0	3.7	87	15	10.4
	16/3/2000	34.6	10.9	6.9	0	5.5	78	10	9.8
	17/3/2000	35.2	9.8	8.8	0	5.9	72	11	10.8
	18/3/2000	36.8	11.5	7.8	0	5.1	80	15	10.4
12	19/3/2000	36.7	13.3	8.3	0	2.2	83	14	10.6
	20/3/2000	36	13	6	0	1.2	73	14	10.4
	21/3/2000	35.5	12.5	7.3	0	1.7	71	13	10.1
	22/3/2000	37.7	12.1	6.7	0	3	65	15	9.8
	23/3/2000	35.3	12.8	7.5	0	5	60	19	9.3
	24/3/2000	34.3	15.1	6.7	0	3.4	71	20	9.7
	25/3/2000	35.7	16.7	7.2	0	4.1	59	23	9.8
13	26/3/2000	36.1	18.2	6.9	0	3.9	68	23	7.6
	27/3/2000	35.5	17.5	6.4	0	4.1	70	19	7.6
	28/3/2000	37.3	17.3	7.4	0	3.9	61	23	9
	29/3/2000	36.7	19.1	6.9	0	4.4	85	30	9.1
	30/3/2000	37.3	18.7	6.6	0	4.9	81	23	9.9
	31/3/2000	37.8	17.7	6.4	0	3.4	78	15	9.7
	1/4/2000	38.6	16.5	7.1	0	3.3	68	15	10
14	2/4/2000	38.9	18.3	7.9	0	3.3	57	18	9.9
	3/4/2000	39.3	19.8	7.9	0	4.5	67	19	9.9
	4/4/2000	39	24.1	6.8	0	7	79	24	9.6
	5/4/2000	39	23.7	7.3	0	9.7	73	25	9.3
	6/4/2000	38.5	21.6	7.3	0	7.2	89	20	9.1
	7/4/2000	39.3	23.7	8	0	5.1	85	26	9
	8/4/2000	39	27.8	6.4	0	3.9	78	22	5.5
15	9/4/2000	39.2	20.4	7.5	0	5.7	77	19	9
	10/4/2000	39.3	19.1	8.5	0	6.2	62	17	9.8
	11/4/2000	39.2	15.6	8.7	0	6.7	43	17	10.2
	12/4/2000	39.3	17.7	7.5	0	5.4	56	18	10.1
	13/4/2000	40	20.7	8.1	0	8.8	43	20	9.8
	14/4/2000	39.3	21.4	8.9	0	12.7	76	30	10.2
	15/4/2000	36.3	27.1	9	0	12.5	78	26	10.3
16	16/4/2000	36.2	19.2	8.7	0	11	77	15	10.4
	17/4/2000	39	19.6	7.7	0	7.7	74	25	10.6
	18/4/2000	38.2	22	7.4	0	6.7	69	24	10.3
	19/4/2000	38.5	23.1	8	0	6.8	66	29	8.7
	20/4/2000	38.3	22.7	8.2	0	6.1	58	13	9.7
	21/4/2000	39.8	25.1	9.7	0	10.1	51	21	10.1
	22/4/2000	38.6	22.6	10	0	11.2	35	19	9.1
17	23/4/2000	37.3	22.1	8	0	4.8	62	17	7.1
	24/4/2000	38.3	19.6	8.5	0	6.5	51	17	10.7
	25/4/2000	37.3	22.5	9.5	0	10.9	65	34	11.1

	26/4/2000	35.8	22.8	9.5	0	12.2	54	28	11
	27/4/2000	38.7	22.2	9.8	0	10.9	70	18	11.1
	28/4/2000	37.8	17.7	9	0	7.1	47	15	11
	29/4/2000	38.3	17.5	10.7	0	3.6	42	18	11.2
18	30/4/2000	38.7	18.6	12.6	0	8.7	58	15	11.3
	1/5/2000	40.3	19.8	9.5	0	5.7	44	12	11.1
	2/5/2000	40	17.1	9	0	7.3	82	21	11.1
	3/5/2000	41.2	20	9.8	0	9.1	65	32	11.3
	4/5/2000	37.8	22.9	9.8	0	13.6	72	32	11.1
	5/5/2000	38.1	22.9	9	0	11.5	72	22	10.5
	6/5/2000	40.1	24.6	9.4	0.06	10.6	73	28	10.6
19	7/5/2000	37.9	24.8	7.8	0	9.6	70	24	7.6
	8/5/2000	38.3	23.5	9.1	0	9.3	71	33	10
	9/5/2000	35	22.1	6.1	0.4	8.7	72	32	9.3
	10/5/2000	35.9	22.6	6.5	0	7.2	76	44	6.1
	11/5/2000	36.1	22.1	5.2	0.5	7.3	69	26	8.4
	12/5/2000	35.7	21.8	9.3	0	13.2	67	31	11.1
	13/5/2000	34.3	20.6	8.8	0	11.4	74	33	11
20	14/5/2000	34.7	19.9	9.4	0	11.1	74	38	11
	15/5/2000	35.4	22.5	8.9	0	9.7	66	39	11
	16/5/2000	33.8	24.7	9.2	0	12.5	66	36	7.7
	17/5/2000	34.3	24.2	7	0	11.8	61	65	9.5
	18/5/2000	32.3	22.6	6.8	6.2	5.3	78	88	7.4
	19/5/2000	26.1	21.5	3.1	8.4	11.7	75	54	0.7
	20/5/2000	32.3	23.4	7.1	0	13.5	68	50	7.5
21	21/5/2000	32.7	22.4	8.1	0	14.1	77	48	10.9
	22/5/2000	34.3	22.5	8.9	0	12.2	76	38	11
	23/5/2000	34.3	22.3	9.4	0	11.4	72	50	10.6
	24/5/2000	33.9	23.7	6.1	0	11.5	73	53	10.9
	25/5/2000	34.8	24.6	9.4	0	11.6	75	62	11.3
	26/5/2000	34.6	24.6	7.8	0	17.5	80	56	10.7
	27/5/2000	34	25.1	6.8	08.2	8.7	76	62	7.8
22	28/5/2000	34.3	23.1	4.8	0.4	9.6	84	58	6.9
	29/5/2000	32.2	21.9	3.7	0	7.1	86	78	7.5
	30/5/2000	34.3	24.5	7.9	0	10.5	69	47	8.1
	31/5/2000	32.5	24.1	7.7	0	15.4	73	49	11.3
	1/6/2000	33.3	24.6	7	0	13.1	83	49	10.6
	2/6/2000	34.5	22	6	1.4	7.2	79	90	5.2
	3/6/2000	32.3	23.4	4.6	8.2	5.1	87	53	4.9
23	4/6/2000	34.1	22.4	5.5	40.8	6.3	92	62	6.3
	5/6/2000	32.8	22.5	6.5	26.1	6.6	97	58	4.6
	6/6/2000	31.3	20.8	6.7	22.3	6.1	96	69	4.5
	7/6/2000	31.1	21.6	4.9	16.4	4.6	97	62	2.7
	8/6/2000	32.3	22.9	4.4	7.4	5.8	91	86	6.3
	9/6/2000	25.8	22.5	1.2	3.1	5.5	92	92	0
	10/6/2000	30.5	23.9	1.9	5.6	5.9	87	72	4.2

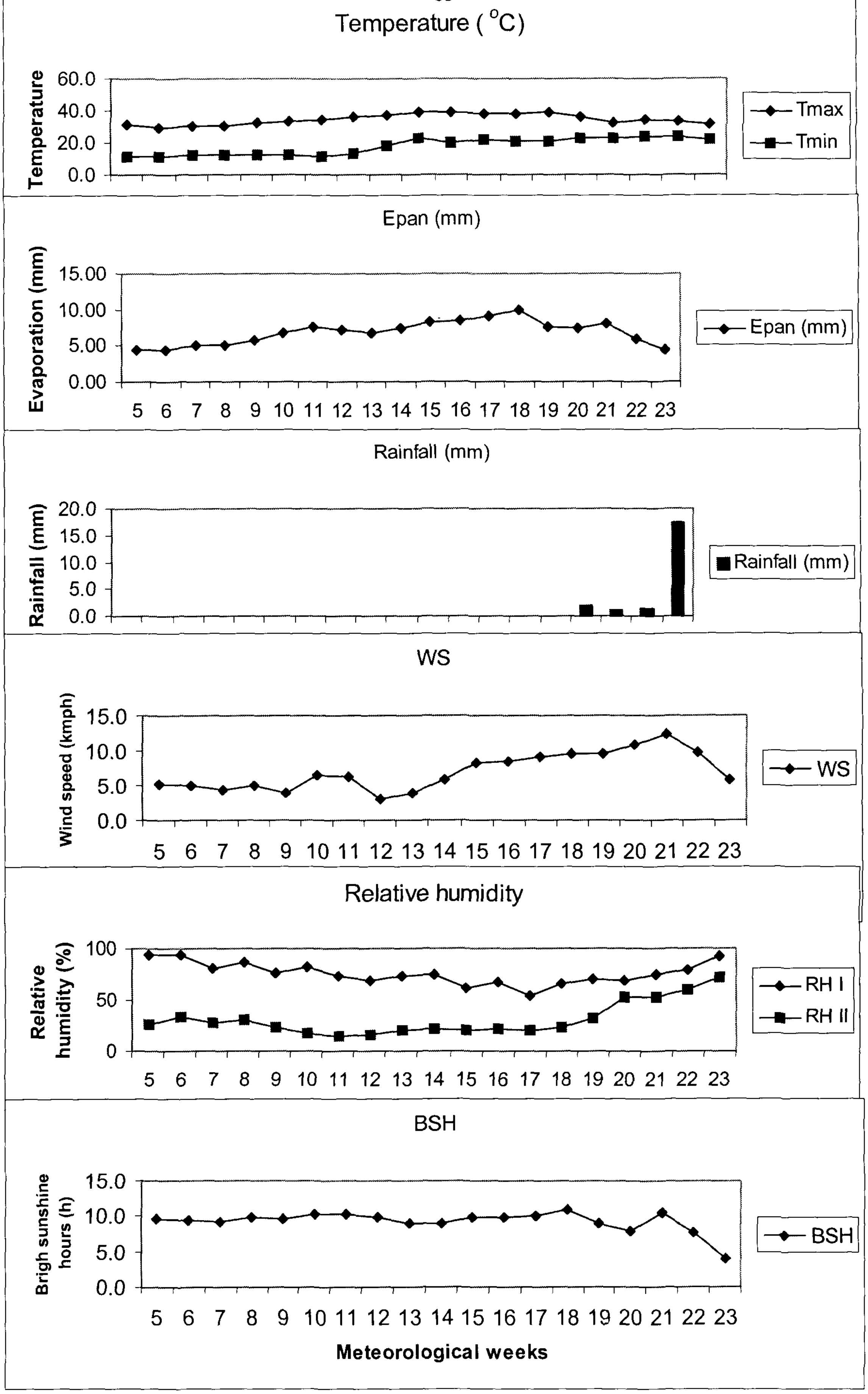


Fig. 2. Weather conditions during the experimental period.

4.2. Micrometeorological studies :

4.2.1. Effect of mulching on soil temperature under different irrigation schedules :

The data showing the mean soil temperature under different mulches at two depths viz., 5 and 15 cm at 1430 h are presented in Table 9 and shown graphically in Fig. 3 (a-d).

The mean soil temperatures at 5 and 15 cm depths under three mulches *viz.*, no mulch, straw mulch and polythene mulch and the irrigation schedules of 75, 100, 125 mm CPE and irrigation at 10 days internal were 44.8 °C and 29.5 °C, 45.4 °C and 31.1 °C, 46.2°C and 29.9 °C, 44.6 °C and 28.9 °C , respectively.

The mean soil temperatures at 5 and 15 cm depths under three mulches viz., no mulch, straw mulch and polythene mulch and irrigation scheduled at 75 mm CPE were 44.9 °C, 43.6°C, 45.9°C and 29.5°C, 28.5°C, 30.6°C, respectively. The maximum and minimum soil temperatures at 5 and 15 cm depths under no mulch and irrigation scheduled at 75 mm CPE were 51.2°C and 34.3°C, 42.1°C and 26.7°C, respectively. The maximum and minimum soil temperatures at 5 and 15 cm depths under straw mulch and irrigation scheduled at 75 mm CPE were 49.0°C and 32.4°C, 39.8°C and 25.1°C, respectively. The maximum and minimum soil temperatures at 5 and 15 cm depths under polythene mulch and irrigation scheduled at 75 mm CPE were 52.5°C and 36.3°C, 43.8°C and 28.5°C, respectively.

The mean soil temperatures at 5 and 15 cm depths under three mulches viz., no mulch, straw mulch and polythene mulch and irrigation scheduled at 100 mm CPE were 45.6, 44.3, 46.3°C, and 31.9, 28.5, 32.9°C, respectively. The maximum and minimum soil temperatures at 5 and 15 cm depths under no mulch and irrigation scheduled at 100 mm CPE were 50.3°C and 34.2°C, 43.0 and 26.7°C, respectively. The maximum and minimum soil temperatures at 5 and 15 cm depths under straw mulch and irrigation scheduled at 100 mm CPE were 47.4°C and 32.0°C, 39.7°C and 25.2°C, respectively. While, the maximum and minimum soil temperatures at 5 and 15 cm depths under polythene mulch and irrigation scheduled at 100 mm CPE were 52.0°C and 36.1°C, 44.9°C and 28.5°C, respectively.

The mean soil temperatures at 5 and 15 cm depths under three mulches viz., no mulch, straw mulch and polythene mulch and irrigation scheduled at 125 mm CPE were 46.2 45.1, 47.3°C, and 30.0, 28.6, 31.2°C, respectively. The maximum and minimum soil temperatures at 5 and 15 cm depths under no mulch and irrigation scheduled at 125 mm CPE were 49.6°C and 33.3°C, 43.0°C and 26.7°C, respectively. The maximum and minimum soil temperatures 5 and 15 cm depth under straw mulch and irrigation scheduled at 125 mm CPE at were 47.7°C and 31.2°C, 42.0°C, and 25.1°C, respectively. While, the maximum and minimum soil temperatures at 5 and 15 cm depths under polythene mulch and irrigation scheduled at 125 mm CPE were 51.8°C and 35.4°C, 44.2°C and 28.2°C, respectively.

The mean soil temperatures at 5 and 15 cm depths under three mulches viz., no mulch, straw mulch and polythene mulch and irrigation scheduled at 10 days interval were 44.7, 43.5, 45.6°C and 29.0, 27.9, 30.0°C,, respectively. The maximum and minimum soil temperatures at 5 and 15 cm depths under no mulch and irrigation scheduled at 10 days interval were 52.0°C and 33.6°C, 38.7°C and 26.0°C, respectively. The maximum and minimum soil temperatures at 5 and 15

Table 9. Soil temperatures at 5 cm and 15 cm depths as influenced by different irrigation schedules and mulches.

DAS	75 mm CPE							Mean
	5 cm			Mean	15 cm			
	M_0	M_1	M_2		M_0	M_1	M_2	
*28	42.1^{x}	39.8^{x}	43.8^{x}	41.9	27.0	25.1^{x}	29.0	27.0
30	43.2	42.8	43.5	43.1	23.5	23.0	23.8	23.4
*40	42.3	40.5	44.8	42.5	26.7^{x}	25.1	28.5^{x}	26.7
42	39.4	39.0	39.7	39.3	23.4	25.1	23.7	24.0
*50	47.8	45.5	48.9	47.4	28.6	25.6	30.0	28.0
52	43.5	43.1	43.8	43.4	25.4	29.5	25.7	26.8
*61	50.2	48.2	52.1	50.1	31.4	29.0	33.3	31.2
63	47.3	47.0	47.8	47.3	29.7	29.6	29.9	29.7
*69	50.0	48.2	52.1	50.1	33.2	31.1	35.0	33.1
71	48.1	47.8	48.4	48.1	29.9	30.0	30.1	30.0
*79	51.2^{xx}	49.0^{xx}	52.5^{xx}	50.9	34.3^{xx}	32.4^{xx}	36.1	34.2
81	42.7	42.4	43.0	42.7	30.4	30.7	30.7	30.6
*87	49.6	47.1	51.2	49.3	33.2	31.3	35.1	33.2
89	50.2	49.8	50.5	50.1	31.0	31.0	31.3	31.1
*95	49.5	47.3	51.2	49.3	34.0	32.1	36.3^{xx}	34.1
97	43.2	42.8	43.5	43.1	31.3	26.2	31.6	29.7
*105	44.0	42.0	46.2	44.0	33.0	31.1	35.5	33.2
107	24.1	23.8	24.4	24.1	26.5	25.5	26.8	26.2
Mean	44.9	43.6	45.9	44.8	29.5	28.5	30.6	29.5

* Day of irrigation, xx' - Max. temperature and x - Min. temperature.

DAS	100 mm CPE							Mean
	5 cm			Mean	15 cm			
	M_0	M_1	M_2		M_0	M_1	M_2	
*32	43.0^{x}	39.7^{x}	44.9^{x}	42.5	26.7^{x}	25.3	28.5^{x}	26.8
34	40.8	40.5	41.0	40.7	23.6	23.3	23.9	23.6
*46	48.0	46.4	48.9	47.7	27.7	25.2^{x}	28.6	27.1
48	44.7	44.4	45.0	44.7	25.5	25.2	25.8	25.5
*61	50.3^{xx}	48.1	52.0^{xx}	50.1	31.5	29.3	33.0	31.2
63	47.3	47.0	47.6	47.3	29.9	29.6	30.1	29.8
*73	47.5	45.1	49.3	47.3	32.5	30.0	33.9	32.1
75	48.3	48.0	43.5	46.6	30.4	30.1	30.7	30.4
*86	49.5	47.4^{xx}	51.3	49.4	33.1	31.0	35.0	33.0
88	46.8	46.5	47.1	46.8	30.4	30.0	30.7	30.3
*98	46.0	44.1	48.1	46.0	34.2^{xx}	32.0^{xx}	36.1^{xx}	34.1
100	43.3	43.0	43.7	43.3	31.2	30.8	31.5	31.1
*110	46.3	44.1	48.5	46.3	30.9	28.7	32.5	30.7
112	37.5	37.2	37.9	37.5	29.4	29.1	29.7	29.4
Mean	45.6	44.3	46.3	45.4	31.9	28.5	32.9	31.1

* Day of irrigation, xx' - Max. temperature and x - Min. temperature.

DAS	125 mm CPE							Mean
	5 cm			Mean	15 cm			
	M_0	M_1	M_2		M_0	M_1	M_2	
*36	43.0^{x}	42.0^{x}	44.2^{x}	43.0	26.7^{x}	25.1^{x}	28.2^{x}	26.6
38	43.3	43.0	43.6	43.3	24.2	24.0	24.5	24.2
*54	44.3	42.7	46.1	44.3	29.9	27.4	31.1	29.4
56	43.4	43.0	43.8	43.4	26.7	26.4	27.0	26.7
*69	49.8^{xx}	47.7^{xx}	51.3	49.6	33.2	31.1	35.0	33.1
71	49.0	48.7	49.2	48.9	29.5	29.3	29.8	29.5
*86	49.6	47.4	51.8^{xx}	49.6	33.3^{xx}	31.2^{xx}	35.1	33.2
88	46.8	46.5	48.0	40.43	30.5	28.4	33.0	30.6
*101	47.6	45.3	49.5	47.4	33.2	31.0	35.4^{xx}	33.2
103	45.5	45.1	45.8	45.4	33.0	32.5	33.2	32.9
Mean	46.2	45.1	47.3	46.2	30.0	28.6	31.2	29.9

* Day of irrigation, xx - Max. temperature and x - Min. temperature.

DAS	10 days interval							Mean
	5 cm			Mean	15 cm			
	M_0	M_1	M_2		M_0	M_1	M_2	
*28	41.3	40.1	42.8	41.4	26.0^{x}	24.5^{x}	27.5^{x}	26.0
30	39.5	39.1	39.8	39.4	24.6	24.3	24.8	24.5
*38	43.0	39.7	44.9	42.5	26.7	25.3	28.5	26.8
40	40.4	40.0	40.7	40.3	23.0	22.7	23.4	23.0
*48	42.6	40.2	44.3	42.3	27.1	25.2	29.8	27.3
50	41.3	41.0	41.5	41.2	24.3	24.0	24.6	24.3
*58	48.6	46.5	49.9	48.3	30.0	28.9	31.0	29.9
60	41.0	40.7	41.3	41.0	26.5	26.1	26.8	26.4
*68	51.5	49.5	52.9	51.3	32.2	30.1	33.2	31.8
70	46.7	46.4	47.0	46.7	30.0	29.5	30.2	29.9
*78	52.0^{xx}	50.0^{xx}	54.0^{xx}	52.0	33.5	31.1	35.3^{xx}	33.3
80	40.2	39.8	40.5	40.1	30.1	29.7	30.5	30.1
*88	51.0	49.5	53.1	51.2	33.6	31.2^{xx}	35.3^{xx}	33.3
90	45.2	45.0	45.5	45.2	30.3	30.0	30.5	30.2
*98	48.5	46.3	50.0	48.2	33.7^{xx}	31.2^{xx}	35.3^{xx}	33.4
100	48.6	48.2	48.8	48.5	30.9	30.6	31.2	30.9
*108	38.7^{x}	36.3^{x}	40.1^{x}	38.3	31.3	29.5	33.2	31.3
110	45.1	44.8	45.4	45.1	29.4	29.0	29.6	29.3
Mean	44.7	43.5	45.6	44.6	29.0	27.9	30.0	28.9

* Day of irrigation, xx - Max. temperature and x - Min. temperature.

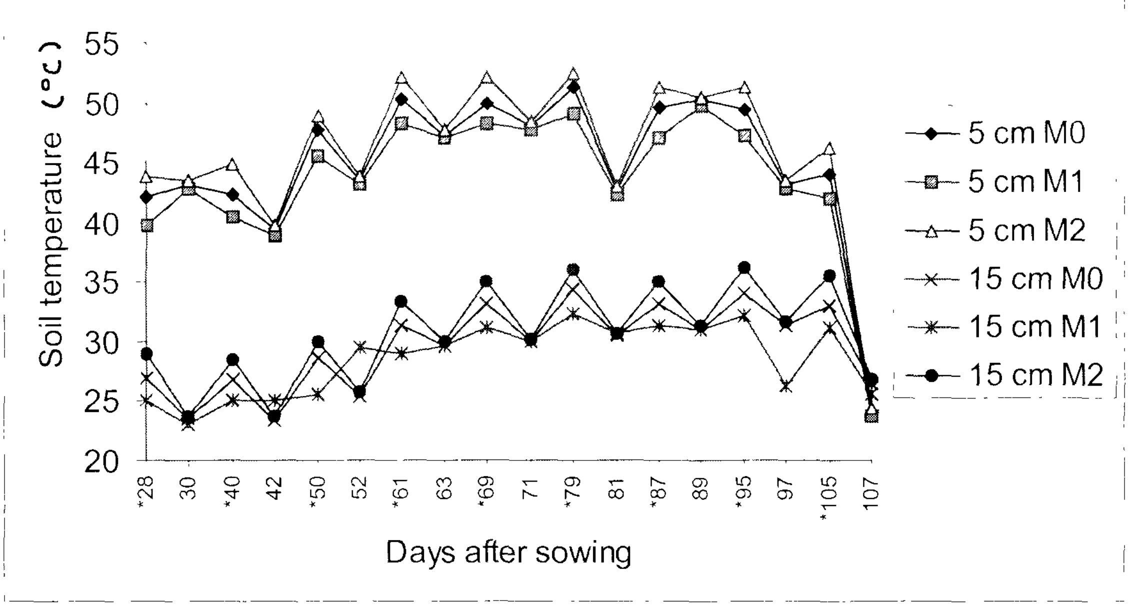


Fig. 3a. Soil temperatures (°C) at 5 cm and 15 cm depth under different mulches as influenced by irrigation schedule of 75 mm CPE.

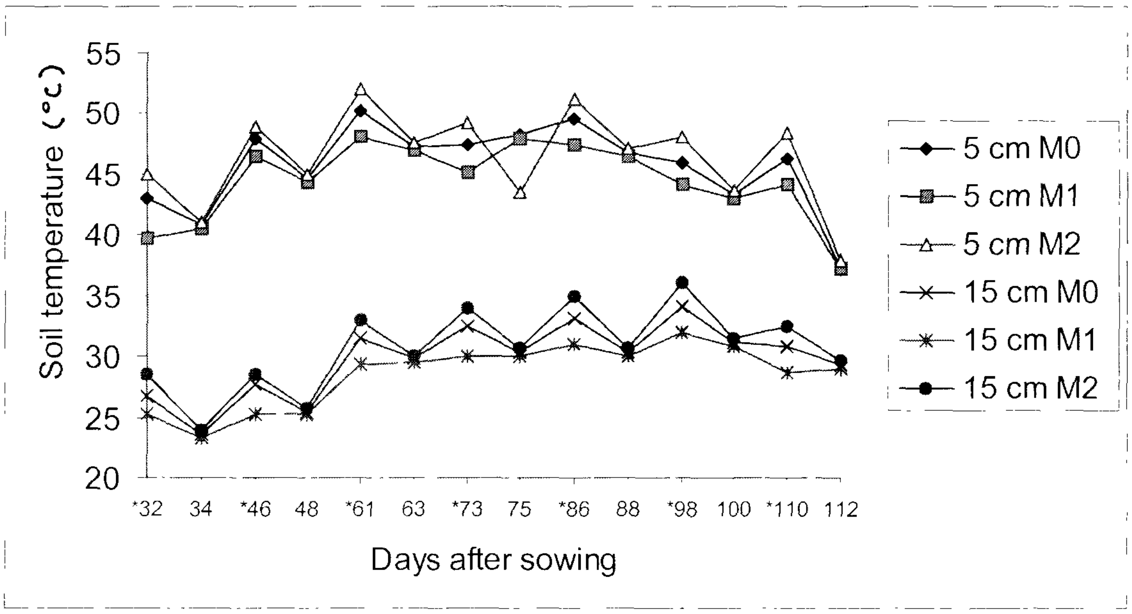


Fig. 3b. Soil temperatures (°C) at 5 cm and 15 cm depth under different mulches as influenced by irrigation schedule of 100 mm CPE.

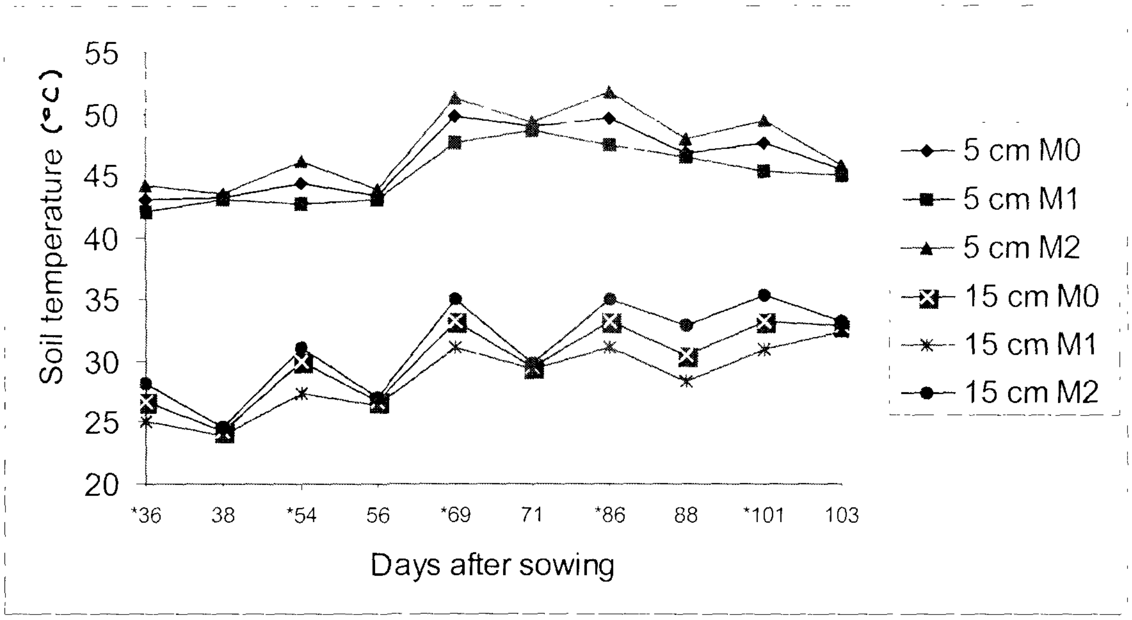


Fig. 3c. Soil temperatures (°C) at 5 cm and 15 cm depth under different mulches as influenced by irrigation schedule of 125 mm CPE.

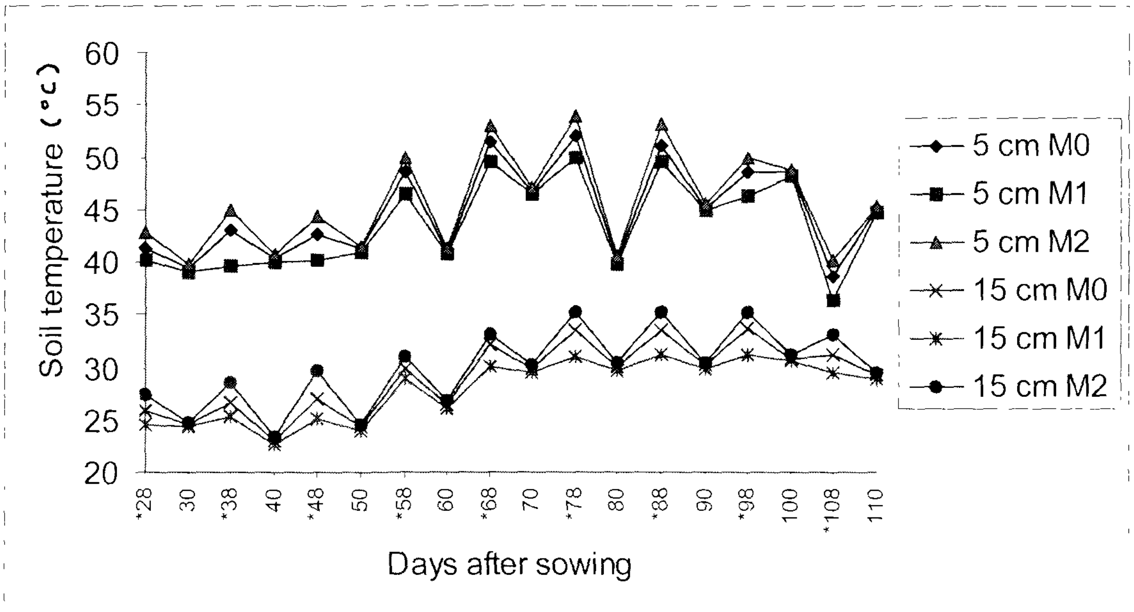


Fig. 3d. Soil temperatures (°C) at 5 cm and 15 cm depth under different mulches as influenced by irrigation schedule of 10 days interval.

cm depths under straw mulch and irrigation scheduled at 10 days interval were 50.0°C and 31.2°C, 36.3°C and 24.5°C, respectively. While, the maximum and minimum soil temperatures at 5 and 15 cm depths under polythene mulch treatment and irrigation scheduled at 10 days interval were 54.0°C and 35.3°C, 40.1°C and 27.5°C, respectively

These results are in conformity with the findings of Hanks *et al.* (1961), Barrows and Larson (1962), Adams (1965), Sowers and Wetterlen (1988), Hu Wenguang (1995), and Park (1996).

Table 10. The mean seasonal soil temperatures at 5 and 15 cm depths as influenced by different irrigation schedules and mulches.

Irrigation schedules CPE (mm)	Soil temperatures (°C) under different mulches					
	M_0		M_1		M_2	
	5 cm	15 cm	5 cm	15 cm	5 cm	15 cm
75	44.9	29.5	43.6	28.5	45.9	30.6
100	45.6	31.9	44.3	28.5	46.3	31.1
125	46.2	30.0	45.1	28.6	47.3	31.2
10 DI	44.7	29.0	43.5	27.9	45.6	30.9

Irrigation scheduling :

The mean seasonal soil temperatures at 5 cm depths were comparatively more under irrigation scheduled at 125 mm CPE followed by irrigation scheduled at 100 mm CPE. There was no much mean seasonal variation in soil temperature recorded under irrigation scheduled at 75 mm CPE and scheduling of irrigation at 10 days interval owing to equal number of irrigations (9) applied under these two schedules. The higher soil temperatures under 125 mm CPE may be due to longer irrigation interval. The same may be true for irrigation scheduling at 100 mm CPE. Similar trend of mean soil temperatures were recorded for the 15 cm depths under different irrigation schedules.

Mulching :

The mean seasonal soil temperatures were more under polythene mulch followed by no mulch and straw mulch. The Polythene mulch allows sunrays to pass the soil but may act as insulating material for evaporative water resulting in increasing the mean seasonal soil temperatures as well as retention of more soil moisture which ultimately resulted in the higher pod and creeper yield under polythene mulch. These results are similar to those reported by Hu Waneguang (1995), Park (1996) and Anonymous (1999).

The seasonal soil temperatures under straw mulch was lower than no mulch because less heat energy riches the soil due to greater reflection of solar radiation. Similar results are reported by Hanks *et al,* (1961), Burrowers and Larson (1962), Adams (1965), Sowers and Wetterlen (1988), Brar and Khera (1988) and Dayal (1991).

4.2.2. Canopy temperature :

4.2.2.1. Seasonal changes of canopy temperature (T_C) :

The data pertaining to seasonal changes in canopy temperatures (T_C) as influenced by different irrigation schedules and mulches are presented in Table 11 and shown graphically in Fig. 4 (a-d).

The canopy temperatures (T_C) were recorded just before the schedule of the irrigation and 48 hours after irrigation under different irrigation schedules and mulches between 13.30 to 14.30 h starting from 28 DAS. It is seen from the data in Table 11 and Fig. 4(a-d) that the values of the canopy temperatures were the highest just before irrigation and the lowest after irrigation under all the irrigation schedules and mulches. Similarly, in the different irrigation schedules and mulches, canopy temperatures were lower in early crop growth periods and higher with advancement in crop age.

The canopy temperatures (T_C) were consistently higher under stressed as compared to unstressed conditions throughout the crop growth period. The values of canopy temperatures under extremely stressed conditions of the irrigation schedules of 125 mm CPE under no mulch, straw mulch and polythene mulch treatments were 39.6, 39.6, 39.1, 40.0, 41.1; 39.2, 39.3, 39.0, 39.7, 40.7 and 39.8, 39.9, 39.4, 40.2, and 41.4 on 36, 54,69, 86 and 101 DAS respectively, and that of stressed conditions of irrigation scheduled at 100 mm CPE under no mulch, straw mulch and polythene mulch were 37.5, 37.0, 38.1, 38.2, 38.7, 39.0 and 39.3; 37.3, 36.8, 37.8, 38.0, 38.4, 38.8 and 39.0 °C and 37.7, 37.3, 38.4, 38.4, 38.9, 39.4 and 39.5 °C , respectively.

Whereas, under unstressed conditions of irrigation scheduled at 10 days interval, the canopy temperature value under no mulch, straw mulch and polythene mulch at 28, 38, 48, 58, 68, 78, 88, 98 and 108 DAS were 31.4, 31.9, 32.4, 33.5, 33.9, 34.1, 34.2, 34.1 and 34.4 °C; 31.2, 31.4, 32.0, 33.2, 33.5, 33.7, 34.0, 33.8, and 34.0°C and 31.6, 32.2, 32.6, 33.7, 34.2, 34.3, 34.4, 34.4 and 34.2, respectively. The irrigation scheduled at 75 mm CPE, the canopy temperatures values during 28, 40, 50, 61,69, 79, 87, 95 and 105 DAS under no mulch (without mulch), straw mulch and polythene mulch were 35.2, 35.5, 36.3, 36.5, 36.8, 36.5, 36.9, 37.1, and 37.3°C, 35.0, 35.4, 35.7, 36.2, 36.0, 36.2, 36.6, 36.8 and 37.0°C and 35.4, 35.6, 36.4, 36.6, 37.0, 36.7, 37.2, 37.4 and 37.6°C, respectively, showing wide variation in canopy temperatures of stressed and unstressed conditions.

The cooler canopy under unstressed conditions than stressed conditions was due to increase in water availability for transpiration, higher values of stomatal

Table 11: Seasonal changes of canopy temperatures (Tc) as influenced by different irrigation schedules and mulches.

DAS	75 mm CPE			DAS	100 mm CPE			DAS	125 mm CPE			DAS	10 days interval		
	M_0	M_1	M_2		M_0	M_1	M_2		M_0	M_1	M_2		M_0	M_1	M_2
*28	35.2	35.0	35.4	*32	37.5	37.3	37.7	*36	39.6	39.2	39.8	*28	31.4	31.2	31.6
30	31.5	31.2	32.0	34	35.0	34.7	35.3	38	36.2	36.0	36.5	30	28.2	28.0	28.5
*40	35.5	35.4	35.6	*46	37.0	36.8	37.3	*54	39.6	39.3	39.9	*38	31.9	31.4	32.2
42	32.4	32.0	32.8	48	35.1	34.7	35.4	56	36.2	35.7	36.5	40	28.3	28.0	28.6
*50	36.3	35.7	36.4	*61	38.1	37.8	38.4	*69	39.1	39.0	39.4	*48	32.4	32.0	32.6
52	33.1	32.9	33.4	63	36.2	36.0	36.5	71	37.0	36.7	37.4	50	29.3	29.0	29.5
*61	36.5	36.2	36.6	*73	38.2	38.0	38.4	*86	40.0	39.7	40.2	*58	33.5	33.2	33.7
63	33.4	33.1	33.7	75	36.0	35.7	36.3	88	37.5	37.2	37.7	60	30.5	30.2	30.7
*69	36.8	36.0	37.0	*86	38.7	38.4	38.9	*101	41.1	40.7	41.4	*68	33.9	33.5	34.2
71	33.5	33.2	33.7	88	38.0	37.7	38.3	103	38.3	38.0	38.5	70	30.5	30.2	30.7
*79	36.5	36.2	36.7	*98	39.0	38.8	39.4	-	-	-	-	*78	34.1	33.7	34.3
81	33.5	33.3	33.7	100	37.2	37.0	37.4	-	-	-	-	80	31.3	31.0	31.7
*87	36.9	36.6	37.2	*110	39.3	39.0	39.5	-	-	-	-	*88	34.2	34.0	34.4
89	34.0	33.5	34.4	112	37.3	37.1	37.5	-	-	-	-	90	31.2	30.9	31.5
*95	37.1	36.8	37.4	-	-	-	-	-	-	-	-	*98	34.1	33.8	34.4
97	34.4	34.1	34.6	-	-	-	-	-	-	-	-	100	31.3	31.0	31.6
*105	37.3	37.0	37.6	-	-	-	-	-	-	-	-	*108	34.0	33.7	34.2
107	35.1	35.0	35.3	-	-	-	-	-	-	-	-	110	31.1	30.8	31.4

DAS–Days after sowing * - days of irrigation.

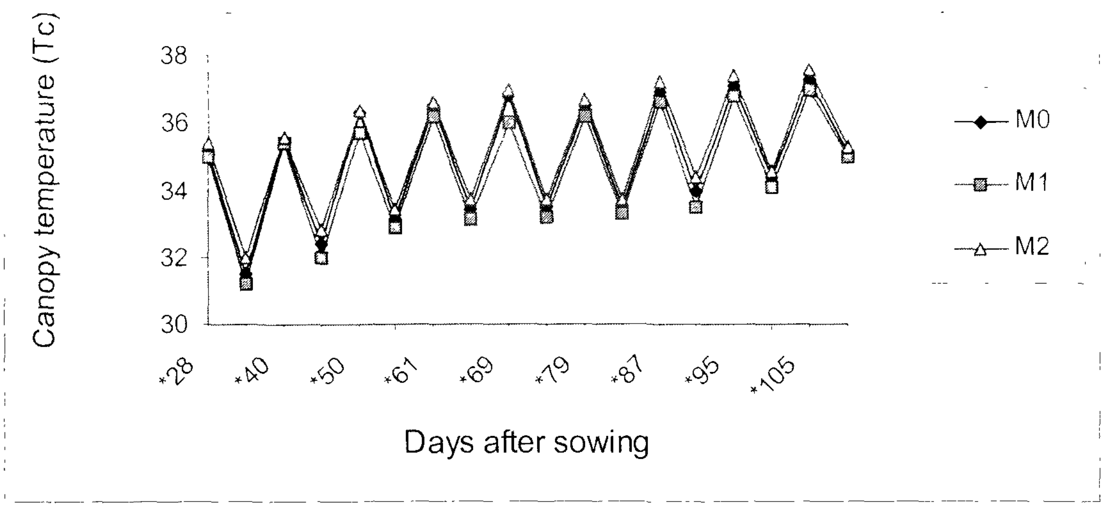


Fig.4a. Seasonal canopy temperatures (Tc) under different mulches influenced by irrigation schedule of 75 mm CPE.

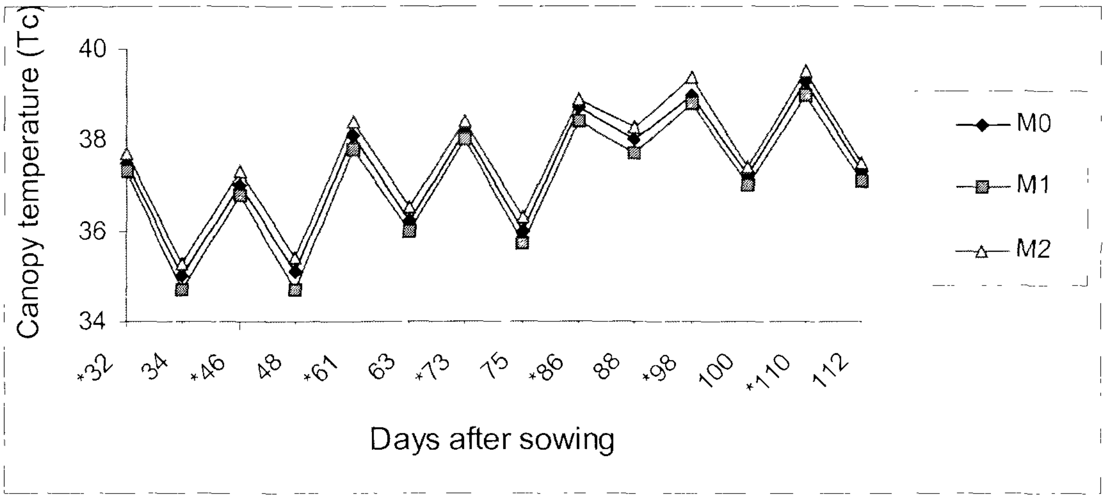


Fig.4b. Seasonal canopy temperatures (Tc) under different mulches influenced by irrigation schedule of 100 mm CPE.

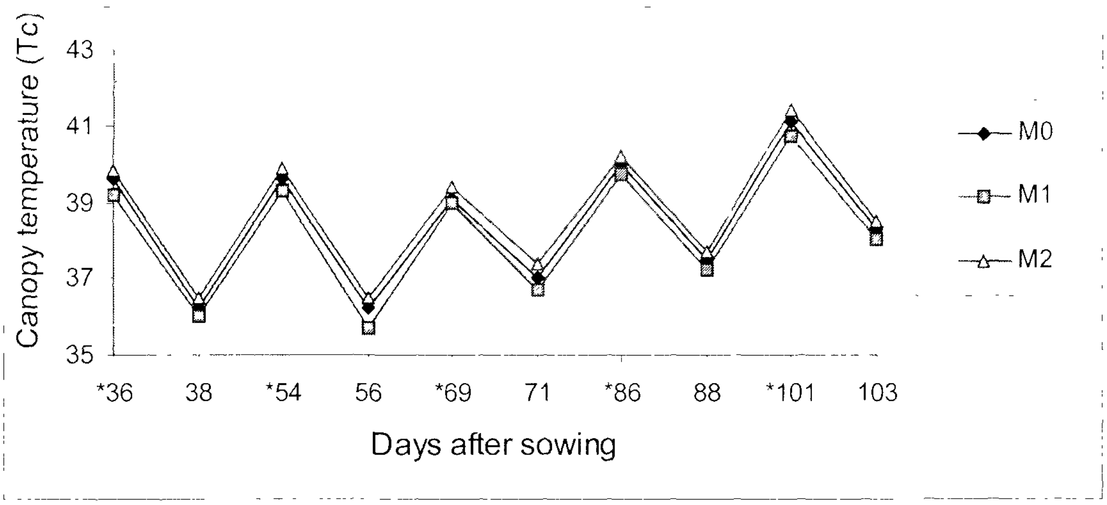


Fig.4c. Seasonal canopy temperatures (Tc) under different mulches influenced by irrigation schedule of 125 mm CPE.

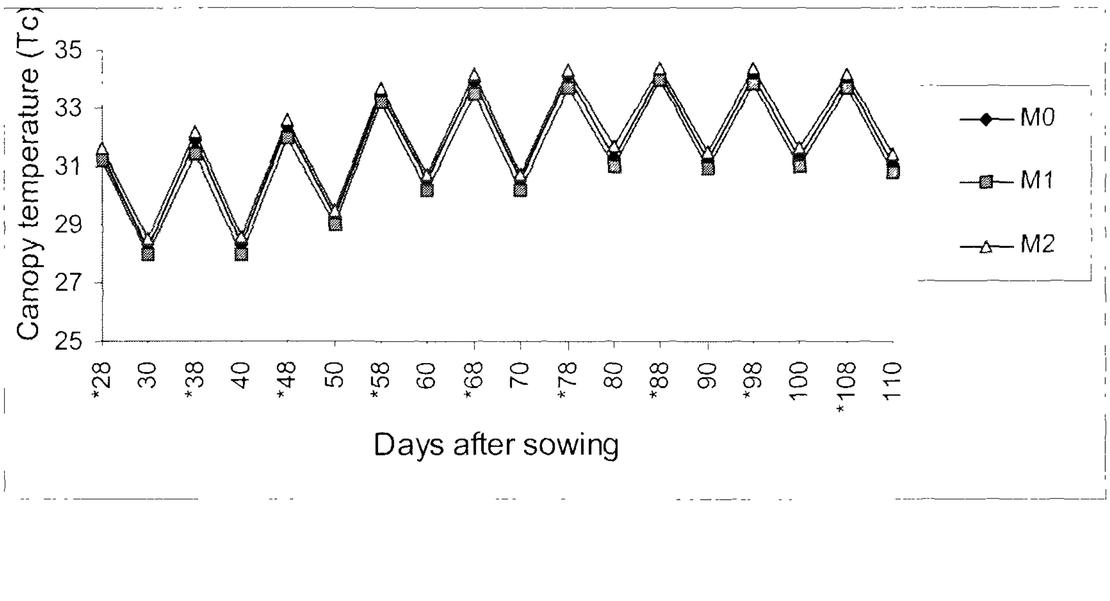


Fig.4d. Seasonal canopy temperatures (Tc) under different mulches influenced by irrigation schedule of 10 days interval.

conductance and lower values of leaf temperatures which inadvertently was due to shorter irrigation interval. However, reverse situations were observed under stressed conditions where in water availability for evaporative cooling was less resulting in less stomatal conductance due to longer irrigation intervals. While, canopy temperatures (T_C) under polythene mulch were higher over no mulch and straw mulch, canopy temperatures of no mulch were also higher over straw mulch under all irrigation schedules. These results are in conformity with findings of Frank *et al.* (1977), Gardner *et al.* (1981a), Throssell *et al.* (1987) and Blad *et al.* (1988).

4.2.2.2. Seasonal changes of canopy - air temperature differential (ΔTc):

The data regarding canopy–air temperature differential (ΔTc) during crop growth periods as influenced by different irrigation schedules and mulches are presented in Table 12 and shown graphically in Fig. 5 (a-d).

The values of canopy –air temperature differential (ΔTc) were recorded in similar fashion as that of canopy temperature under different irrigation schedules and mulches.

It would be seen from the data presented in Table 12 and from Fig. 5(a-d) that the values of ΔTc were recorded highest just before the schedule of irrigation and the lowest after 48 hours of under all the irrigation schedules and mulches. The leaf water potential and stomatal conductance were in tune with moisture availability just before irrigation causing partial or complete stomatal closure resulting in higher canopy temperatures than air temperatures. Whereas, after irrigation, plenty of water was available for absorption by the plants. This resulted in higher leaf water potential and stomatal conductance which resulted in increase in transpiration and thereby less canopy temperature due to evaporative cooling

Table 12. Seasonal changes of canopy- air temperatures (ΔTc) as influenced by different irrigation schedules and mulches.

DAS	75 mm CPE			DAS	100 mm CPE			DAS	125 mm CPE			DAS	10 days interval		
	M_0	M_1	M_2		M_0	M_1	M_2		M_0	M_1	M_2		M_0	M_1	M_2
*28	1.9	1.3	2.2	*32	1.2	1.1	1.5	*36	0.2	0.3	1.5	*28	1.3	1.1	1.5
30	-0.9	-0.7	-1.2	34	-1.2	-1.3	-1.8	38	-2.2	-1.7	-2.5	30	-0.9	-0.7	-1.2
*40	0.9	1.6	1.2	*46	0.5	0.5	1.0	*54	1.0	0.7	1.5	*38	1.7	1.5	2.0
42	-0.5	-0.3	-0.8	48	-1.5	-1.2	-1.7	56	-1.3	-1.0	-1.5	40	-0.5	-0.5	-0.7
*50	1.0	0.8	1.3	*61	1.2	0.9	1.5	*69	1.4	1.0	1.7	*48	0.9	0.6	1.2
52	-0.9	-0.8	-1.1	63	-0.9	-0.5	-1.1	71	-1.5	-1.1	-1.8	50	-0.9	-0.7	-1.2
*61	0.9	0.6	1.2	*73	1.7	1.5	2.0	*86	1.9	1.5	2.1	*58	1.3	1.0	1.5
63	-0.3	-0.5	-0.5	75	-1.7	-1.3	-1.9	88	-1.9	-1.6	-2.2	60	-0.3	-0.1	-0.5
*69	2.0	1.7	2.3	*86	1.2	1.0	1.5	*101	1.2	1.0	1.5	*68	0.8	0.5	1.2
71	-1.2	-1.1	-1.5	88	-0.5	-0.5	-0.7	103	-1.7	-1.6	-2.0	70	-0.2	-0.2	-0.5
*79	1.5	1.0	1.7	*98	1.7	1.4	1.9	-	-	-	-	*78	1.2	0.9	1.5
81	-0.5	-0.3	-0.8	100	-0.9	-0.5	-1.2	-	-	-	-	80	-0.7	-0.5	-0.9
*87	0.9	1.7	1.2	*110	2.2	1.9	2.4	-	-	-	-	*88	1.9	1.6	2.2
89	-0.5	-0.3	-0.8	112	-0.7	-0.5	-1.0	-	-	-	-	90	-0.7	-0.5	-1.0
*95	1.7	1.1	1.9	-	-	-	-	-	-	-	-	*98	1.3	0.7	1.5
97	-0.7	-0.5	-1.1	-	-	-	-	-	-	-	-	100	-0.3	-0.1	-0.5
*105	1.9	0.6	2.1	-	-	-	-	-	-	-	-	*108	1.4	1.1	1.7
107	-0.8	-0.5	-1.0	-	-	-	-	-	-	-	-	110	-0.4	-0.2	-0.8

DAS–Days after sowing * - days of irrigation.

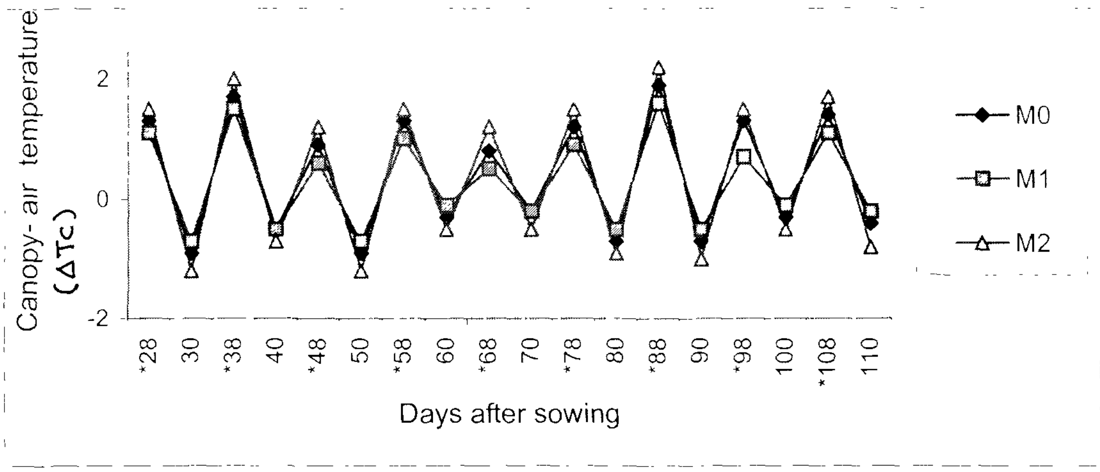


Fig.5a. Seasonal canopy - air temperature differential (ΔTc) under different mulches as influenced by irrigation schedule of 75 mm CPE.

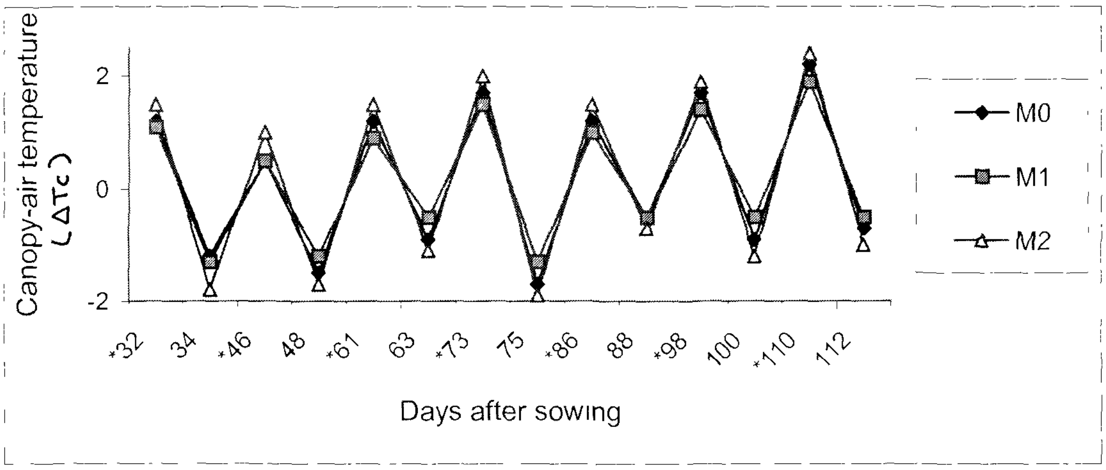


Fig.5b. Seasonal canopy - air temperature differential (ΔTc) under different mulches as influenced by irrigation schedule of 100 mm CPE.

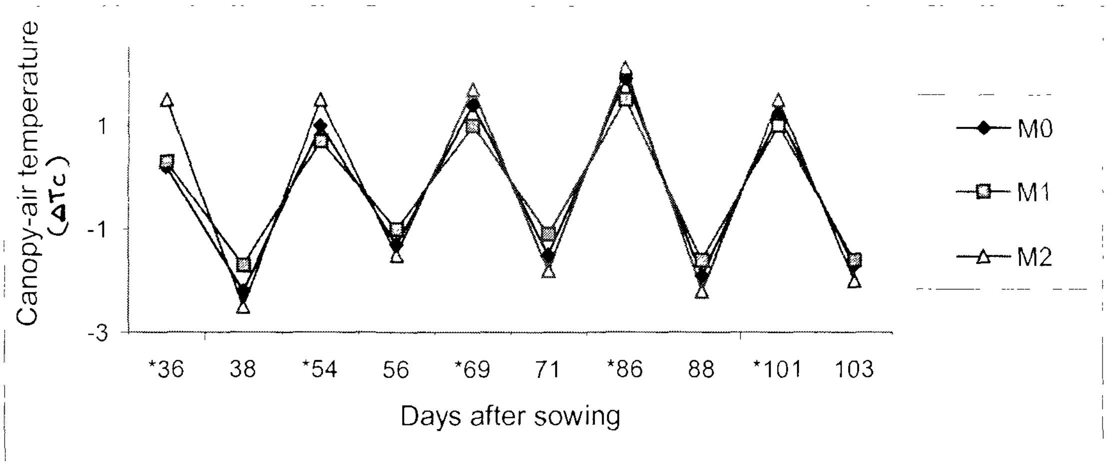


Fig.5c. Seasonal canopy - air temperature differential (ΔTc) under different mulches as influenced by irrigation schedule of 125 mm CPE.

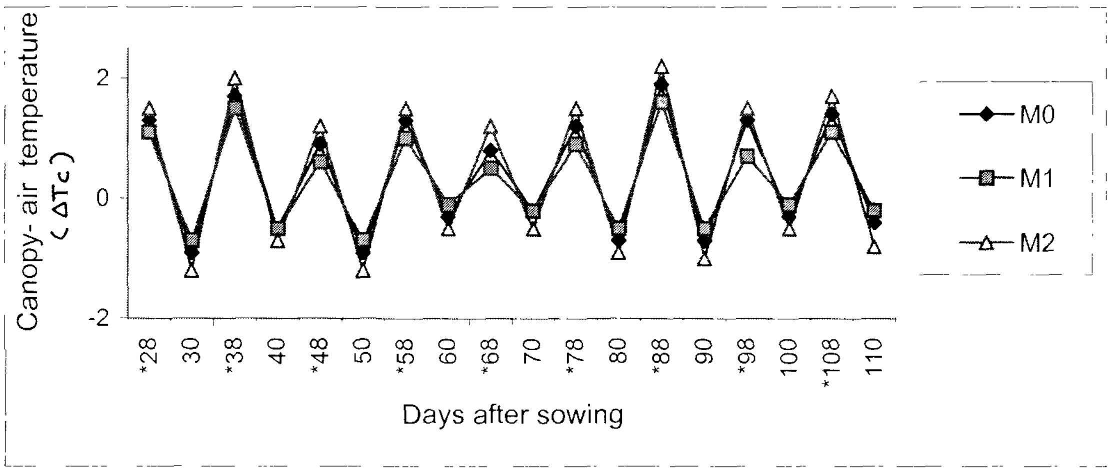


Fig.5d. Seasonal canopy - air temperature differential (ΔTc) under different mulches as influenced by irrigation schedule of 10 days interval.

than air temperatures and hence, ΔTc values were negative after scheduling of the irrigations.

Similarly, ΔTc values were lower during early crop growth period and higher during later crop growth period in all the irrigation schedules and mulches because of more active growth of the leaves during early crop growth period and less active functional leaves due to their ageing during later crop growth period resulted in increased ΔTc values.

The ΔTc values under unstressed conditions (irrigation scheduled at 10 days interval) under no mulch (without mulch), straw mulch and polythene mulch were 1.3, 1.7, 0.9, 1.3, 0.8, 1.2, 1.9, 1.3, and 1.4°C; 1.1, 1.5, 0.6, 1.0, 0.5, 0.9, 1.6, 0.7 and 1.1, 1.5, 2.0, 1.2, 1.5, 1.2, 1.5, 2.2, 1.5. and 1.7 at 28, 48, 58, 68, 78, 88, 98 and 108 DAS, respectively, and moderately unstressed condition (irrigation scheduled at 75 mm CPE) under no mulch, straw mulch and polythene mulch were 1.9, 0.9, 1.0, 0.9, 2.0, 1.5, 0.9, 1.7 and 1.9°C; 1.3, 1.6, 0.8, 0.6, 1.7, 1.0, 1.7, and 0.6°C, and 2.2, 1.2, 1.3., 1.2, 2.3, 1.7, 1.2, 1.9 and 2.1°C at 28, 40, 50, 61, 69, 79, 87, 95 and 105 DAS, respectively.

While under highly stressed conditions (irrigation scheduled at 125 mm CPE) under no mulch, straw mulch and polythene mulch were 0.2, 1.0, 1.4, 1.9 and 1.2°C; and 0.3, 0.7, 1.0, 1.5 and 1.0°C; and 0.5, 1.5, 1.7, 2.1 and 1.5°C at 36, 54, 69, 86 and 101 DAS, respectively, and that of moderately stressed condition (irrigation scheduled at 100 mm CPE) under no mulch, straw mulch and polythene mulch were 1.2, 0.5, 1.2, 1.7, 1.2, 1.7 and 2.2°C, 1.1, 0.5, 0.9, 1.5, 1.9, 1.4 and 1.9°C and 1.5, 1.0, 1.5, 2.0, 1.5, 1.9 and 2.4°C , respectively, showing lot of variations in ΔTc which were due to variations in leaf water potential, stomatal conductance and leaf temperatures which have been attributed due to variations in irrigation intervals. Similar pattern was observed in subsequent irrigation schedules. These results are in conformity with the findings of Jackson. (1981), Singh and Kanemasu (1983), Khera and Sandhu (1986) and Blad *et al.* (1988).

4.2.3. Stomatal conductance, diffusive resistance and transpiration :

4.2.3.1 Stomatal conductance of abaxial and adaxial leaf surface at various growth stages of summer groundnut.

The abaxial and adaxial stomatal conductance as influenced periodically by different treatments are presented in Table 13 and shown graphically in Fig. 6(a-d).

The mean stomatal conductance (cms^{-1}) decreased with the advancement of crop age (from initiation of branching phase to harvest phase).

Irrigation scheduling :

In general, it was observed that stomatal conductance was decreased with increased the CPE values indicating that stress conditions offered more resistance to water flow resulting in decrease in stomatal conductance. Similar results were reported by Rao and Bhatt (1991). Stomatal conductance was found identical under 75 mm CPE and irrigation scheduled at 10 days interval.

It was also observed that abaxial stomatal conductance was more than adaxial stomatal conductance at all days of observations under all the irrigation schedules. Bodlaender *et al.*(1986), Vos.(1986), Yera *et al.* (1986), Misra and Gangwar (1987) and Vieira (1989) also reported more values of abaxial stomatal conductance than adaxial stomatal conductance.

Table 13. Mean abaxial and adaxial stomatal conductance (cms^{-1}) as influenced by different irrigation schedules and mulches.

DAS	75 mm CPE					
	No mulch		Straw Mulch		Polythene mulch	
	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial
28	0.53	0.38	0.55	0.38	0.56	0.39
42	0.42	0.38	0.43	0.39	0.43	0.40
50	0.41	0.38	0.42	0.39	0.43	0.40
61	0.40	0.37	0.41	0.38	0.42	0.39
69	0.39	0.36	0.40	0.37	0.41	0.37
79	0.39	0.30	0.40	0.31	0.40	0.31
87	0.38	0.30	0.38	0.30	0.39	0.30
95	0.37	0.30	0.37	0.31	0.38	0.31
105	0.37	0.30	0.38	0.30	0.39	0.30
Harvest	0.39	0.30	0.39	0.30	0.40	0.31
DAS	100 mm CPE					
32	0.44	0.34	0.46	0.33	0.48	0.34
46	0.30	0.30	0.31	0.30	0.31	0.31
61	0.39	0.31	0.40	0.32	0.41	0.32
73	0.36	0.31	0.37	0.31	0.37	0.32
86	0.36	0.31	0.38	0.32	0.37	0.32
98	0.35	0.29	0.36	0.30	0.37	0.30
110	0.37	0.30	0.38	0.31	0.39	0.31
Harvest	0.39	0.31	0.40	0.31	0.41	0.32
DAS	125 mm CPE					
36	0.45	0.28	0.46	0.29	0.47	0.29
54	0.34	0.31	0.35	0.31	0.35	0.32
69	0.34	0.30	0.34	0.30	0.34	0.31
86	0.30	0.27	0.31	0.27	0.31	0.28
101	0.29	0.25	0.30	0.26	0.30	0.26
Harvest	0.29	0.25	0.29	0.25	0.30	0.26
DAS	10 days interval					
28	0.61	0.36	0.62	0.36	0.65	0.37
38	0.54	0.34	0.56	0.35	0.57	0.35
48	0.42	0.39	0.43	0.39	0.44	0.40
58	0.41	0.36	0.47	0.37	0.43	0.38
68	0.39	0.31	0.40	0.31	0.41	0.32
78	0.38	0.30	0.39	0.31	0.40	0.31
88	0.36	0.29	0.37	0.29	0.38	0.30
98	0.36	0.30	0.37	0.30	0.37	0.30
108	0.36	0.29	0.36	0.29	0.37	0.29
Harvest	0.36	0.28	0.35	0.28	0.36	0.26

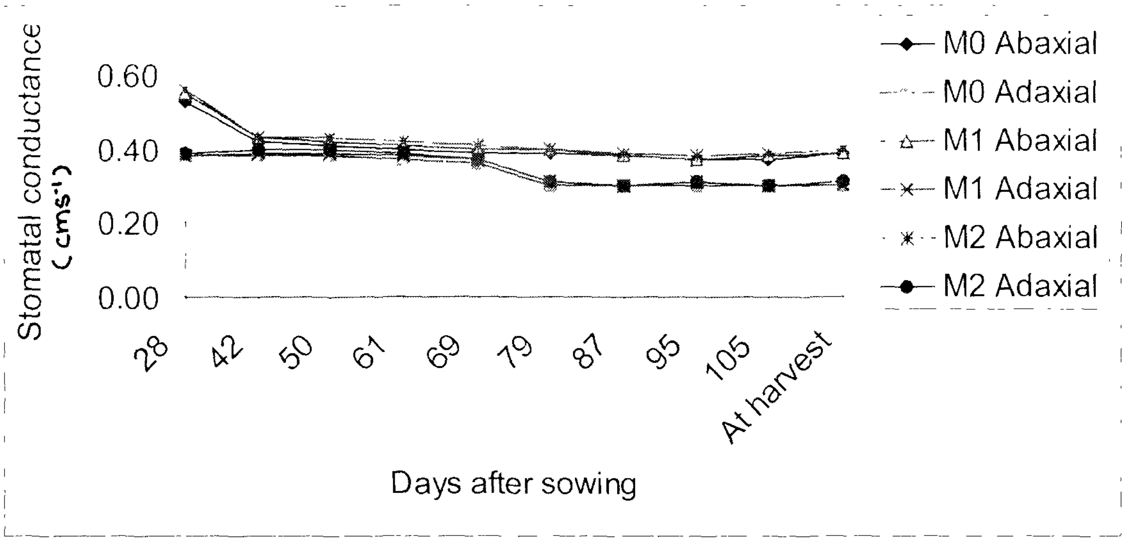


Fig.6a. Mean abaxial and adaxial stomatal conductance (cms^{-1}) under mulches as influenced by irrigation schedule of 75 mm CPE.

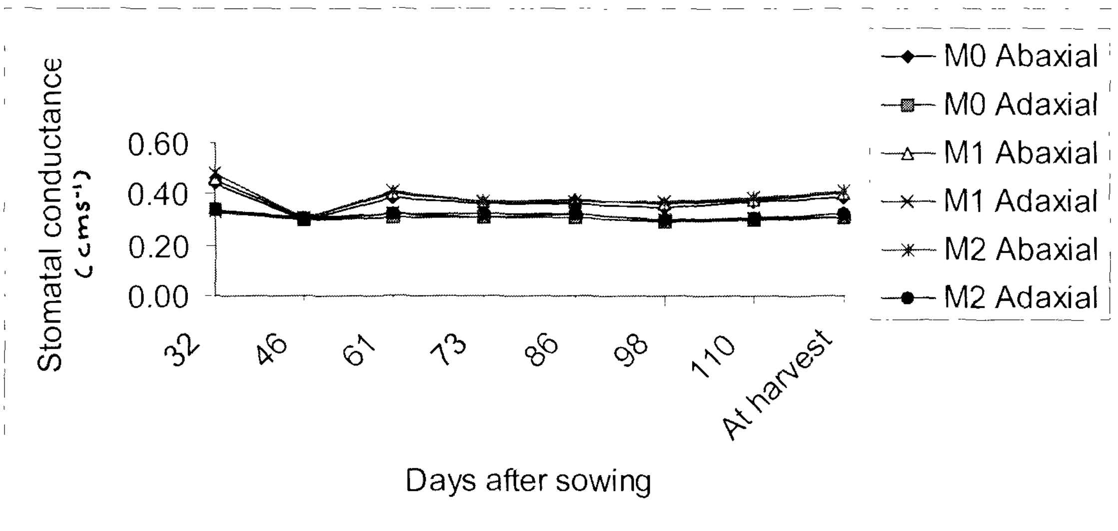


Fig.6b. Mean abaxial and adaxial stomatal conductance (cms^{-1}) under mulches as influenced by irrigation schedule of 100 mm CPE.

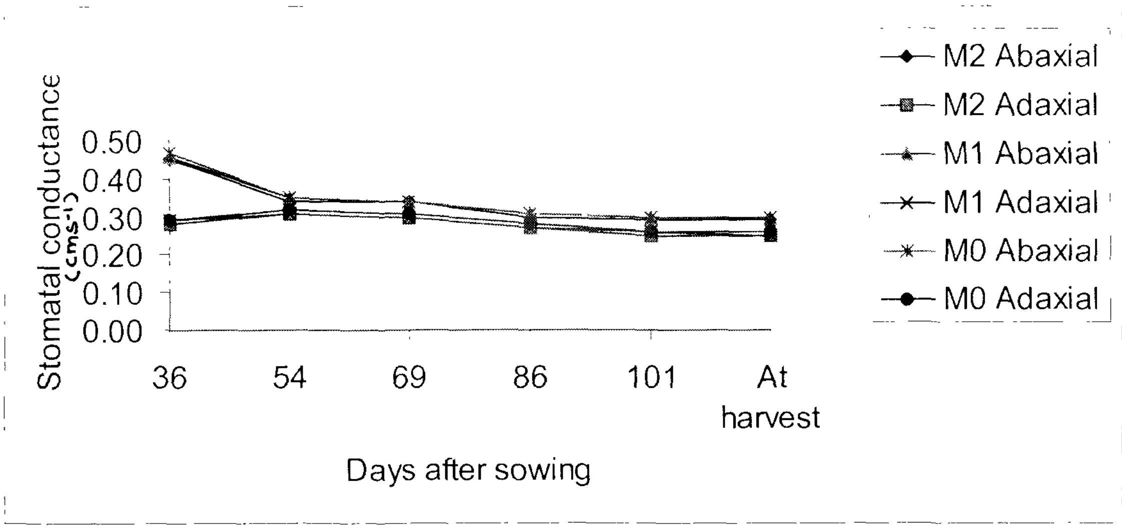


Fig.6c. Mean abaxial and adaxial stomatal conductance (cms^{-1}) under mulches as influenced by irrigation schedule of 125 mm CPE.

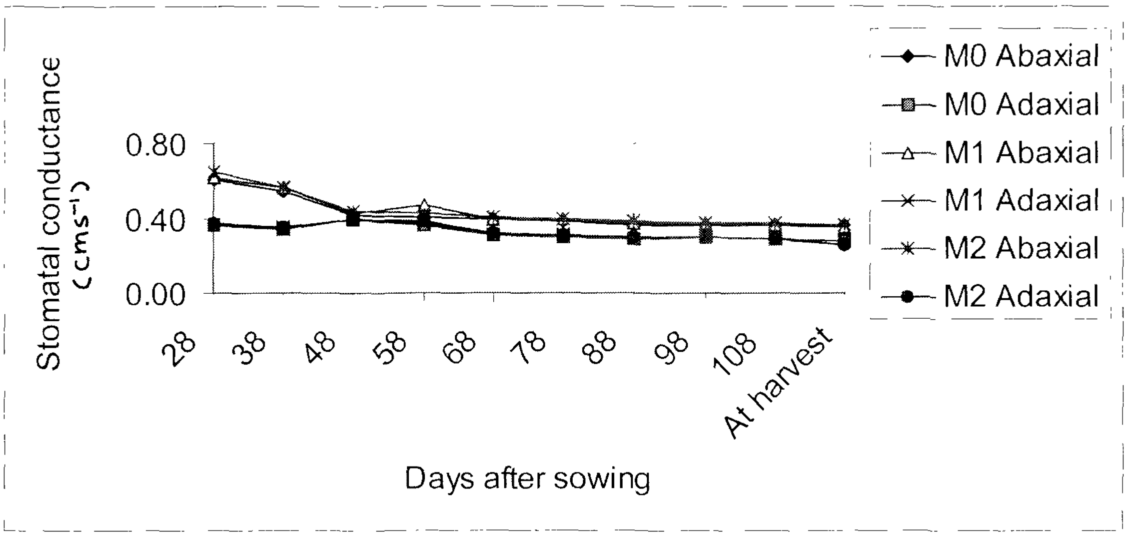


Fig.6d. Mean abaxial and adaxial stomatal conductance (cms^{-1}) under mulches as influenced by irrigation schedule at 10 days interval.

Mulching :

Stomatal conductance of abaxial surfaces was also more than adaxial surfaces in all the mulches. Stomatal conductance of both abaxial and adaxial surfaces were comparatively more under polythene mulch than straw mulch and no mulch in all the irrigation schedules.

4.2.3.2. Mean abaxial and adaxial stomatal diffusive resistance (scm^{-1}) as influenced periodically by different treatments :

The data regarding mean abaxial and adaxial stomatal diffusive resistance (scm^{-1}) as affected periodically by different treatments are presented in Table 14 and shown graphically in Fig.7 (a-d).

The stomatal diffusive resistance (scm^{-1}) were greater on adaxial surfaces than abaxial surfaces for all the irrigation schedules (CPE) values during the day. Similar results were reported by Misra and Gangwar (1987) and Vieira (1989). The abaxial and adaxial stomatal diffusive resistance increased progressively with the advancement of the crop age indicating that resistance of the crop to the loss of water by transpiration increase with advancement in age as senescence set in.

Irrigation scheduling :

The stomatal diffusive resistance were comparatively more under the irrigation scheduled at 125 mm CPE followed by 100, 75 mm CPE and 10 days interval. The irrigation scheduled at 125 mm CPE recorded the lowest irrigation frequency. The plants were unable to satisfy evaporative demand due to lesser

availability of water which experienced stress and consequently increase stomatal diffusive resistance due to remaining of stomata close. However, the

Table 14. Mean abaxial and adaxial stomatal diffusive resistance (scm^{-1}) as I

nfluenced by different irrigation schedules and mulches.

DAS	75 mm CPE					
	No mulch		Straw Mulch		Polythene mulch	
	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial
28	1.86	2.62	1.81	2.57	1.76	2.52
42	2.36	2.58	2.31	2.52	2.28	2.47
50	2.40	2.62	2.36	2.56	2.29	2.50
61	2.47	2.64	2.43	2.61	2.36	2.55
69	2.51	2.77	2.47	2.69	2.43	2.66
79	2.54	3.24	2.50	3.18	2.48	3.13
87	2.62	3.32	2.57	3.27	2.54	3.23
95	2.67	3.24	2.64	3.20	2.58	3.17
105	2.64	3.32	2.59	3.28	2.52	3.25
Harvest	2.56	3.27	2.53	3.24	2.50	3.21
DAS	100 mm CPE					
32	1.34	1.92	1.31	1.87	1.27	1.82
46	3.26	3.29	3.19	3.24	3.15	3.20
61	2.52	3.14	2.49	3.10	2.43	3.05
73	2.75	3.21	2.69	3.17	2.64	3.12
86	2.73	3.15	2.68	3.12	2.65	3.09
98	2.78	3.34	2.74	3.30	2.96	3.25
110	2.65	3.24	2.60	3.20	2.55	3.16
Harvest	2.54	3.17	2.49	3.13	2.43	3.10
DAS	125 mm CPE					
36	2.21	3.46	2.15	3.40	2.10	3.35
54	2.89	3.19	2.85	3.14	2.81	3.10
69	2.94	3.28	2.91	3.24	2.86	3.21
86	3.23	3.64	3.20	3.60	3.17	3.55
101	3.34	3.79	3.30	3.75	3.25	3.71
Harvest	3.40	3.90	3.34	3.86	3.30	3.80
DAS	10 days interval					
28	1.62	2.74	1.59	2.71	1.52	2.66
38	1.83	2.89	1.78	2.83	1.73	2.78
48	2.34	2.56	2.30	2.52	2.25	2.47
58	2.43	2.72	2.37	2.68	2.32	2.63
68	2.51	3.17	2.45	3.13	2.40	3.09
78	2.59	3.24	2.54	3.21	2.50	3.16
88	2.73	3.38	2.67	3.34	2.63	3.29
98	2.73	3.33	2.69	3.30	2.64	3.25
108	2.76	3.44	2.73	3.41	2.68	3.37
Harvest	2.86	4.56	2.83	3.52	2.77	3.47

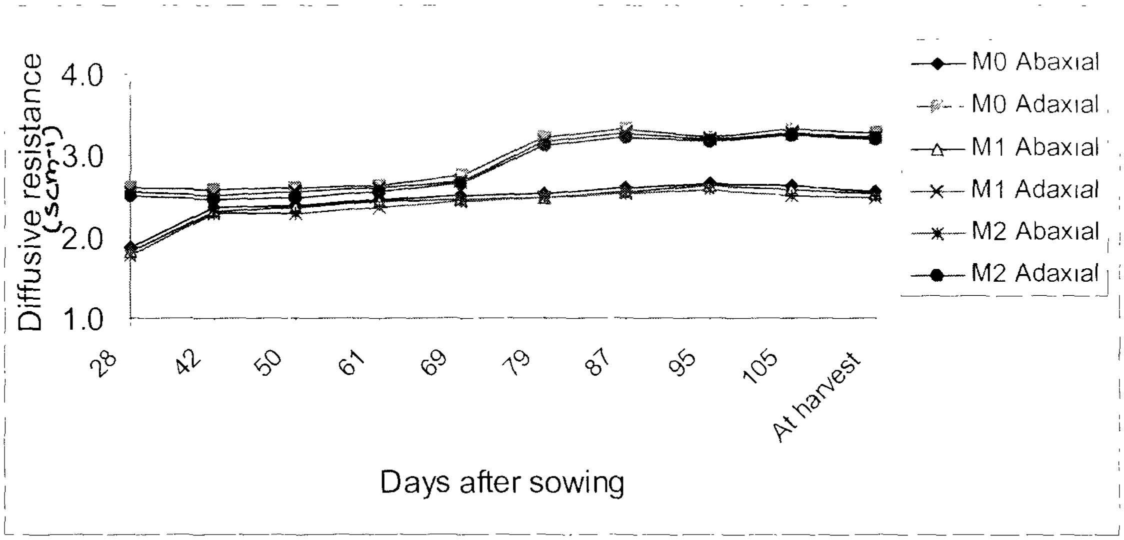


Fig.7a. Mean abaxial and adaxial stomatal diffusive resistance (scm^{-1}) under mulches as influenced by irrigation schedule of 75 mm CPE.

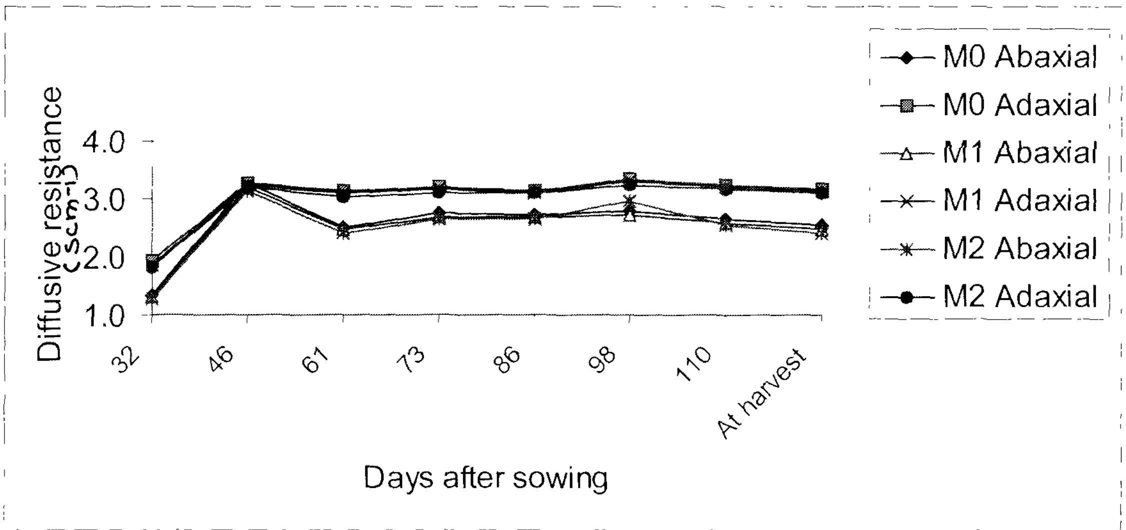


Fig.7b. Mean abaxial and adaxial stomatal diffusive resistance (scm^{-1}) under mulches as influenced by irrigation schedule of 100 mm CPE.

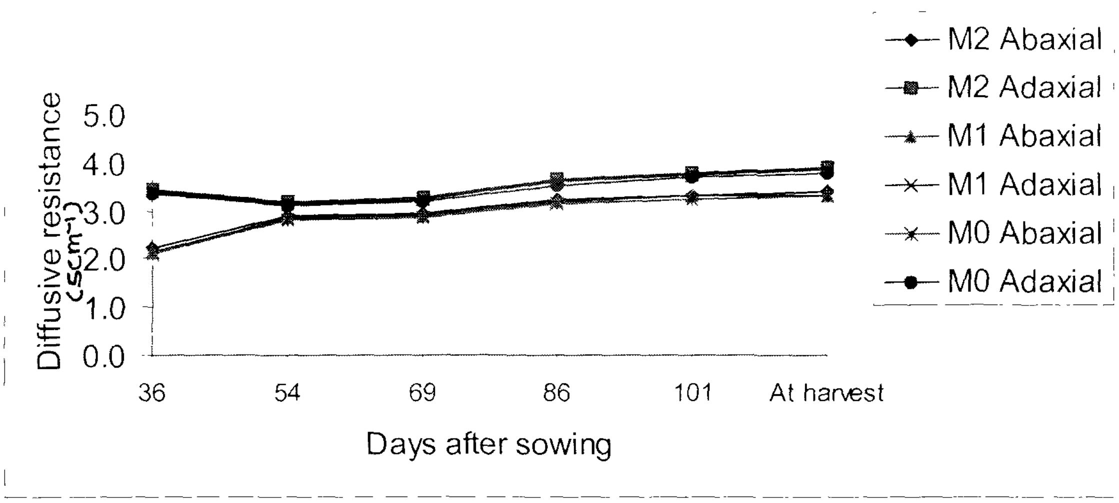


Fig.7c. Mean abaxial and adaxial stomatal diffusive resistance (scm^{-1})under mulches as influenced by irrigation schedule of 125 mm CPE.

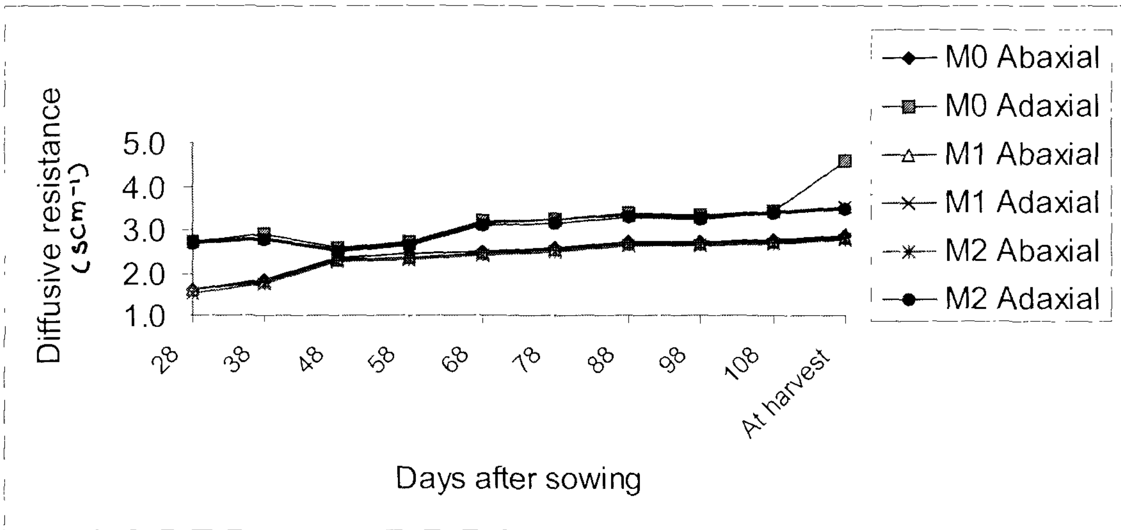


Fig.7d. Mean abaxial and adaxial stomatal diffusive resistance (scm^{-1}) under mulches as influenced by irrigation schedule at 10 days interval.

resistance were least under more frequently irrigation schedule of 75 mm CPE and 10 days interval because of stomata remained fully open offering least resistance to flow of water in the plant system.

Mulching :

The stomatal diffusive resistance values were comparatively more under no mulch followed by straw mulch and polythene mulch. Stomatas were more closed under no mulch treatment offering more resistance where as they were fully opened under polythene mulch treatments offering less resistance to flow of water in the plant system. Similar results were reported by Davies (1977) and Lu (1990).

4.2.3.3. Mean abaxial and adaxial transpiration ($\mu gcm^{-2}s^{-1}$) rate as influenced periodically by different treatments :

The data regarding mean abaxial and adaxial transpiration rate as influenced by different treatments are presented in Table 15 and shown graphically in Fig. 8(a-d).

In general, the mean abaxial transpiration rate were higher than adaxial transpiration rate during all the crop growth phases. Similar findings were also reported by Misra and Gangwar (1987) Vieira (1989). The transpiration rate were increased with increase in crop age. This was on account of greater atmospheric demand developed with the increase in air temperature as the crop season advanced.

Irrigation scheduling :

The transpiration rate were identical under irrigation scheduled at 75 mm CPE and 10 days interval but it was comparatively more than irrigation scheduled at 100 and 125 mm CPE at all the days of observations. The stomatas were fully opened under irrigation schedules of 75 mm CPE and 10 days interval

Table 15. Mean abaxial and adaxial transpiration rate ($\mu g cm^{-2} s^{-1}$) as influenced by different irrigation schedules and mulches.

DAS	75 mm CPE					
	No mulch		Straw Mulch		Polythene mulch	
	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial
28	13.03	11.04	13.10	11.12	13.17	11.23
42	15.20	15.00	15.67	15.30	15.80	15.66
50	15.28	15.25	15.95	15.56	15.57	15.98
61	16.10	13.99	16.30	14.23	16.49	14.56
69	17.23	15.24	17.74	15.43	17.96	15.68
79	18.09	16.34	18.20	16.58	18.47	16.87
87	18.17	16.39	18.87	16.91	18.96	17.20
95	19.10	17.08	19.64	17.34	19.88	17.56
105	20.01	18.24	20.13	18.67	20.36	18.99
Harvest	20.15	18.31	20.28	18.66	20.55	18.96
DAS	100 mm CPE					
32	15.40	12.2	15.71	12.81	16.00	13.02
46	10.98	10.04	11.21	11.41	11.54	11.63
61	11.96	11.20	12.17	11.58	12.56	11.81
73	13.74	12.32	14.01	12.88	14.38	12.98
86	16.01	13.05	16.24	13.10	16.68	13.21
98	16.59	14.30	17.01	14.44	17.41	14.68
110	16.18	13.46	16.98	13.88	17.10	14.07
Harvest	16.84	14.28	17.04	14.56	17.38	14.75
DAS	125 mm CPE					
36	11.23	9.11	11.52	9.21	11.84	9.50
54	10.68	10.37	10.92	10.57	11.29	10.68
69	12.50	10.10	12.94	10.19	13.20	10.35
86	13.19	13.25	13.58	13.41	13.88	13.57
101	14.21	13.09	14.55	13.38	14.75	13.54
Harvest	14.79	13.68	15.05	13.94	15.35	14.12
DAS	10 days interval					
28	12.08	10.15	12.2	10.24	12.48	10.38
38	14.17	14.01	14.34	14.15	14.71	14.29
48	14.22	14.07	14.49	14.25	14.89	14.60
58	15.04	13.98	15.15	14.13	15.38	14.39
68	17.00	15.08	17.10	15.24	17.40	15.60
78	17.18	15.13	17.44	15.47	17.89	15.75
89	18.14	16.03	18.32	16.17	18.78	16.51
98	19.00	17.15	19.06	17.35	19.22	17.72
108	19.01	17.11	19.14	17.33	19.42	17.66
Harvest	19.39	17.51	19.50	17.85	19.89	18.02

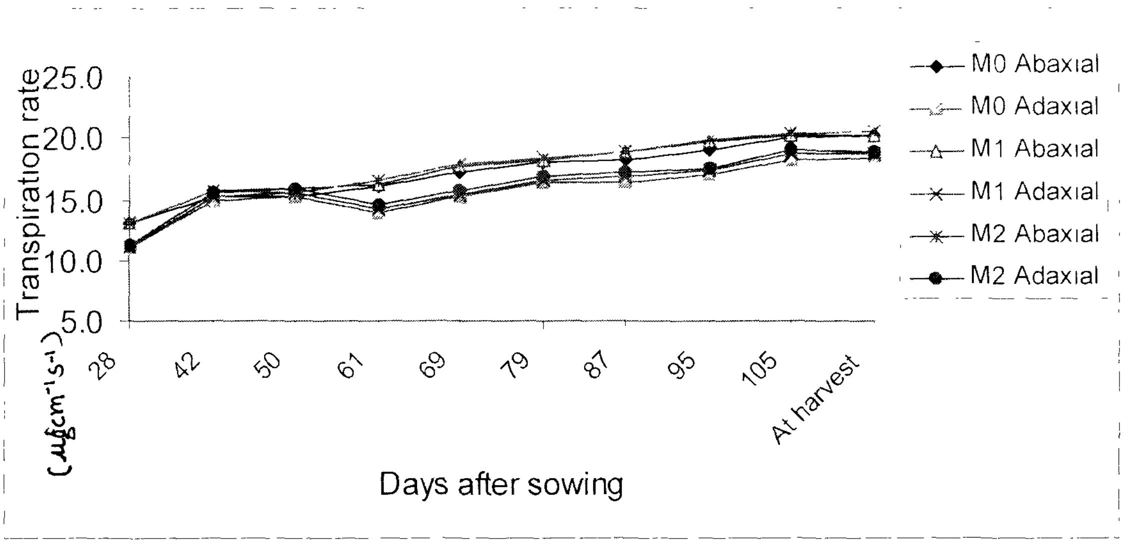


Fig.8a. Mean abaxial and adaxial transpiration rate ($\mu g cm^{-1} s^{-1}$) under mulches as influenced by irrigation schedule of 75 mm CPE.

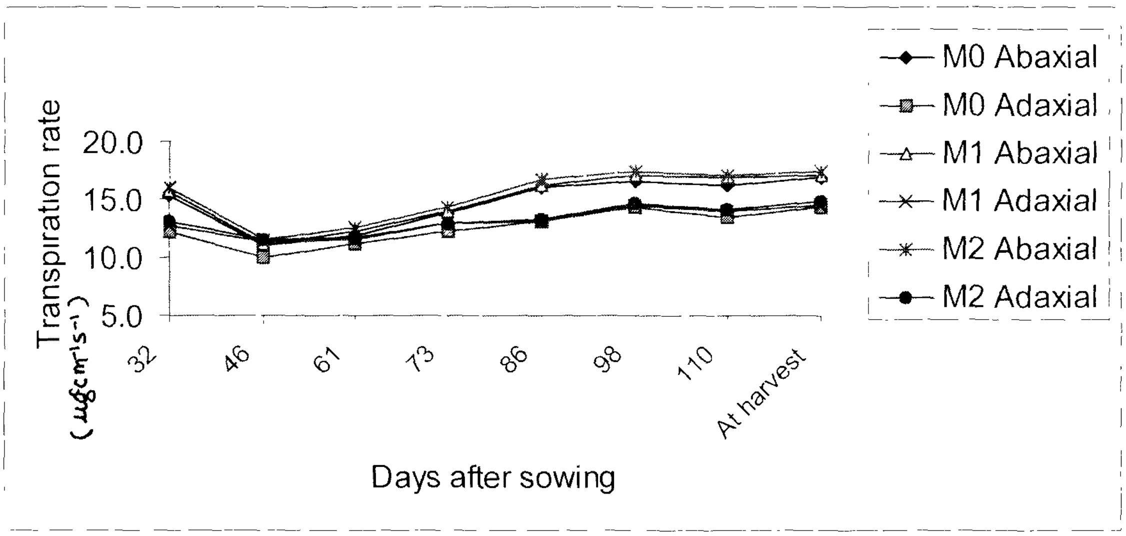


Fig.8b. Mean abaxial and adaxial transpiration rate ($\mu g cm^{-1} s^{-1}$) under mulches as influenced by irrigation schedule of 100 mm CPE.

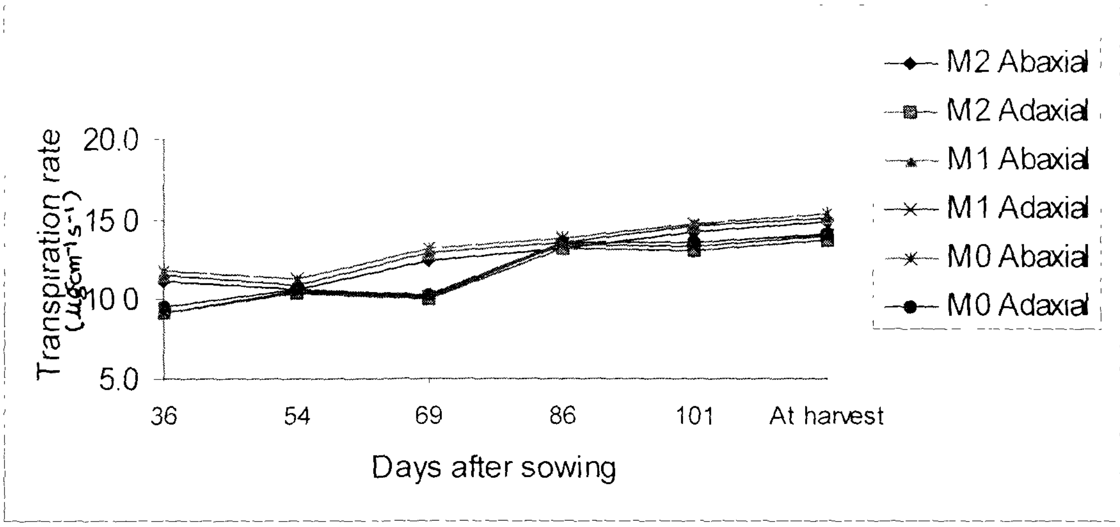


Fig.8c. Mean abaxial and adaxial transpiration rate ($\mu gcm^{-1}s^{-1}$) under mulches as influenced by irrigation schedule of 125 mm CPE.

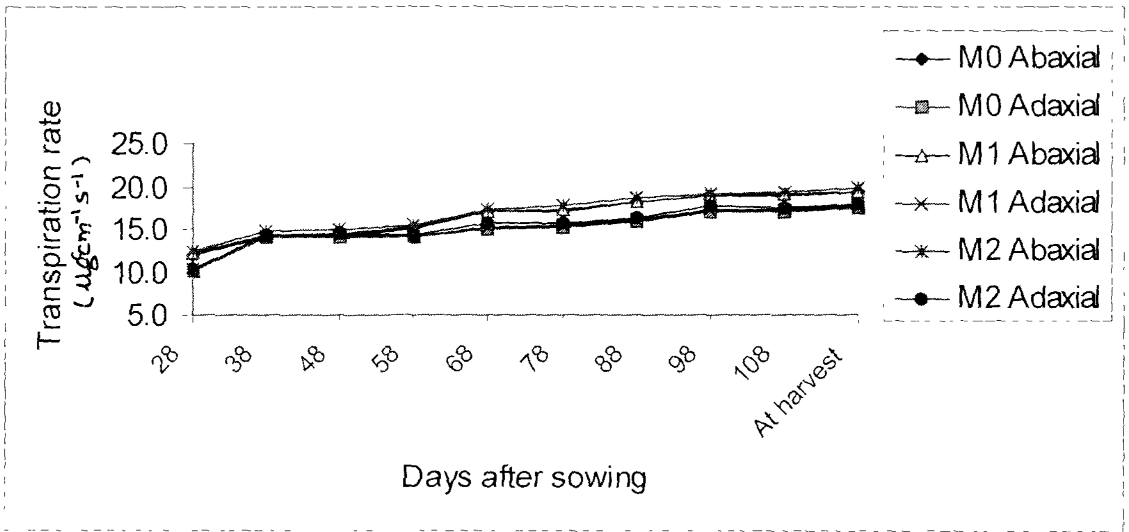


Fig.8d. Mean abaxial and adaxial transpiration rate ($\mu gcm^{-1}s^{-1}$) under mulches as influenced by irrigation schedule at 10 days interval.

meeting the evaporative demand and consequently increase in the transpiration rate. However, stomatas were remain closed for most of the time under irrigation schedules at 125 mm CPE offering more diffusive resistance and consequently less transpiration rate. Similar results were also reported by Vos (1986), Bodlaender (1986), Naidu and Venkataramana (1987), Dolman and van den Berg (1988), Sukumaran *et al.,* (1989), Whitfield (1990), Subrahmanian and Maheshwari (1990) and Laker (1992).

Mulching :

The transpiration rate were comparatively more under polythene mulch followed by straw mulch and no mulch. The retention of soil moisture was more under polythene mulch which met the evaporative demand through opened stomata resulting in higher transpiration rate. Under no mulch treatment the loss of water from the soil surface was more created stress condition and hence decrease in transpiration rate.

4.2.4. Spectral characteristics :

4.2.4.1 Blue reflectance (425-490 nm) :

The data pertaining to the reflectance of blue waveband (425-490 nm) recorded periodically as influenced by different treatments are presented in Table 16 and shown graphically in Fig. 9(a-b).

The mean of blue reflectance were 3.24, 3.37, 3.07, 2.09, 2.09, 2.10, 3.34 and 3.64 recorded at 28, 42, 56, 70, 84, 98, 112 DAS and at harvest, respectively. Blue reflectance increased upto flowering (42 DAS) then decreased upto early pod development (84 DAS) and again increased upto harvest stage or phase. This was due to increase in leaf area, decrease in blue reflectance indicates increase in absorption of blue band upto early pod development (84 DAS) and then increase upto harvest stage indicates senescence.

Table 16. Mean blue reflectance (nm) as influenced periodically by different irrigation schedules and mulches.

Treatment	Days after sowing							
	28	42	56	70	84	98	112	At harvest
IRRIGATION								
CPE (mm)								
75	3.18	3.34	3.02	2.07	2.08	2.10	3.30	3.63
100	3.26	3.37	3.05	2.10	2.09	2.11	3.36	3.66
125	3.28	3.44	3.06	2.11	2.10	2.12	3.37	3.64
10 DI	3.27	3.36	3.05	2.10	2.09	2.11	3.33	3.65
SE ±	0.06	0.03	0.002	0.0003	0.0002	0.0005	0.004	0.02
C.D. at 5%	–	–	0.007	0.0009	0.0008	0.002	0.01	–
MULCHING								
Without mulch	3.30	3.39	3.07	2.11	2.10	2.13	3.36	3.66
Straw mulch	3.28	3.41	3.04	2.10	2.09	2.10	3.34	3.65
Polythene mulch	3.17	3.34	3.02	2.08	2.08	2.09	3.32	3.63
SE ±	0.06	0.03	0.002	0.0003	0.0002	0.0005	0.003	0.0
C.D. at 5%	—	0.08	0.006	0.001	0.0008	0.002	0.01	–
INTERACTION								
SE ±	0.10	0.05	0.004	0.0006	0.0003	0.0009	0.005	0.03
C.D. at 5%	—	—	0.01	0.002	0.001	0.001	0.02	—
Mean	3.24	3.37	3.07	2.09	2.09	2.10	3.34	3.64

Irrigation scheduling :

The blue reflectance were not influenced significantly due to different irrigation scheduling during initial stages (phases) upto 42 days and at harvest. However, it was the lowest and significant under irrigation schedule of 75 mm CPE from 56 to 112 days indicating more absorption of energy in blue reflectance and better plant growth and pod development. Similar results were also reported by Tuker *et al.* (1997) , Leamer and Noriega (1981), Rajhans (1991).

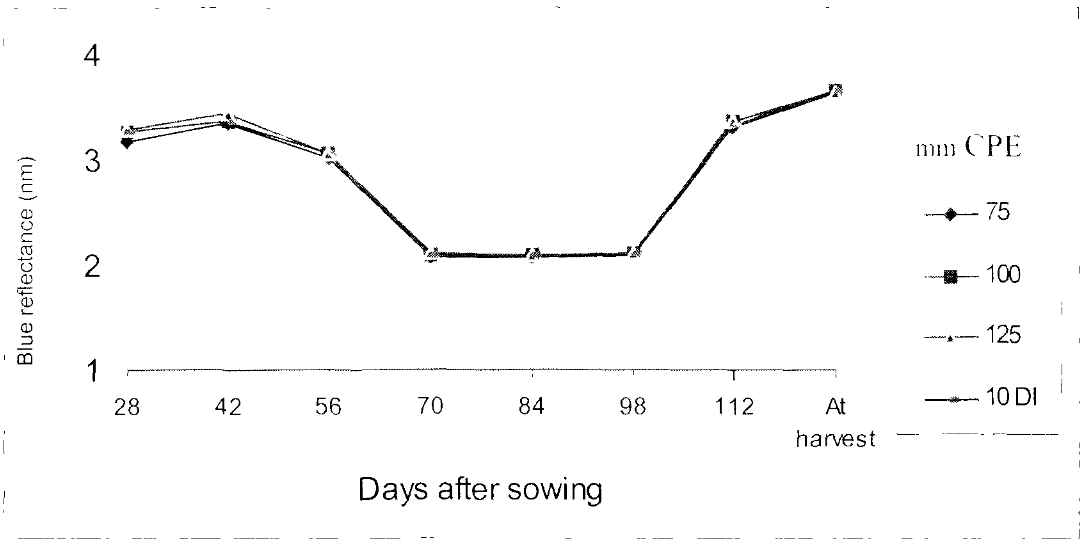


Fig. 9a Mean blue reflectance (nm) influenced periodically by different irrigation schedules.

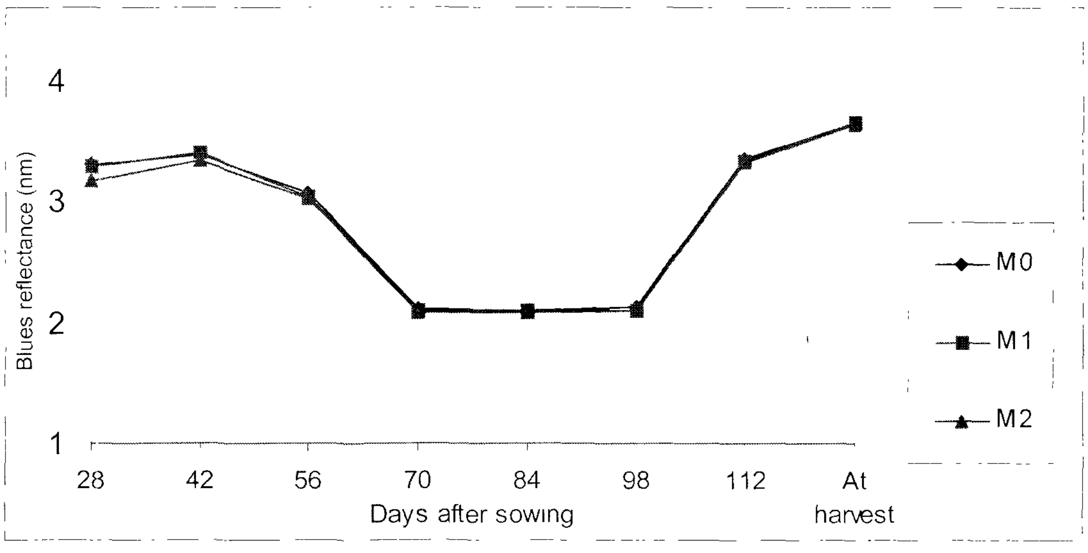


Fig. 9b Mean blue reflectance (nm) influenced periodically by different mulches.

Mulching:

The blue reflectance was not influenced significantly at initial stage of 28 days and harvest but reflectance in blue waveband were significantly lower under polythene mulch than straw mulch and no mulch from 42 to 112 days indicating more absorption of energy in blue waveband during advanced crop stages of flowering and pod development.

Interaction :

Interaction effects between irrigation schedules and different mulches were found to be significant during the period between 56 to 112 days.

4.2.4.2. Green reflectance (490-560 nm):

The data pertaining to the reflectance of green waveband (490-560 nm) as influenced periodically by different treatments are presented in Table 17 and shown graphically in Fig. 10 (a-b). The mean values of green reflectance were 4.40, 4.85, 5.15, 4.74, 4.85, 5.19, 3.24 and 3.57 at 28, 42, 56, 70, 84, 98, 112 DAS and at harvest, respectively.

The reflectance in green waveband increased upto pegging phases (56 DAS) and decreased upto early pod development (84 DAS) and then increased at pod development stage (98 DAS) and thereafter decreased upto harvest stage.

Irrigation scheduling :

The reflectance in green waveband were not influenced significantly due to different irrigation schedules on the 98^{th} day. The reflectance in green waveband was significantly less under irrigation scheduled at 75 mm CPE followed by 10 days interval, 100 mm CPE and 125 mm CPE at all the crop growth stages. Similar results were reported by Kanemasu (1974), Tuker (1979); Leamer *et al.* (1978) and Alrichs and Bauer (1983).

Table 17. Mean green reflectance (nm) as influenced periodically by different irrigation schedules and mulches.

Treatment	Days after sowing							
	28	42	56	70	84	98	112	At harvest
IRRIGATION								
CPE (mm)								
75	4.38	4.83	5.13	4.71	4.83	5.96	3.21	3.55
100	4.41	4.86	5.16	4.76	4.86	4.94	3.26	3.58
125	4.42	4.87	5.17	4.77	4.87	4.95	3.27	3.59
10 DI	4.40	4.85	5.15	4.74	4.85	4.93	3.24	3.57
SE ±	0.002	0.006	0.0004	0.0002	0.0002	0.57	0.0008	0.0005
C.D. at 5%	0.006	0.02	0.001	0.0008	0.0008	____	0.003	0.002
MULCHING								
Without mulch	4.44	4.88	5.18	4.77	4.88	4.92	3.27	3.60
Straw mulch	4.41	4.86	5.16	4.74	4.85	4.93	3.24	3.58
Polythene mulch	4.37	4.82	5.13	4.72	4.82	5.74	3.21	3.54
SE ±	0.002	0.006	0.0005	0.0002	0.0002	0.55	0.0005	0.0005
C.D. at 5%	0.005	0.02	0.002	0.001	0.008	____	0.001	0.002
INTERACTION								
SE ±	0.003	0.01	0.001	0.0007	0.0004	0.95	0.0008	0.0008
C.D. at 5%	____	____	0.003	0.002	0.001	____	0.003	0.003
Mean	4.41	4.85	5.15	4.74	4.85	5.19	3.24	3.57

Mulching :

The reflectance in green waveband were significantly lower under polythene mulch than straw mulch and no mulch at all the days of observations except on 98^{th} day indicating more absorption. Further, it was observed that reflectance in green wave band was significantly lower under straw mulch than no mulch treatment at all crop growth stages except on 98^{th} day. Similar results were reported by Kanemasu (1974) and Leamer *et al.* (1978),

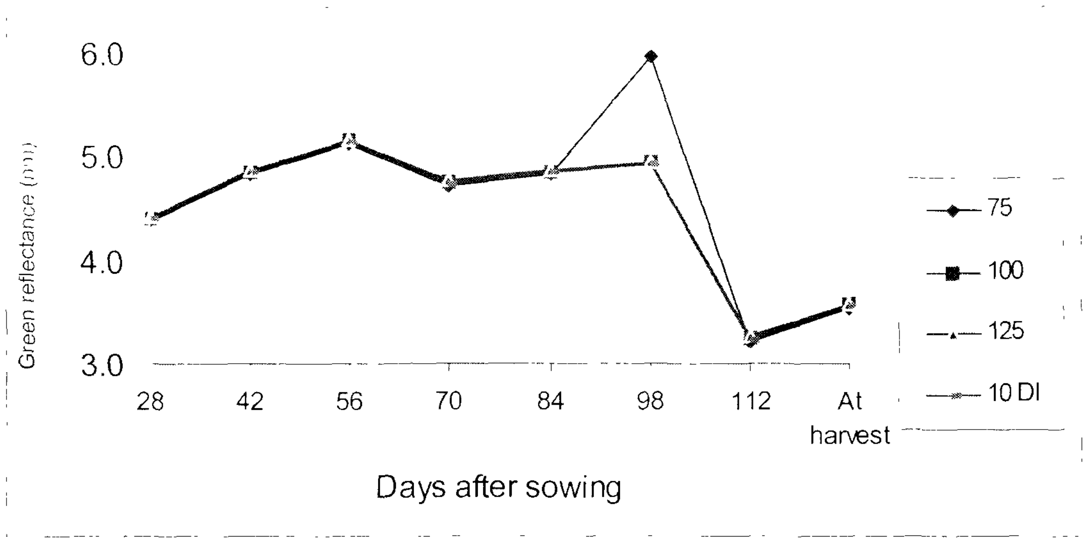


Fig. 10a Mean green reflectance (nm) influenced periodically by different irrigation schedules.

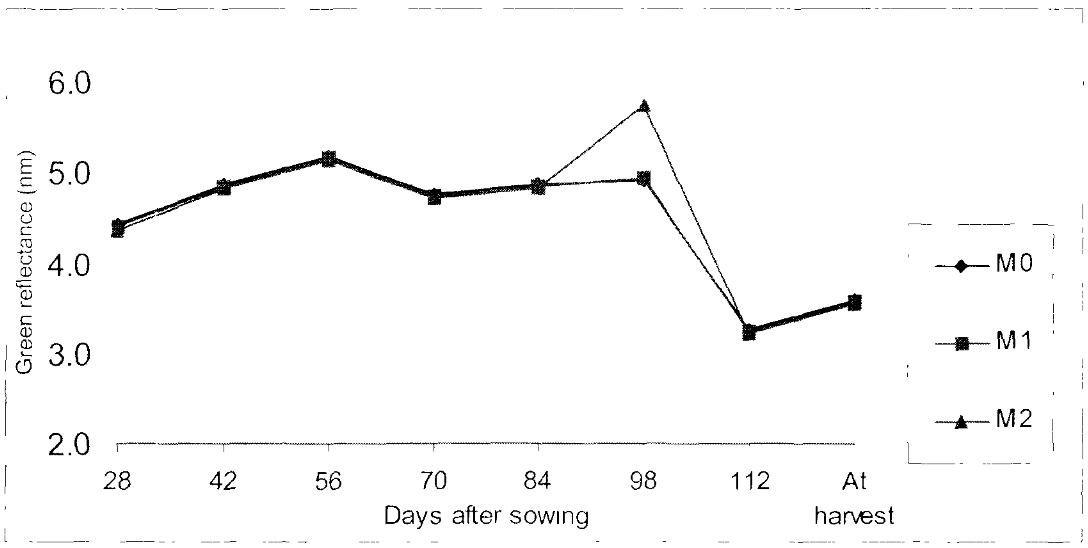


Fig. 10b Mean green reflectance (nm) influenced periodically by different mulches.

Interaction :

Interaction effects between irrigation scheduling and mulching were found to be significant from 56 days onwards except on 98th day.

4.2.4.3. Red reflectance (640-740 nm) :

The data pertaining to the reflectance of red waveband (640-740 nm) as influenced periodically by different treatments are presented in Table 18 and shown graphically in Fig. 11(a-b)..

The mean values of red reflectance were 7.83, 8.89, 8.65, 8.45, 8.34, 8,64, 8.84 and 9.74 at 28, 42, 56, 70, 84, 98, 112 DAS and at harvest stage , respectively. The reflectance in red waveband increased upto flowering (42 DAS) then decreased upto early pod development (84 DAS) and again increased upto harvest stage of crop. This was due to increase in vegetative growth of crop upto flowering then absorption in red waveband increased in pod development stage resulting in decrease in red reflectance and subsequently red reflectance increased because of senescence.

Irrigation scheduling :

The reflectance in red waveband was significantly more under irrigation scheduling of 125 mm CPE followed by 100 mm CPE, 10 days interval and 75 mm CPE on all the days of observations. This shows that reflection was more under stressed condition and absorption was more under unstressed conditions. Similar results were reported by Kanemasu (1974), Tucker (1979), Leamer *et al.* (1978) and Alrichs and Bauer (1983).

Table 18. Mean red reflectance (nm) as influenced periodically by different irrigation schedules and mulches.

Treatment	Days after sowing							
	28	42	56	70	84	98	112	At harvest
IRRIGATION								
CPE (mm)								
75	7.81	8.90	8.65	8.42	8.32	8.62	8.83	9.73
100	7.84	8.93	8.66	8.46	8.35	8.65	8.85	9.75
125	7.85	8.94	8.67	8.46	8.36	8.66	8.86	9.76
10 DI	7.83	8.92	8.65	8.44	8.34	8.64	8.84	9.74
SE ±	0.0008	0.0002	0.0004	0.002	0.0004	0.0005	0.0003	0.005
C.D. at 5%	0.002	0.0008	0.001	0.009	0.001	0.002	0.001	0.2
MULCHING								
Without mulch	7.86	8.96	8.68	8.47	8.37	8.67	8.87	9.77
Straw mulch	7.85	8.92	8.66	8.44	8.34	8.65	8.85	9.74
Polythene mulch	7.80	8.70	8.63	8.42	8.32	8.61	8.82	9.73
SE ±	0.0005	0.0003	0.0005	0.003	0.0003	0.0005	0.0002	0.005
C.D. at 5%	0.001	0.0008	0.001	0.009	0.0008	0.002	0.0007	0.02
INTERACTION								
SE ±	0.0008	0.0005	0.0008	0.005	0.0004	0.0009	0.0004	0.01
C.D. at 5%	0.003	0.001	0.002	____	0.001	0.003	0.001	____
Mean	7.83	8.89	8.65	8.45	8.34	8.64	8.84	9.74

Mulching :

The reflectance in red waveband were significantly lower under polythene mulch followed by straw mulch and no mulch on all the days of observations indicating more reflectance under no mulch and less under polythene mulch.

Interaction:

Interaction effects between irrigation scheduling and mulching were found to be significant on all the days of observation except on 70th day and at harvest.

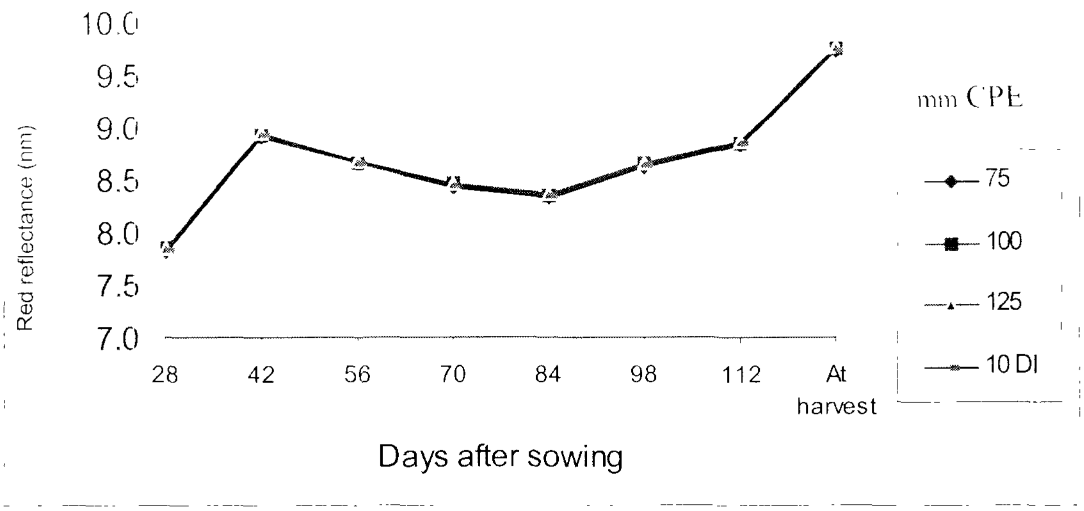


Fig. 11a Mean red reflectance (nm) influenced periodically by different irrigation schedules.

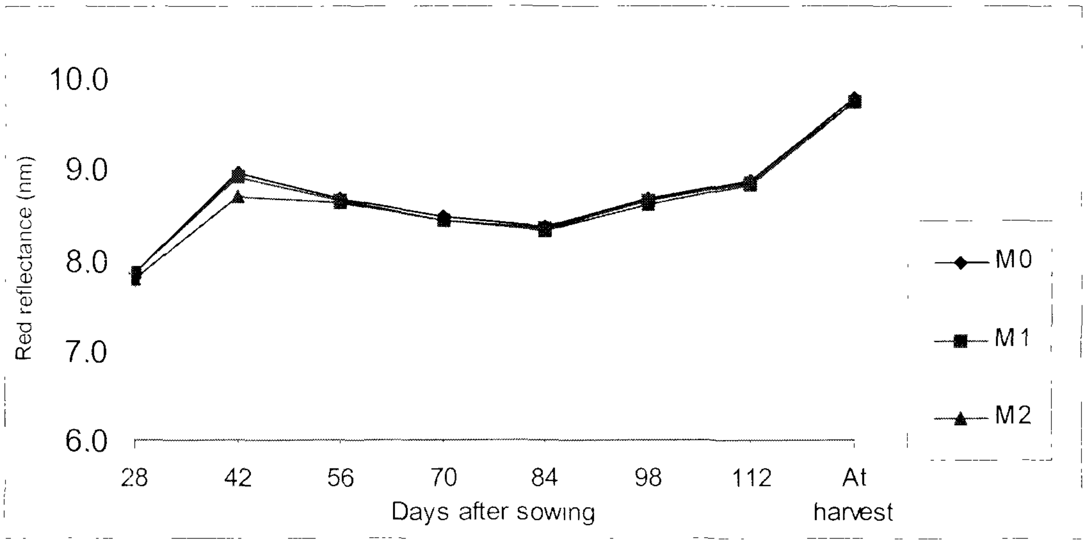


Fig. 11b Mean red reflectance (nm) influenced periodically by different mulches.

4.2.4.4. Near infrared reflectance (NIR) (750-850 nm) :

The data pertaining to the reflectance in near infrared waveband (750-850 nm) as influenced periodically by different treatments are presented in Table19 and shown graphically in Fig. 12 (a-b).

The mean NIR reflectance values were 11.27, 15.41, 23.01, 29.27, 31.01, 33.15, 33.25 and 36.81 at 28, 42, 56, 70, 84, 98, 112 days and at harvest stage, respectively.

Table 19. Mean near infrared reflectance (NIR) (nm) as influenced periodically by different irrigation schedules and mulches.

Treatment	Mean NIR reflectance (nm)							
	28	42	56	70	84	98	112	At harvest
IRRIGATION								
CPE (mm)								
75	11.25	15.39	23.00	29.20	31.00	33.12	35.21	36.79
100	11.27	15.43	23.01	29.27	31.01	33.15	35.24	36.82
125	11.30	15.44	23.01	29.30	31.02	33.18	35.26	36.83
10 DI	11.26	15.41	23.01	29.28	31.01	33.14	35.23	36.81
SE ±	0.01	0.0002	0.0002	0.05	0.0002	0.01	0.01	0.0003
C.D. at 5%	0.03	0.0008	0.0006	___	0.0008	0.03	0.03	0.001
MULCHING								
Without mulch	11.29	15.45	23.01	29.32	31.02	33.17	35.37	36.84
Straw mulch	11.28	15.41	23.01	29.29	31.01	33.15	35.24	36.81
Polythene mulch	11.25	15.39	23.01	29.18	31.00	33.13	35.20	36.78
SE ±	0.01	0.0004	0.0002	0.05	0.0002	0.01	0.008	0.0004
C.D. at 5%	0.03	0.001	0.0007	___	0.0006	0.03	0.02	0.001
INTERACTION								
SE ±	0.02	0.0007	0.0004	0.10	0.0004	0.02	0.01	0.0007
C.D. at 5%	0.05	0.002	0.001	___	0.001	0.05	0.04	0.003
Mean	11.27	15.41	23.01	29.27	31.01	33.15	35.25	36.81

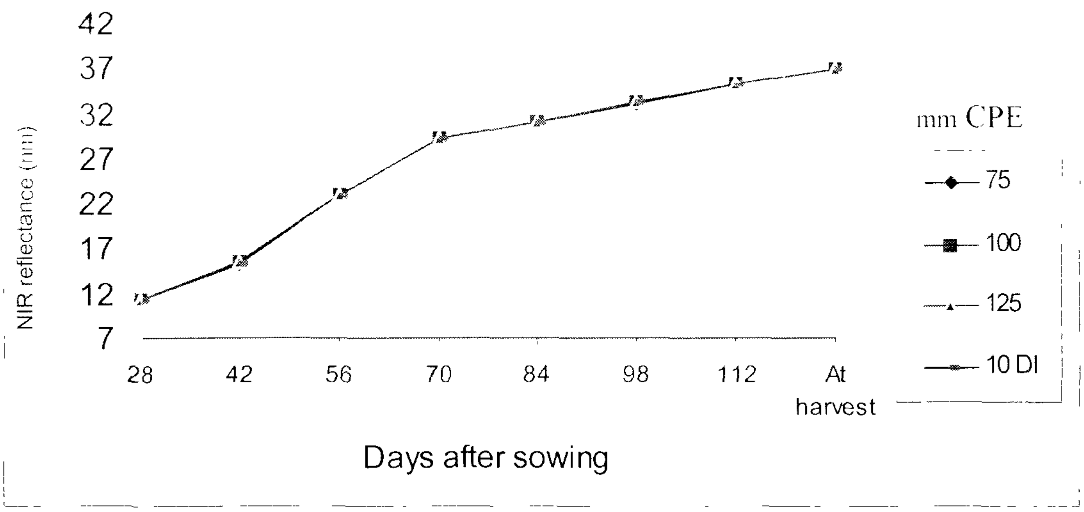


Fig. 12a Mean near infrared reflectance (nm) influenced periodically by different irrigation schedules.

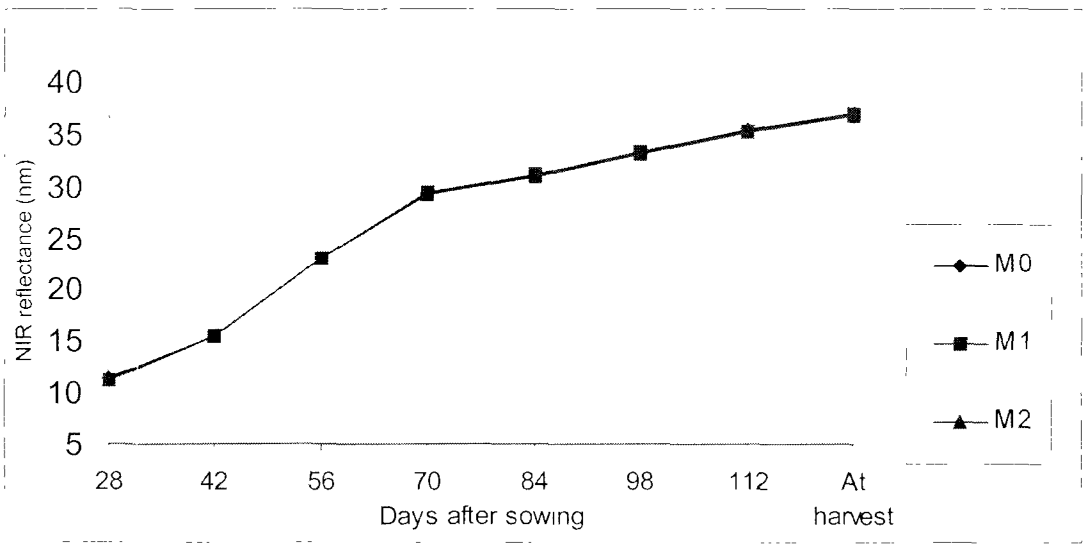


Fig. 12b Mean near infrared reflectance (nm) influenced periodically by different mulches.

Irrigation scheduling :

The reflectance in near infrared waveband expressed the water status of plant. The reflectance in near infrared waveband was significantly more under irrigation scheduling of 125 mm CPE than irrigation scheduling at 75 mm CPE and 10 days interval on the initial stage of 28^{th} day. The reflectance in near infrared waveband was the lowest and significant under irrigation scheduled at 75 mm CPE from 42^{nd} day onward except on 70^{th} day indicating better moisture availability throughout the crop growth period under these irrigation schedule. The reflectance in near infrared waveband was also significantly low under 10 days intervals irrigation scheduling than 100 and 125 mm CPE on 42, 98, 112 days and at harvest indicating better soil moisture status under this schedule also. Similar results were reported by Tucker (1979), Kanemasu (1974), Alrichs & Bauer (1983), Ayyanger *et al.* (1980) and Weigand and Richardson (1984).

Mulching :

The reflectance in near infrared waveband was the lowest and significant under polythene mulch on all the days of observations except on 70^{th} days indicating that retention of soil moisture was more throughout the crop growth period under polythene mulch resulting in better growth and plant development and consequently higher pod yield. It was further observed that the reflectance in infrared was also significantly low under straw mulch than no mulch on 42^{nd} and 84^{th} day onwards indicating better moisture availability.

Interaction:

The interactions effect between irrigation scheduling and mulching were present on all the days of observations except on 70^{th} day.

4.2.5. Diurnal measurement of stomatal conductance and transpiration.

4.2.5.1. Diurnal measurement of stomatal conductance (cms^{-1}) :

The diurnal pattern of the stomatal conductance (cms^{-1}) at the initiation of branching, 50% flowering, pod development and harvest stages of summer groundnut for various treatments are shown graphically in Fig. 13(a-d).

In general, stomatal conductance (cms^{-1}) were low in the early morning, rise gradually to the maximum value and decreased in the afternoon (Dolman and Van den Burg, 1988). Xu *et al.* (1987) reported that the stomata of Ginseng leaves opended at 0530h and closed at 2030 h but did not remain close at mid day.

The stomatal conductance increased from the initiation of branching phase to the harvest stage. As the day hours advanced, the stomatal conductance inclined, attaining the maximum value at 1200 h in most cases.

Irrigation scheduling :

During the initiation of branching phase, the conductance was the least for 125 mm CPE as compared to the other irrigation treatments. This may be because, the stomata were more opened in the irrigation at 75, 100 mm CPE and irrigation at 10 day interval, while in irrigation scheduled at 125 mm CPE stomate were not fully opened offering higher resistance and the least stomatal conductance to the flow of water outside the body. This treatment having the lowest irrigation frequency, the plants were unable to satisfy the demand due to less moisture availability, thus stress resulting in increase in resistance due to closure of stomata. Similar phenomenon were occurred during 50% flowering, pod development and at harvest stage.

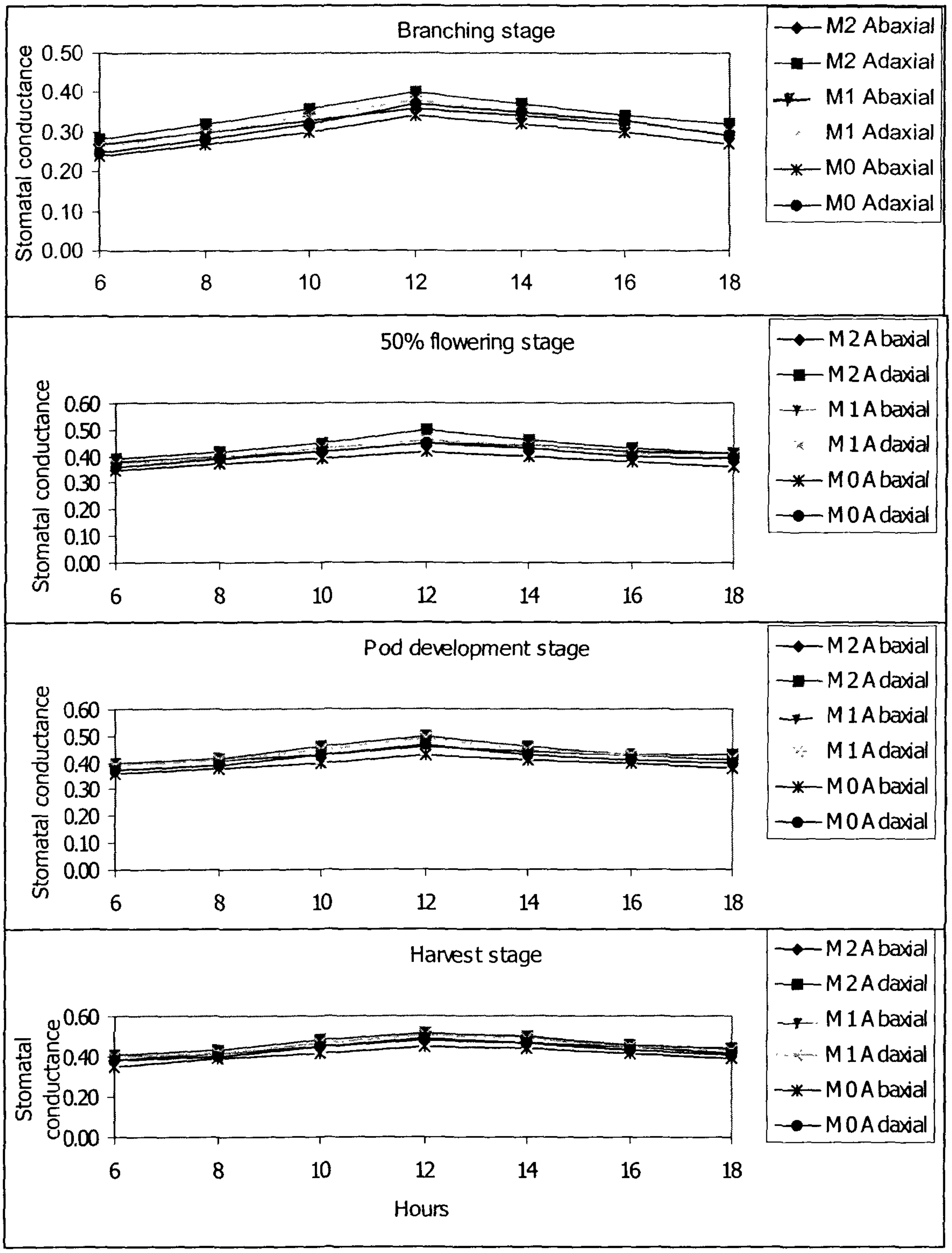


Fig.13a. Dirunal pattern of stomatal conductance (cms^{-1}) under different mulches at branching, 50% flowering, pod development and at harvest stage of summer groundnut influence by 75 mm CPE.

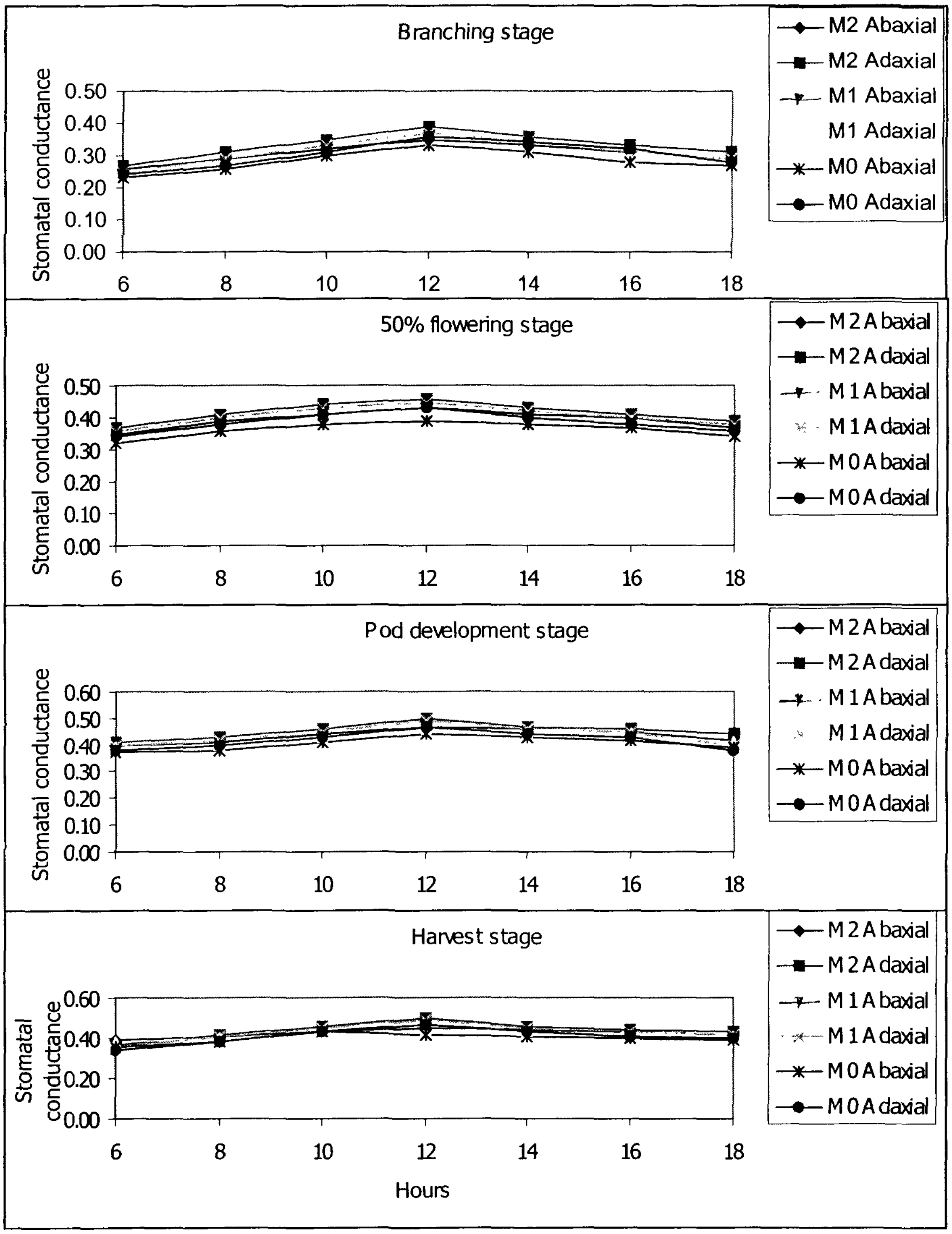


Fig. 13b. Dirunal pattern of stomatal conductance (cms^{-1}) under different mulches at branching, 50% flowering, pod development and at harvest stage of summer groundnut influence by 100 mm CPE.

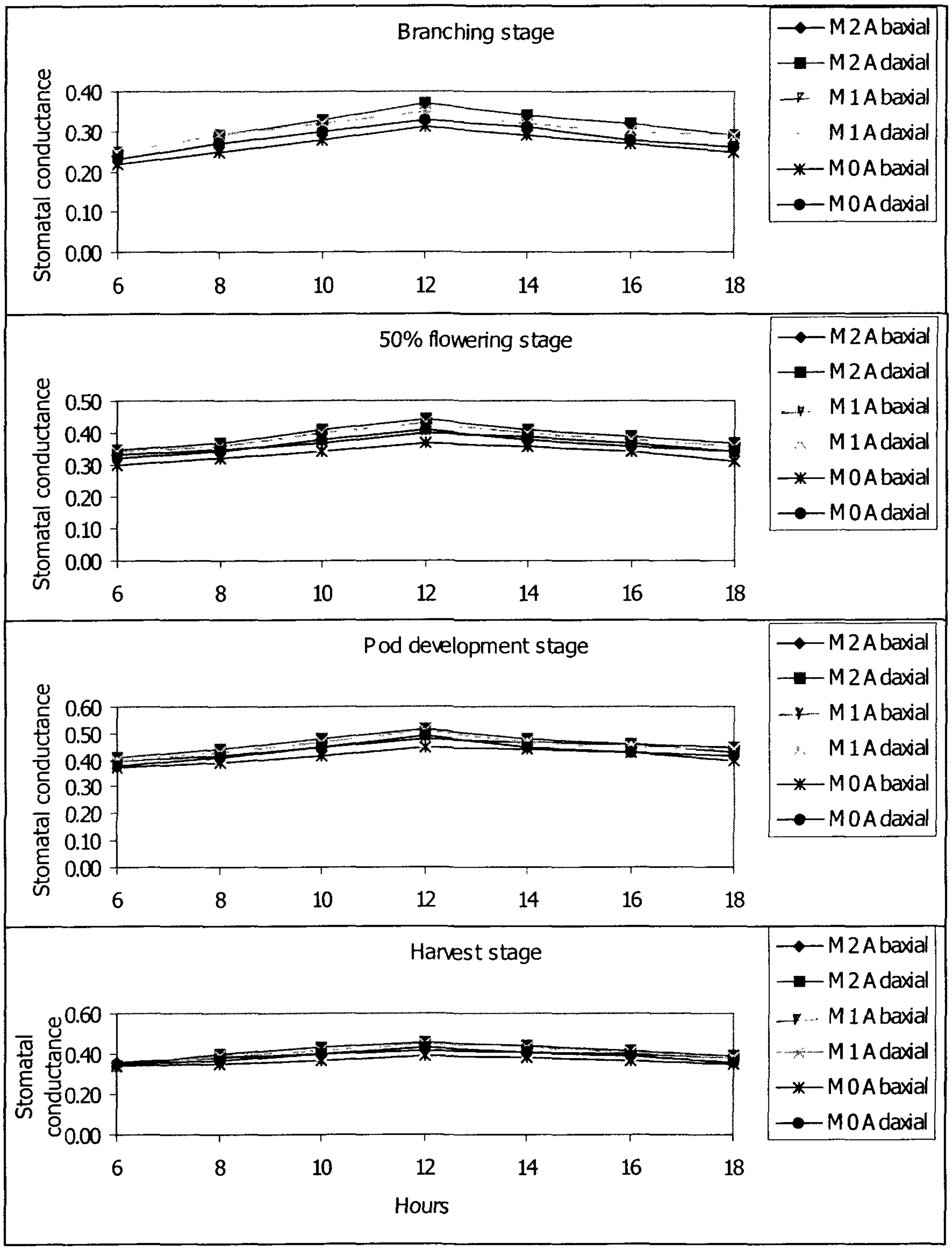


Fig.13c. Dirunal pattern of stomatal conductance (cms^{-1}) under different mulches at branching, 50% flowering, pod development and at harvest stage of summer groundnut influence by 125 mm CPE.

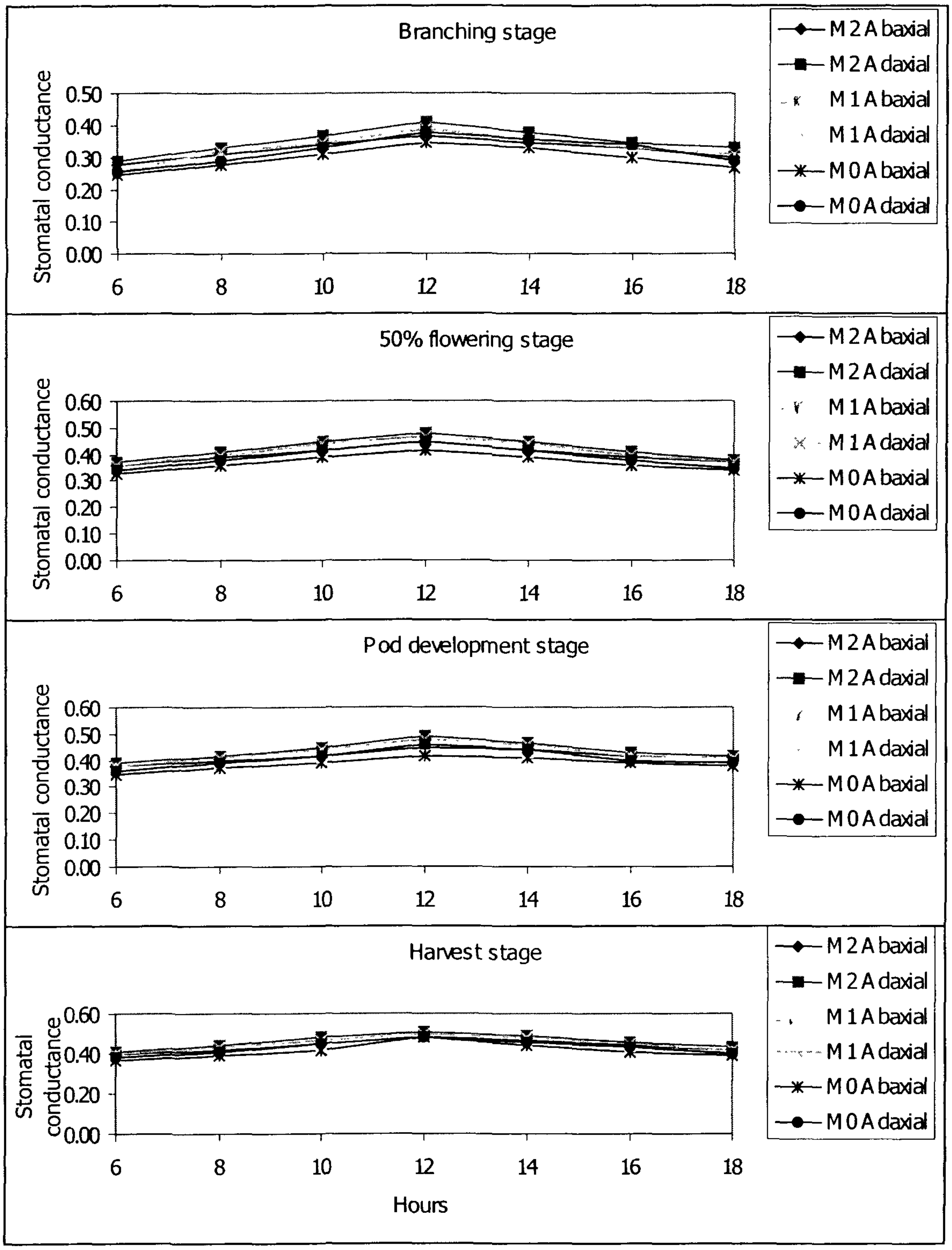


Fig. 13d. Dirunal pattern of stomatal conductance (cms^{-1}) under different mulches at branching, 50% flowering, pod development and at harvest stage of summer groundnut influence by irrigation at 10 days interval.

Mulching :

The stomatal conductance was less under no mulch and the least than the polythene and straw mulch. No mulch induced the highest resistance to loss of water vapour outside. Similar results of the stomatal conductance were obtained under no mulch, straw mulch and polythene mulch at the initiation of branching phase, 50% flowering, pod development stage (phase) and at harvest stage (phase).

4.2.5.2.Diurnal rate of transpiration ($\mu gcm^{-2}\ s^{-1}$) of abaxial and adaxial leaf surfaces :

The diurnal pattern of the abaxial and adaxial transpiration rate at branching, 50% flowering, pod development and at harvest stage of summer groundnut for the different irrigation schedules and mulches are shown graphically in Fig. 14(a-d).

The transpiration rate on the abaxial leaf surface exceeded than that on the adaxial leaf surface for all irrigation treatments during all the crop growth stages of summer groundnut. Similar results were reported by Misra and Gangwar (1987), Vieira (1989) in brinjal crop. However, at 0600h, the adaxial leaf surfaces transpired at a comparatively greater rate than the abaxial leaf surfaces under different irrigation and mulch treatments irrespective of the crop growth stages. These results are supported by the findings of Davies (1977) and Lu (1990). They reported that the adaxial stomates were more active / sensitive to light intensity than abaxial stomates. The peak transpiration rates at 1200 h, coincided with the solar noon. Similar results were also reported by Sterne *et al.* (1977) who have proved the conductances higher at higher PAR than at lower PAR. After 1200 h, the transpiration rates of both the surfaces declined slowly as the incident radiation progressively decrease and the least at 1800 h when the stomata began to close.

This coincided with the sigmoidal nature of the diurnal trend of transpiration of various crops, (Pallas, 1973; Xu and Valle 1987).

The magnitude of the water vapour transpired by both the surfaces were remarkably greater in the branching stages as compared to the flowering and pod formation stages. It can be deduced that with the advancement of the crop growth and senescence set in, the transpiration from both the leaf surfaces decline. These results are in conformity with the findings of Davis and Mc Cree (1978) they have found that leaf conductance of bush bean declined with leaf age. Leaf transpiration is found to decline with ageing in groundnut, maize and pearl millet (Turner 1969, Golakiya 1989, Selvaraju 1994).

Irrigation scheduling :

The transpiration rate was less under 125 mm CPE followed by 100 and 75 mm CPE and 10 days interval. The former irrigation schedule was having less irrigation frequency and hence, plants were unable to satisfy the demand of water due to lesser moisture availability, thus stress has resulted in increase in resistance due to clouser of stomata. Similar results were reported by Vos (1986), Bodlaender (1986), Whitefield (1990), Subramanian and Maheshwari (1990) and Lacker (1992).

Mulching :

The differences in transpiration were also observed under different mulches. The rate of the transpiration under polythene mulch was founds higher values than that of no mulch and straw mulch, owing to the retention of more water under polythene mulch which consequently available for meeting the evaporative demand through opened stomata resulting in higher transpiration rate. However, loss of more water from soil surface under no mulch created more stress

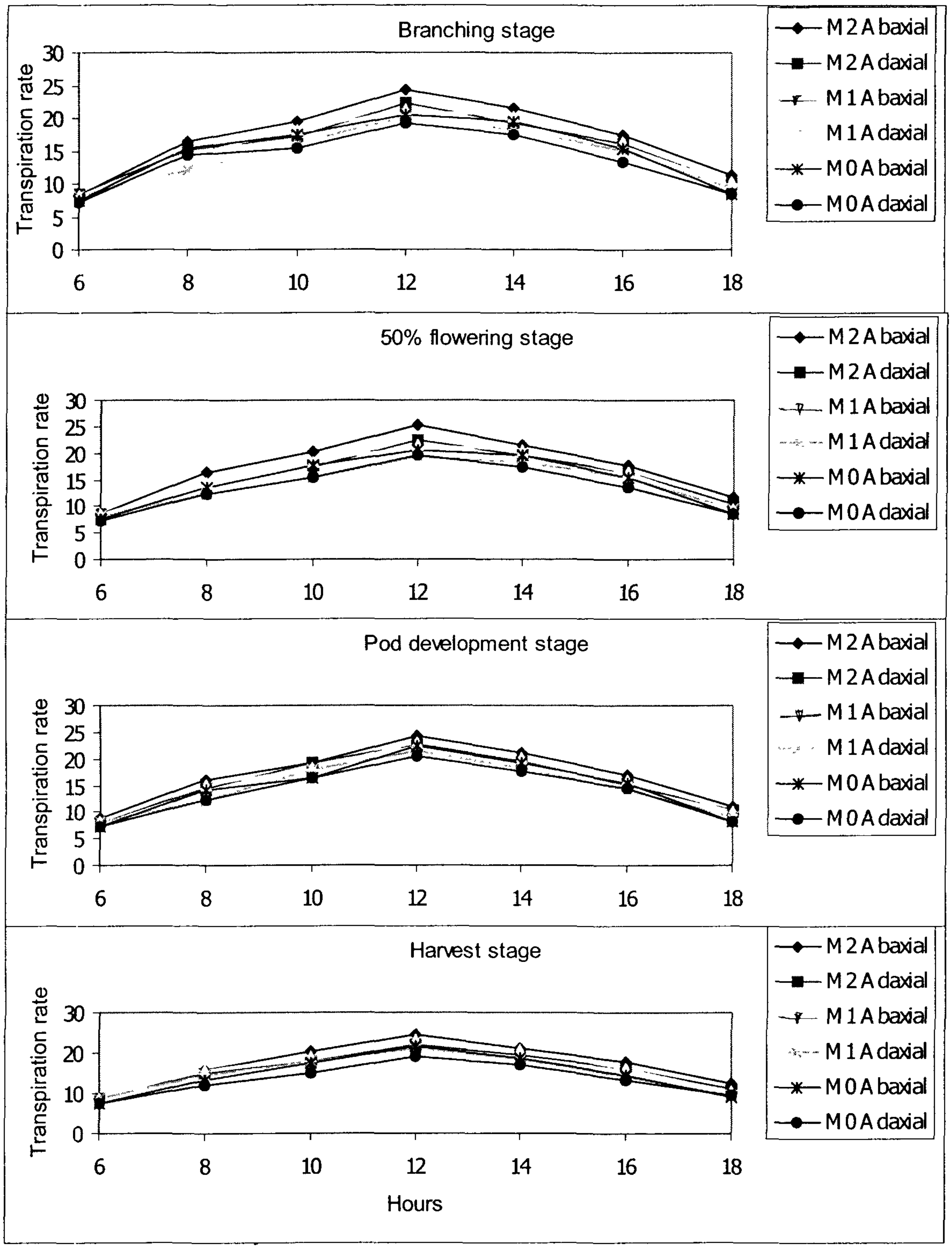


Fig. 14a. Dirunal pattern of transpiration rate ($\mu gcm^{-1}s^{-1}$) under different mulches at branching, 50% flowering, pod development and at harvest stage of summer groundnut influence by 75 mm CPE.

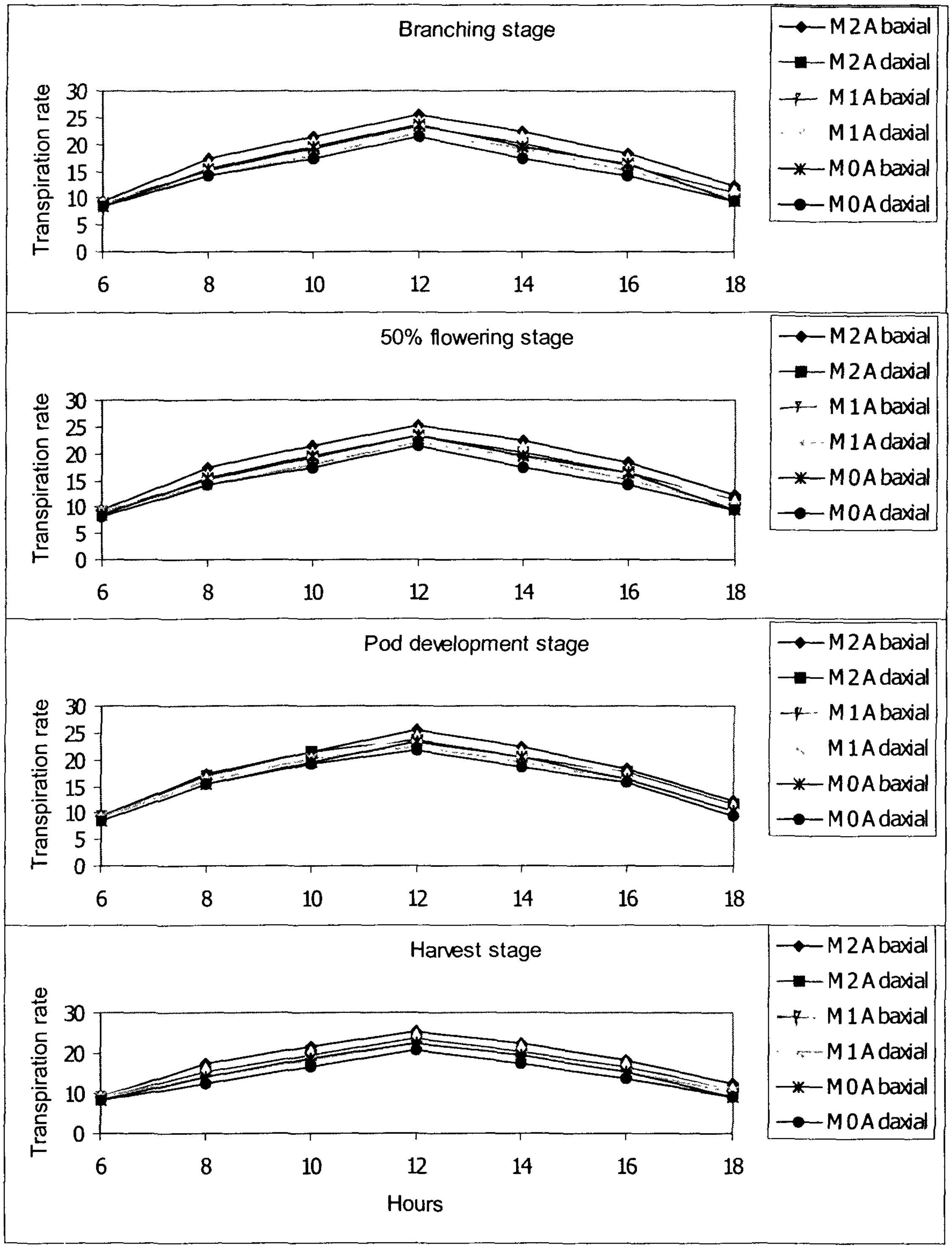


Fig. 14b. Dirunal pattern of transpiration rate (μgcm^{-1}s^{-1}) under different mulches at branching, 50% flowering, pod development and at harvest stage of summer groundnut *influence by 100 mm CPE.*

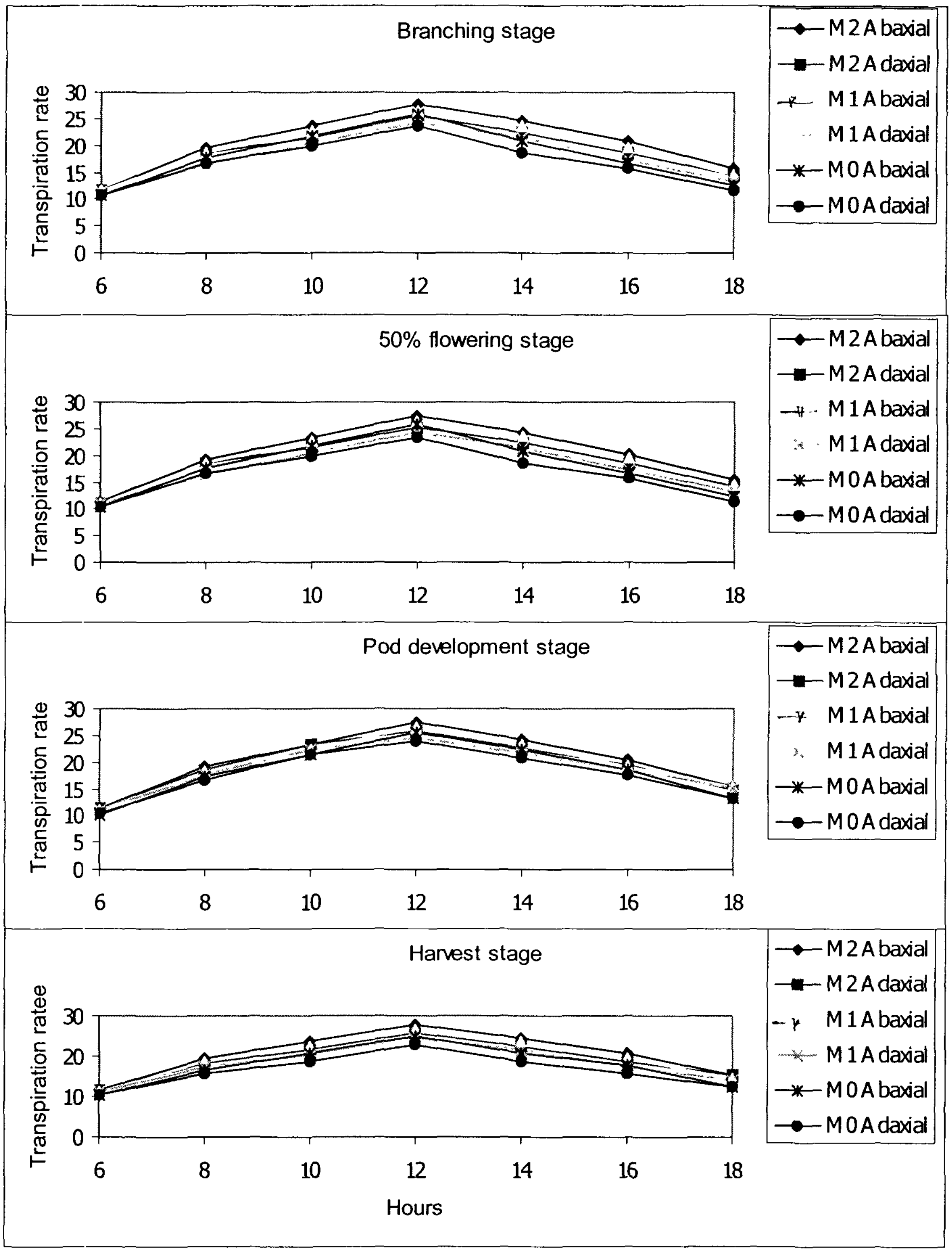


Fig. 14c. Dirunal pattern of transpiration rate ($\mu g cm^{-1} s^{-1}$) under different mulches at branching, 50% flowering, pod development and at harvest stage of summer groundnut influence by 125 mm CPE.

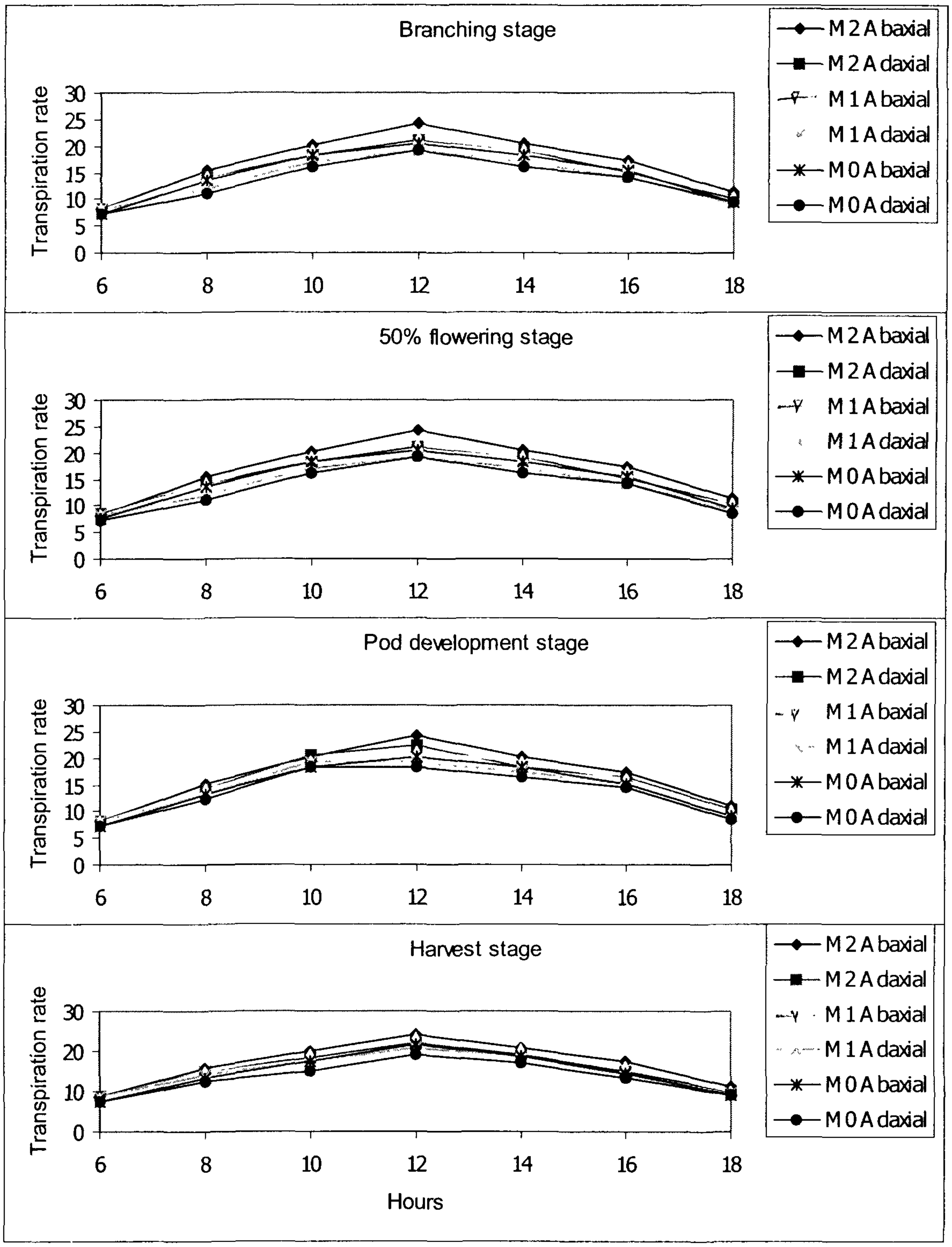


Fig. 14d. Dirunal pattern of transpiration rate (μgcm^{-1}s^{-1}) under different mulches at branching, 50% flowering, pod development and at harvest stage of summer groundnut influence by irrigation at 10 days interval.

condition due to remaining of stomates were close for most of the time and consequently decrease transpiration rate.

4.3. Biometric studies:

4.3.1 Plant height :

The data showing mean plant height as affected periodically by different treatments are presented in Table 20 and shown graphically in Fig. 15(a-b).

The data in Table 20 indicated that mean plant height was 6.00, 8.49, 10.09, 11.96, 14.03, 15.22, 15.75 and 15.48 cm at 28, 42, 56, 70, 84, 98, 112 DAS and

Table 20. Mean plant height (cm) as influenced periodically by different irrigation schedules and mulches.

Treatment	Days after sowing							
	28	42	56	70	84	98	112	At Harvest
IRRIGATION								
CPE (mm)								
75	6.12	8.66	10.32	12.27	14.19	15.63	16.13	15.88
100	6.07	8.56	10.26	12.15	14.27	15.47	15.97	15.72
125	5.89	8.32	9.79	11.46	13.56	14.67	15.17	14.92
10 DI	5.95	8.42	9.99	11.98	14.13	15.14	15.69	15.39
SE ±	0.03	0.02	0.01	0.08	0.17	0.06	0.06	0.001
C.D. at 5%	0.11	0.10	0.04	0.27	0.60	0.21	0.24	0.02
MULCHING								
Without mulch	5.70	8.02	9.13	11.30	12.93	13.99	14.49	14.24
Straw mulch	5.79	8.20	9.71	11.37	13.42	14.42	14.97	14.72
Polythene mulch	6.53	9.26	11.43	13.23	15.76	17.28	17.83	17.53
SE ±	0.02	0.02	0.001	0.06	0.16	0.04	0.05	0.006
C.D. at 5%	0.08	0.07	0.004	0.18	0.51	0.12	0.15	0.02
INTERACTION								
SE ±	0.04	0.04	0.002	0.10	0.29	0.07	0.08	0.01
C.D. at 5%	___	0.12	0.006	___	0.88	0.22	___	0.03
Mean	6.00	8.49	10.09	11.96	14.03	15.22	15.75	15.48

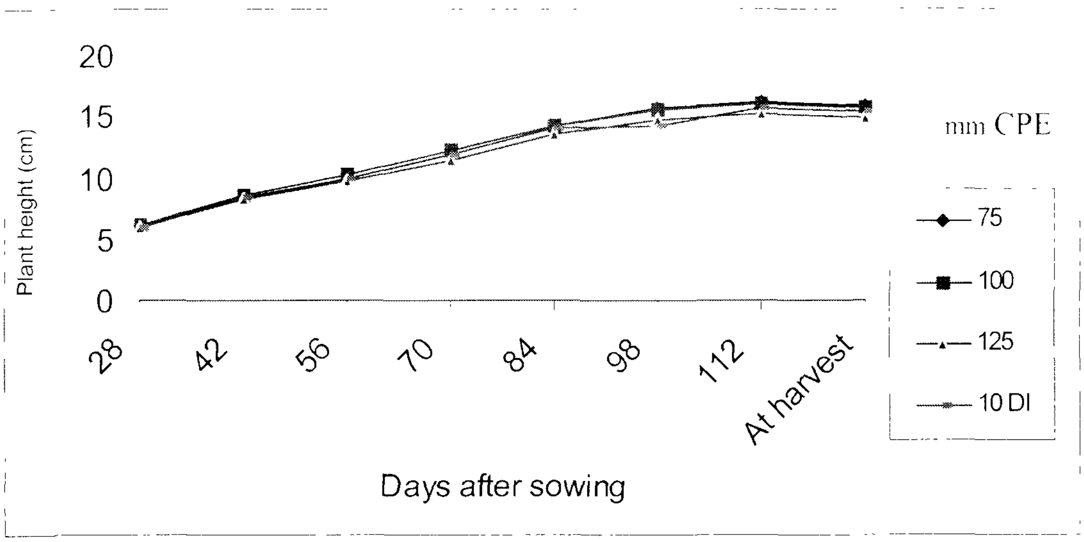


Fig.15a. Mean plant height (cm) as influenced periodically by different irrigation schedules.

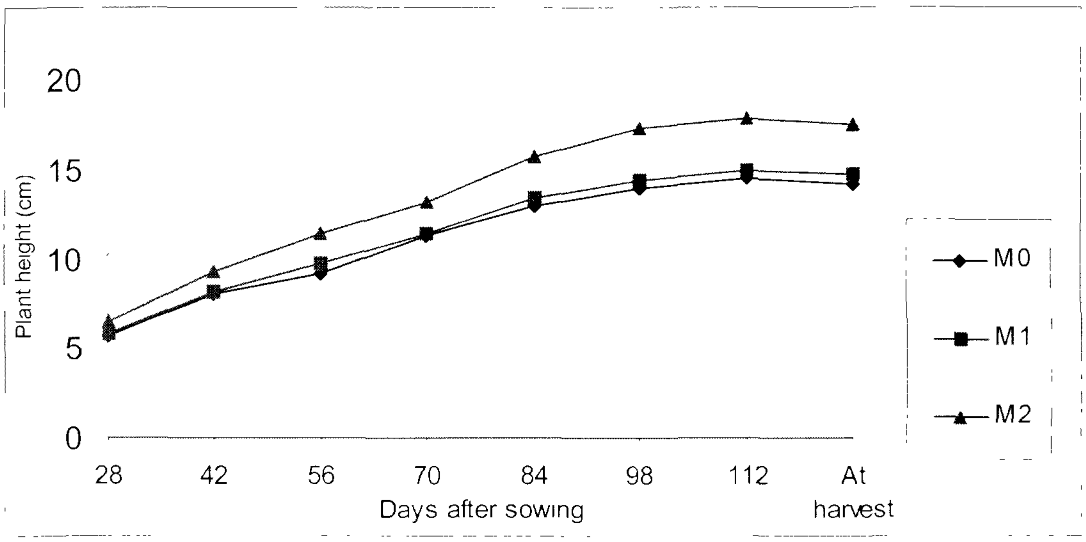


Fig.15b. Mean plant height (cm) as influenced periodically by different mulches.

at harvest, respectively. It showed that mean plant height increase with increase in age of crop upto 112 DAS and decrease slightly at harvest due to senescence of the leaves. It was also observed that plant height increase rapidly upto 70 DAS and thereafter slow down upto harvest stage.

Irrigation scheduling:

The scheduling of irrigation at 75 and 100 mm CPE significantly produced taller plants than irrigation scheduled at 125 mm CPE and 10 days interval on 28, 42, 70 and 98 days after sowing which may be due to adequate availability of soil moisture at critical crop growth stages. The plant height was significantly more under irrigation scheduling at 75 mm CPE on 56, 112 DAS and at harvest which may be ascribed adequate water availability of soil moisture under this irrigation schedule. Plant height was significant the lowest and significant under irrigation scheduled at 125 mm CPE. These results are similar to those results reported by Birajdar and Ingle (1974), Joshi (1978) , Desai *et al.* (1985) Madhusudhan Rao *et al.* (1988) , Patel *et al.* (1995) and Tiwari (1997) .

Mulching :

The plant height was the highest and significant under polythene mulch because of conservation of more soil moisture and higher temperature resulted in better availability of soil moisture throughout the crop growth period. Whereas, the plants were significantly dwarf under no mulch treatment at all the crop growth stages because of less moisture availability to the crop. These results are in conformity with the finding of Sang *et al.* (1987), Hu Weneguang *et al.* (1995), Sandhu *et al.* (1996) and Duan Shufan *et al.* (1998).

Interaction :

The interaction effects between irrigation scheduling and mulching were found to be significant at most of the crop growth stages except on 28, 70 and 112 DAS.

4.3.2. Number of branches per plant :

The data showing mean number of branches per plant as influenced periodically by different treatments are presented in Table 21 and shown graphically in fig. 16(a-b).

The data in the Table 21 showed that the mean number of branches plant^{-1} were 4.23, 4.26, 5.34, 5.68, 5.92, 6.62, 6.32 and 6.20 at 28, 42, 56, 70, 84, 98, 112 DAS and at harvest, respectively. The number of branches were increased upto 98 DAS and slightly decreased thereafter due to crop senescence.

Irrigation scheduling :

The number of branches were significantly the lowest under the irrigation scheduling of 125 mm CPE owing to longer irrigation interval which might have created stressed conditions to the crop. Whereas, the irrigation scheduled at 75 mm CPE produced significantly the highest number of branches at all the crop growth stages because of adequate soil moisture availability at most of the critical growth stages. It was also noticed that irrigation scheduled at 100 mm CPE significantly increase number of branches as compared to irrigation scheduled at an regular interval of 10 days particularly during advanced crop growth stages from 70 DAS onwords. These results are in conformity with the findings of Kumthekar (1974) and Patel *et al.* (1995).

Table 21. Mean number of branches $plant^{-1}$ as influenced periodically by different irrigation schedules and mulches.

Treatment	Days after sowing							
	28	42	56	70	84	98	112	At Harvest
IRRIGATION CPE (mm)								
75	4.81	4.65	5.64	5.89	6.01	6.73	6.44	6.31
100	4.31	4.28	5.43	5.79	6.16	6.85	6.58	6.39
125	3.69	3.79	4.94	5.45	5.65	6.34	6.02	5.95
10 DI	4.11	4.33	5.37	5.60	5.86	6.59	6.24	6.15
SE ±	0.06	0.08	0.04	0.02	0.01	0.01	0.03	0.03
C.D. at 5%	0.20	0.29	0.13	0.09	0.05	0.04	0.11	0.12
MULCHING								
Without mulch	3.52	3.74	4.46	4.66	4.94	5.62	5.37	5.23
Straw mulch	4.09	4.02	5.24	5.42	5.66	6.30	6.06	5.92
Polythene mulch	5.08	5.03	6.33	6.97	7.16	7.96	7.53	7.46
SE ±	0.04	0.09	0.04	0.01	0.03	0.03	0.04	0.02
C.D. at 5%	0.12	0.26	0.13	0.07	0.10	0.08	0.13	0.07
INTERACTION								
SE ±	0.07	0.15	0.07	0.03	0.05	0.04	0.07	0.04
C.D. at 5%	0.21	0.45	0.23	0.11	0.17	___	___	___
Mean	4.23	4.26	5.34	5.68	5.92	6.62	6.32	6.20

Mulching :

The number of branches were significantly more under polythene mulch and significantly less under no mulch at all the crop growth stages. The increase in number of branches under polythene mulch may be attributed due to initial increase in soil temperature, better retention of soil moisture and reduced crop weed competition. The less number of branches under no mulch treatment was due to more evaporation of soil moisture, more crop weed competition and more incidence of sucking pest. These results are in conformity with the findings of

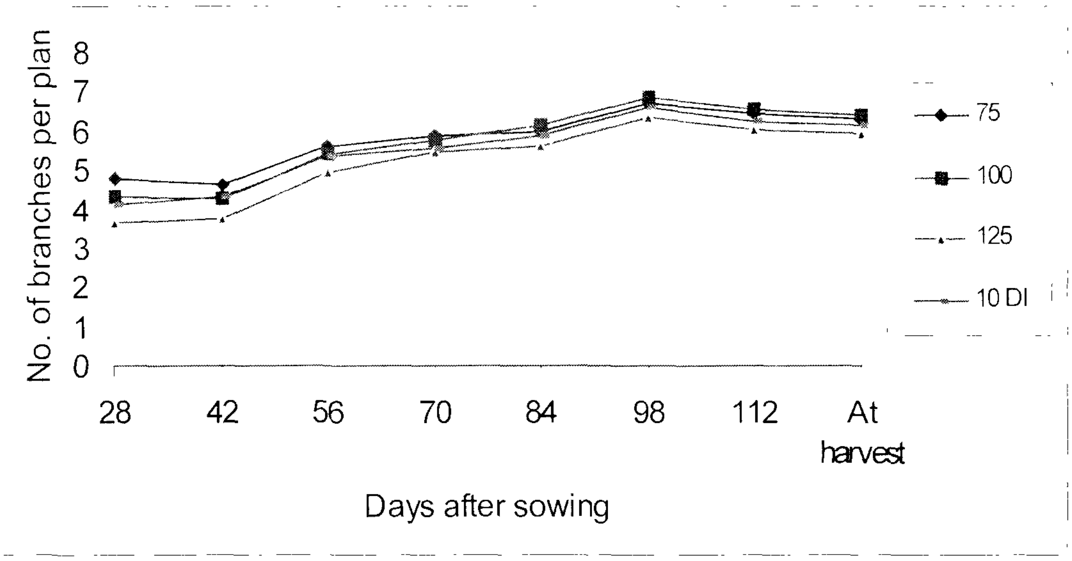


Fig.16a. Mean number of branches per plant as influenced periodically by different irrigation schedules.

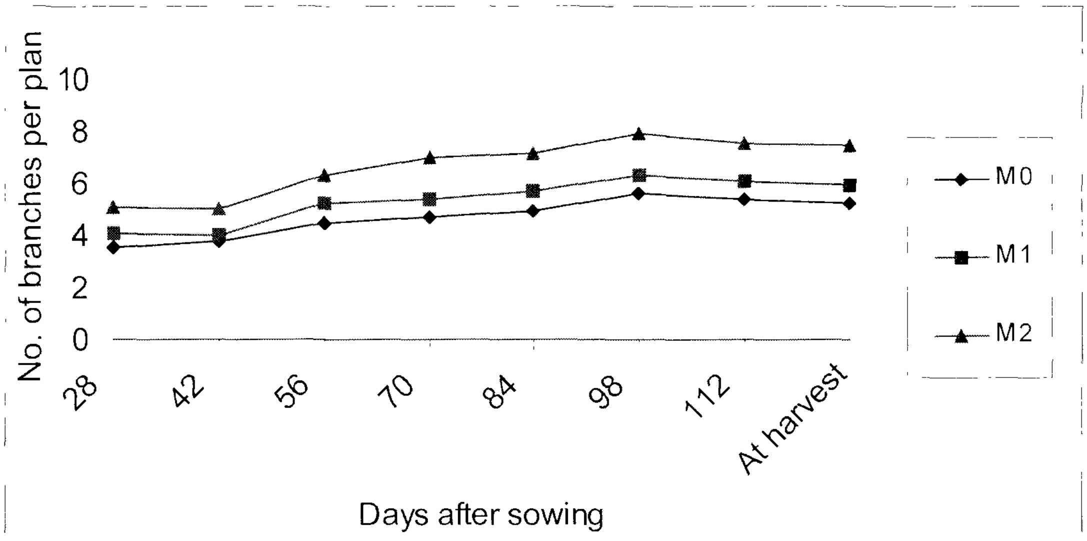


Fig.16b. Mean number of branches per plant as influenced periodically by different mulches.

Sang *et al.* (1987), Park (1996), Hu Wenguang *et al.* (1995) and Duan Shufan *et al.* (1998), Nalwade (1999), Chavan (1999) and Anonymous (1999).

Interaction :

Interactions effect between irrigation scheduling and mulches were significant up to 84 days and thereafter interactions were not present between these two factors.

4.3.3. Leaf area per plant :

The data regarding mean leaf area per plant of functional leaves influenced periodically by different treatments are presented in Table 22 and shown graphically in Fig. 17(a-b).

The data in Table 22 indicated that the mean leaf area plant^{-1} were 25.4, 32.5, 37.0, 39.8, 43.1, 44.8, 44.5 and 44.2 sq. cm at 28, 42, 56, 70, 84, 98, 112 DAS and at harvest, respectively. It indicates that the leaf area of functional leaves per plant was increased upto 98 days and slightly decreased thereafter due to senescence of leaves. The rapid increase in leaf area was observed upto 84th day.

Irrigation scheduling:

The leaf area is a reliable index of crop growth which was significantly influenced by irrigation scheduling at all the crop growth stages. The leaf area was significantly the highest under irrigation schedule of 75 mm CPE followed by 100 mm CPE, 10 days interval and 125 mm CPE at all the crop growth stages. The better leaf area development under 75 mm CPE was attributed to the better availability of soil moisture, increased efficiency of soil micro-organism and less crop weed competition. whereas, less leaf area developed under 125 mm CPE due to stress conditions and more crop weed competition. These results corroborate the findings of Thanzuala (1997) and Patel *et al.* (1995)

Table.22. Leaf area (cm^2) per plant as influenced periodically by different irrigation schedules and mulches.

Treatment	Days after sowing							
	28	42	56	70	84	98	112	At Harvest
IRRIGATION								
CPE (mm)								
75	26.6	34.5	37.4	41.0	44.5	46.0	45.7	45.3
100	25.6	32.9	37.0	40.7	44.0	45.6	45.3	45.0
125	24.5	30.3	36.7	37.7	40.1	41.9	41.6	41.3
10 DI	25.3	32.5	36.8	39.0	43.2	45.0	44.7	44.4
SE ±	0.002	0.001	0.008	0.02	0.0006	0.0003	0.008	0.06
C.D. at 5%	0.005	0.004	0.00	0.06	0.002	0.001	0.03	0.19
MULCHING								
Without mulch	22.7	32.3	36.6	40.8	42.4	44.3	44.0	43.7
Straw mulch	23.5	31.1	36.2	39.6	43.4	45.2	44.8	44.5
Polythene mulch	30.1	34.1	38.4	40.4	44.2	46.1	45.8	45.5
SE ±	0.001	0.002	0.008	0.01	0.0005	0.0004	0.009	0.04
C.D. at 5%	0.003	0.006	0.02	0.04	0.001	0.001	0.03	0.15
INTERACTION								
SE ±	0.00	0.00	0.01	0.02	0.00	0.00	0.01	0.08
C.D. at 5%	0.00	0.04	0.04	0.07	0.00	0.00	0.05	0.26
Mean	25.4	32.5	37.0	39.8	43.1	44.8	44.5	44.2

Mulching :

The leaf area development was significantly more under polythene mulch than straw mulch and no mulch at all the crop growth stages because of higher soil temperature, better retention of soil moisture, improved microclimate and reduced crop weed competition. It was further observed that straw mulch also significantly increased leaf area per plant than no mulch because of initial increase in soil temperature, conservation of more soil moisture and less crop weed competition. Similar results were reported by Chavan (1999), Nalawade (1999) and Anonymous (1999).

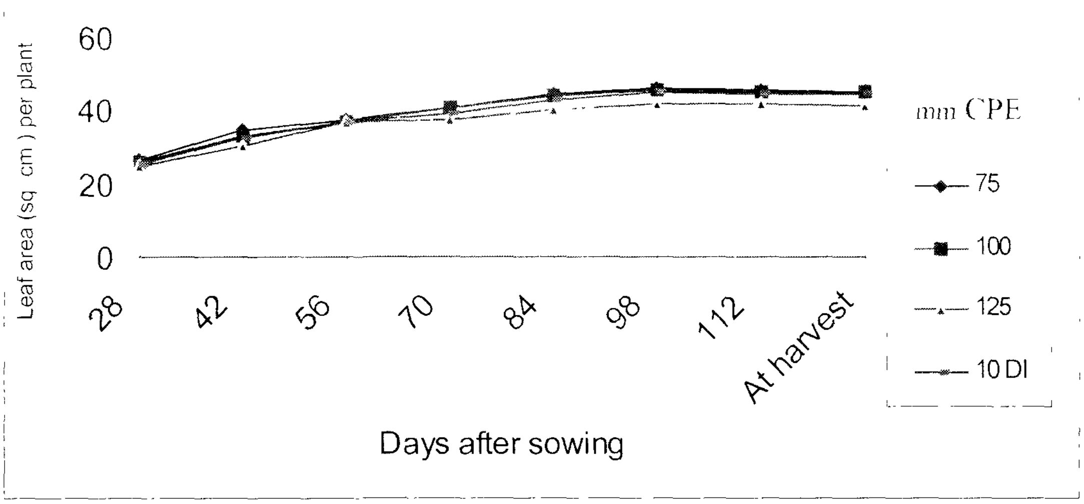


Fig.17a. Mean leaf area (sq. cm.) per plant as influenced periodically by different irrigation schedules.

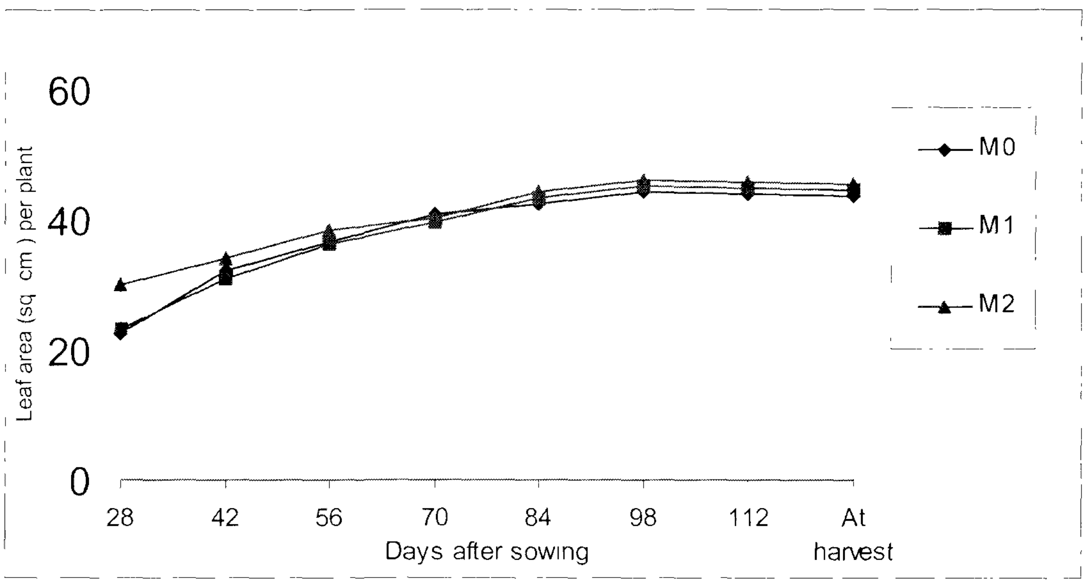


Fig.17b. Mean leaf area (sq. cm.) per plant as influenced periodically by different mulches.

Interaction :

Interactions effect between the irrigation scheduling and mulching were found to be significant at all the crop growth stages.

4.3.4. Dry matter per plant :

The data on total dry matter plant^{-1} as affected periodically by various treatments are given in Table 23 and shown graphically in Fig 18 (a-b).

The data shown in Table 23 indicated that the mean dry matter plant^{-1} were 2.58, 8.15, 12.49, 18.66, 20.69, 22.47, 27.32 and 30.37 g at 28, 42, 56, 70, 84, 98, 112 DAS and at harvest, respectively. It indicates that dry matter plant^{-1} were increased with the age advancement of the crop.

Irrigation scheduling :

The dry matter production plant^{-1} was significantly the lowest under irrigation scheduled at 125 mm CPE at all the crop growth stages owing to stressed conditions experienced by the crop at most of the critical growth stages of the crop. Irrigation scheduled at 75 mm CPE produced significantly more dry matter plant^{-1} than irrigation scheduled at 10 days interval on 42, 56 and 112 days owing adequate soil moisture at most of the critical growth stages of the crop. These results are in the conformity with the findings of Birajdar (1973), Babalad and Kulkarni (1988), Madhusudhan Rao *et al.* (1988) and Patel *et al.* (1995).

Table 23. Dry matter (g) $plant^{-1}$ as influenced periodically by different irrigation schedules and mulches.

Treatment	Days after sowing							
	28	42	56	70	84	98	112	At Harvest
IRRIGATION CPE (mm)								
75	2.63	8.27	12.65	18.95	20.93	22.45	27.55	31.68
100	2.61	8.18	12.60	18.99	20.78	22.60	27.58	30.64
125	2.38	8.03	12.25	18.06	20.27	22.31	26.33	28.87
10 DI	2.66	8.16	12.46	18.67	20.82	22.53	27.42	30.15
SE ±	0.04	0.03	0.04	0.09	0.09	0.09	0.02	0.76
C.D. at 5%	0.15	0.11	0.14	0.31	0.31	0.31	0.09	2.74
MULCHING								
Without mulch	2.49	8.05	12.33	17.11	17.19	20.22	25.23	28.16
Straw mulch	2.56	8.09	12.47	17.28	21.14	22.13	27.16	30.31
Polythene mulch	2.73	8.33	12.67	19.61	23.76	25.06	30.03	32.80
SE ±	0.01	0.01	0.01	0.10	0.09	0.08	0.03	0.79
C.D. at 5%	0.03	0.05	0.04	0.31	0.28	0.26	0.09	2.41
INTERACTION								
SE ±	0.02	0.03	0.02	0.18	0.16	0.15	0.05	1.36
C.D. at 5%	0.05	0.08	___	0.54	___	___	___	___
Mean	2.58	8.15	12.49	18.66	20.69	22.47	27.32	30.37

Mulching :

The dry matter production $plant^{-1}$ was significantly the highest under polythene mulch and significantly the lowest under no mulch at all the days of observations. The differences were more pronounced particularly during advanced crop growth stages. The higher dry matter production under polythene mulch was attributed due to more retention of soil moisture, higher soil temperatures, reduce crop weed competition, better microclimate, increases efficiency of soil microorganism and reduce incidence of sucking pest. Similar findings were also

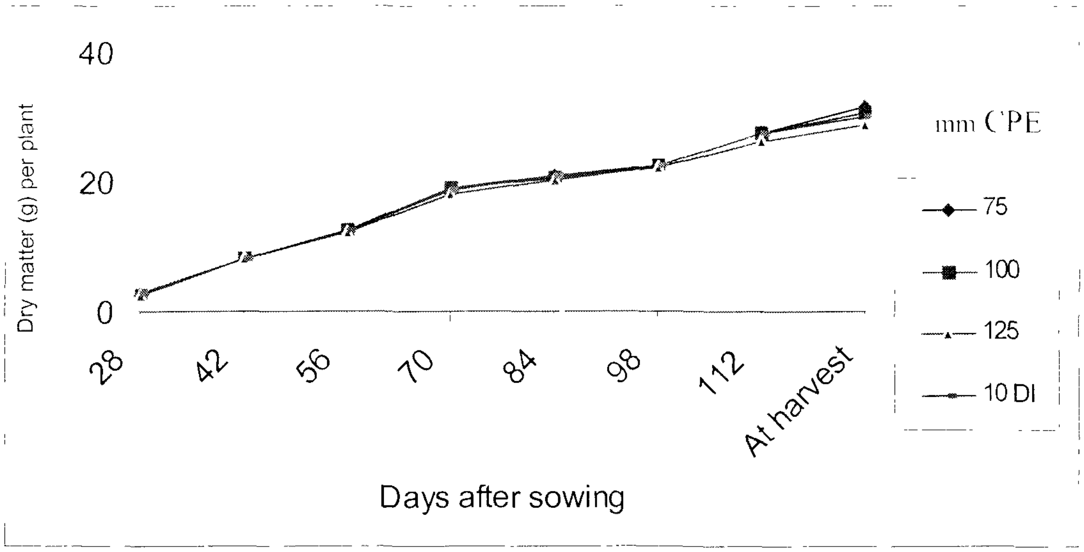


Fig.18a. Mean dry matter (g) per plant as influenced periodically by different irrigation schedules.

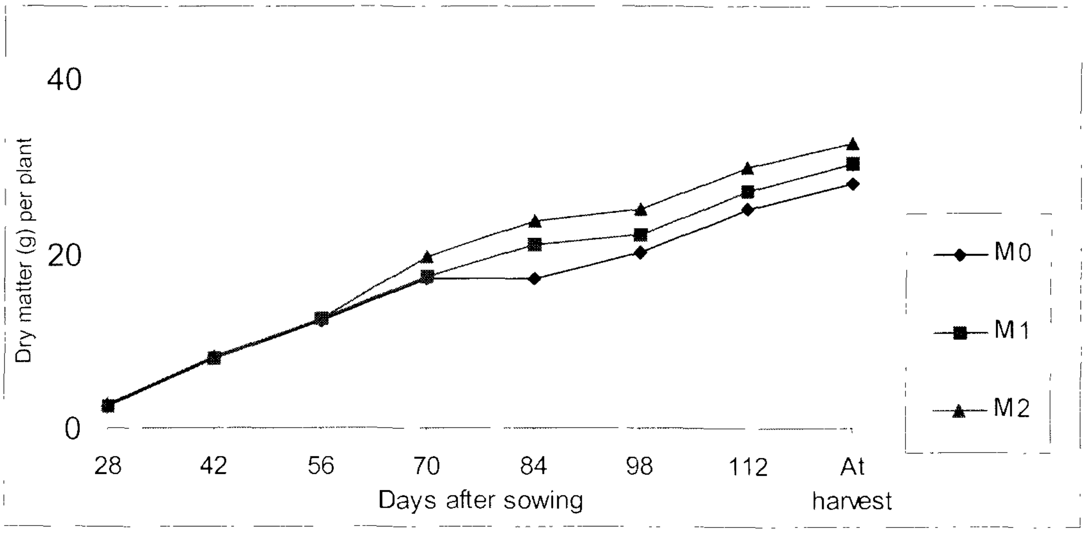


Fig.18b. Mean dry matter (g) per plant as influenced periodically by different mulches.

reported by Sang *et al.*(1987), Hu Wenguang *et al.*(1995) and Duan Shufan *et al.*(1998), Chavan (1999), Nalawade (1999)and Anonymous (1999).

Interaction :

Interactions effect between irrigation schedule and mulches were significant on 28, 42 and 70 days.

4.3.5. Days to 50% flowering and physiological maturity:

The data showing mean days to 50% flowering and maturity as influenced by the different treatments are presented in Table 24.

Table 24. Days to 50% flowering and days to physiological maturity as influenced by different irrigation schedules and mulches.

Treatment	Days to 50% flowering	Days to physiological maturity
IRRIGATION		
CPE (mm)		
75	46.11	116.11
100	46.33	116.66
125	49.00	118.33
10 DI	46.55	117.00
SE ±	0.18	0.16
C.D. at 5%	0.64	0.55
MULCHING		
Without mulch	48.25	118.00
Straw mulch	47.08	117.00
Polythene mulch	45.66	116.08
SE ±	0.18	0.20
C.D. at 5%	0.56	0.61
INTERACTION		
SE ±	0.32	0.35
C.D. at 5%	0.97	1.06
Mean	46.99	117.02

The data shown in Table 24 indicates that mean days to 50% flowering were 46.99 days and that for physiological maturity were 117.02 days.

Irrigation scheduling :

Significantly more number of days were required for 50% flowering and physiological maturity when irrigation schedule at 125 mm CPE than other irrigation schedules owing to stressed conditions under 125 mm CPE might have delayed flowering and maturity period.

Mulching:

Significantly more number of days for 50% flowering and physiological maturity was required under no mulch and significantly less under polythene mulch owing to stress condition under former case. These results are inconformity with the finding of Sang *et al.*(1987), Hu Wenguang *et al.*(1995) and Duan Shufan *et al.*(1998).

Interaction:

Interactions between irrigation scheduling and mulching were present for both; days to 50% flowering and physiological maturity.

4. 3. 6. Number of nodules and their weight per plant :

The data showing mean number of nodules and weight of nodules as influenced by different treatments at branching, 50% flowering and at harvest are presented in Table 25 and shown graphically in Fig. 19(a-b).

The data presented in Table 25 indicate that the mean number of nodules and their weight (mg) at the initiation of branching, 50% flowering and harvest stage were 1.55, 32.01, 6.71 and 0.61, 1.20, 0.28 mg, respectively.

Irrigation scheduling :

The nodule number plant^{-1} was significantly more under irrigation scheduling of 75 mm CPE than other irrigation scheduling at branching and 50% flowering stages. Where as, it was significantly the lowest under irrigation scheduling at 125 mm CPE at all the crop growth stages. The weight of nodule

Table 25. Mean number of nodules and their weight per plant as affected by different irrigation schedules and mulches at important crop growth stages.

Treatment	Branching		50% flowering		Harvest	
	No of nodules	Wt. of nodules	No of nodules	Wt. of nodules	No of nodules	Wt. of nodules
IRRIGATION						
CPE (mm)						
75	1.56	0.67	32.54	1.24	7.01	0.31
100	1.55	0.62	32.35	1.21	7.00	0.30
125	1.53	0.56	31.00	1.16	6.00	0.21
10 DI	1.55	0.60	32.33	1.20	7.00	0.28
SE ±	0.001	0.006	0.0007	0.006	0.005	0.004
C.D. at 5%	0.004	0.02	0.002	0.02	0.02	0.01
MULCHING						
Without mulch	1.54	0.57	31.11	1.21	6.00	0.24
Straw mulch	1.55	0.61	32.29	1.18	7.00	0.28
Polythene mulch	1.56	0.64	32.51	1.23	7.01	0.31
SE ±	0.008	0.002	0.0001	0.003	0.006	0.003
C.D. at 5%	0.002	0.08	0.0004	0.009	0.02	0.01
INTERACTION						
SE ±	0.001	0.005	0.0002	0.005	0.01	0.006
C.D. at 5%	___	0.015	___	___	0.03	___
Mean	1.55	0.61	32.81	1.20	6.71	0.28

plant^{-1} was significantly the highest under scheduling of irrigation at 75 mm CPE at the initiation of branching and flowering stages and it was significantly the lowest under the irrigation scheduling at 125 mm CPE at all the crop growth stages owing to stressed conditions under this irrigation schedule. It was further observed that nodule weight plant^{-1} was significantly more under 75 mm CPE than that of irrigation scheduling at 10 days interval at the harvest stage of the crop. These results are in conformity with the finding of Rasve *et al.* (1983) and Patel *et al.* (1995)

Mulching :

The number of nodules plant^{-1} were increased significantly under polythene mulch than straw mulch and no mulch at branching and 50% flowering owing to

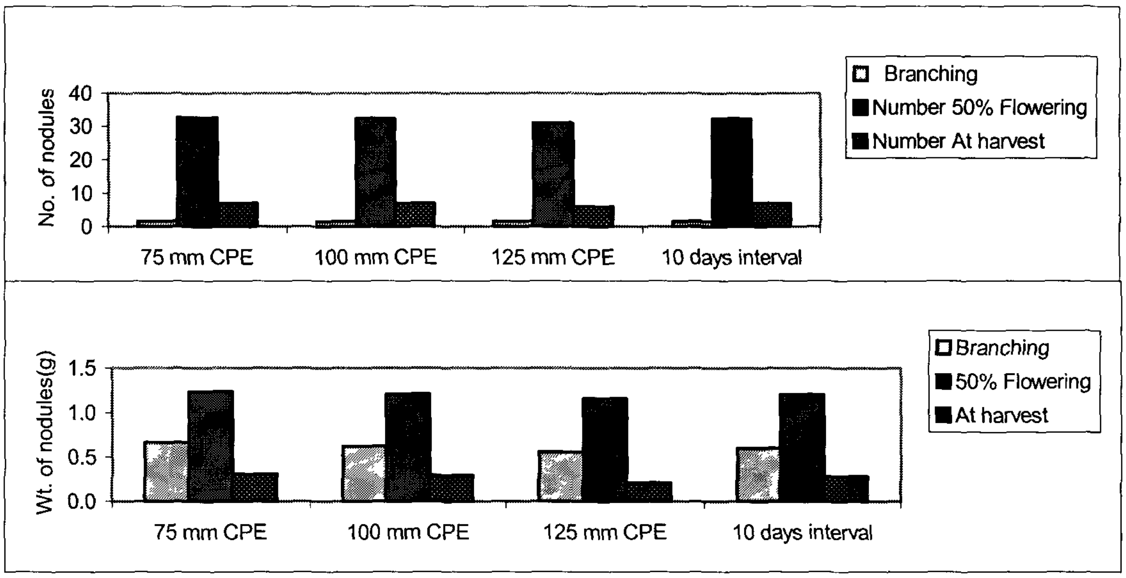


Fig.19a. Mean number of nodules and their weight per plant under different irrigation schedules at important crop growth stages.

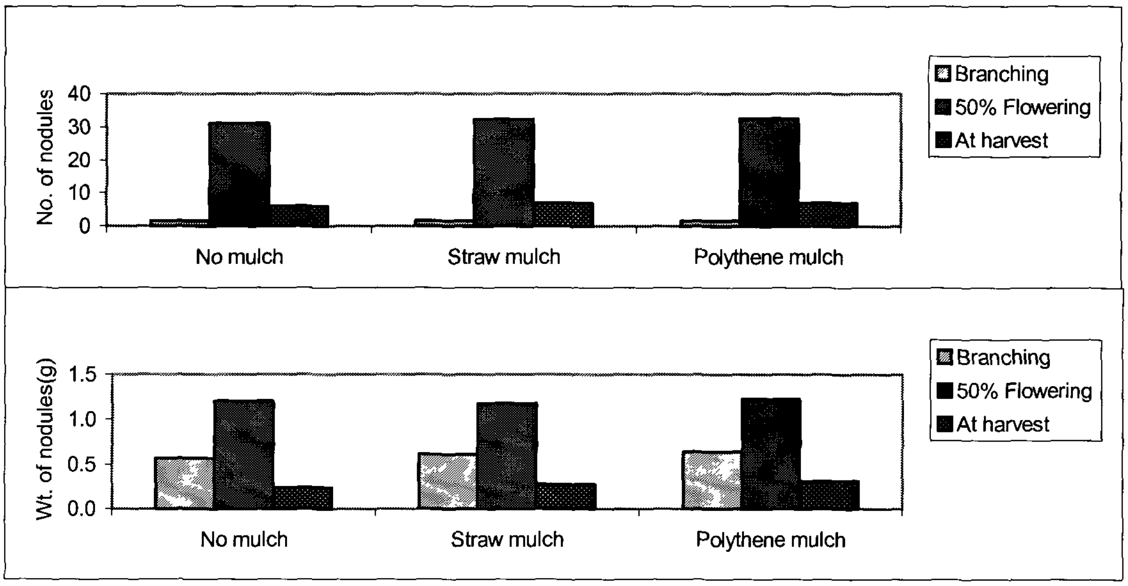


Fig.19b. Mean number of nodules and their weight per plant under different mulches at important crop growth stages.

better moisture availability, less crop weed competition and better microclimate. The nodule number plant^{-1} was significantly the lowest under no mulch at all the days of observations owing to stressed conditions. The weight of nodules plant^{-1} was significantly more under polythene mulch followed by straw mulch and no mulch at the initiation of branching, 50% flowering and at harvest owing to more moisture retention under former case and less under latter one. These results are similar to those are reported by Sang *et al.*(1987), Hu Wenguang *et al.*(1995) and Duan Shufan *et al.*(1998).

Interaction :

Interaction between irrigation schedules and mulching was present for number of nodules plant^{-1} at harvest and for weight of nodules plant^{-1} at the initiation of branching.

4.4. Post harvest studies :

4.4.1. Yield contributing characters:

The data in respect of yield contributing characters as influenced by different treatments are presented in Table 26 and shown graphically in Fig. 20 (a-b). The mean values of yield contributing characters viz, number of pods plant^{-1} and their weight and 100 kernel weight were 36.44, 43.37 and 44.91g, respectively.

Irrigation scheduling :

The number of pods and their weight plant^{-1} and 100 kernal weight were significantly the lowest under irrigation scheduled at 125 mm CPE as crop experienced stresse conditions resulting in stunted growth and less dry matter accumulation and consequently lower values of these yield attributes. However,

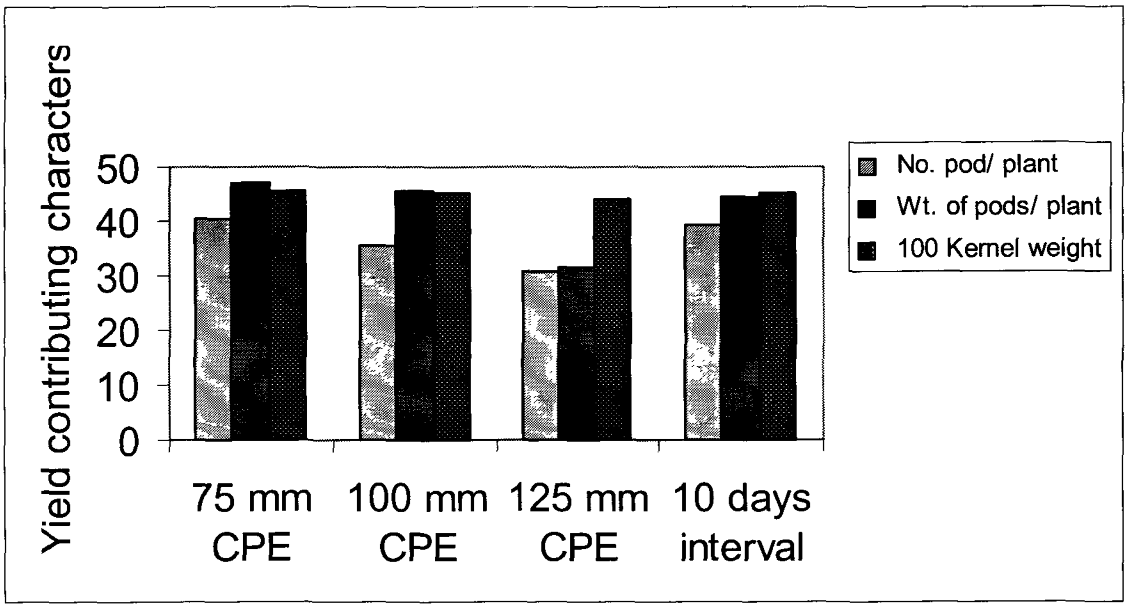


Fig.20a. Yield contributing characters as influenced by different irrigation schedules.

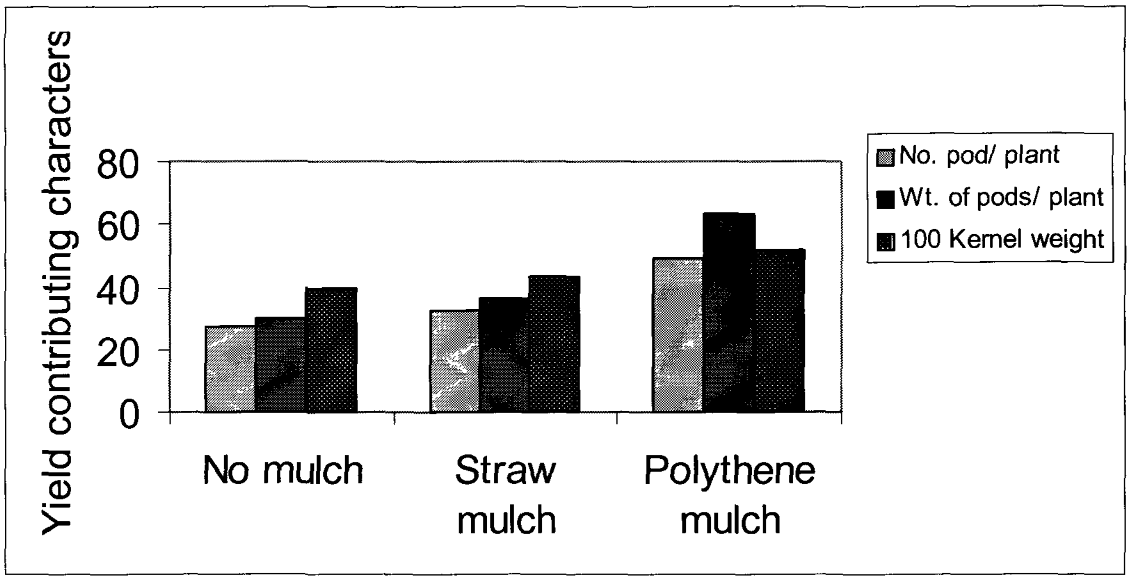


Fig.20b. Yield contributing characters as influenced by different mulches.

Table 26. Yield contributing characters as influenced by different irrigation schedules and mulches.

Treatment	No. of pods / Plant	Wt. of pods / Plant (g)	100 kernel wt. (g)
IRRIGATION			
CPE (mm)			
75	40.33	46.94	45.50
100	35.55	45.48	45.10
125	30.66	31.64	43.91
10 DI	39.22	44.42	45.01
SE ±	1.74	0.11	0.05
C.D. at 5%	6.14	0.40	0.18
MULCHING			
Without mulch	27.50	30.35	39.87
Straw mulch	32.58	36.29	43.44
Polythene mulch	49.25	63.48	51.55
SE ±	0.87	0.13	0.06
C.D. at 5%	2.67	0.41	0.18
INTERACTION			
SE ±	1.51	0.23	0.10
C.D. at 5%	4.63	0.71	0.31
Mean	36.44	43.37	44.91

weight of pods $plant^{-1}$ and 100 kernel weight were significantly more under irrigation scheduled at 75 mm CPE because of adequate moisture availability created congenial conditions for the activities of micro organism and consequently increased the values of yield attributes. The irrigation scheduled at 100 mm CPE also increased the weight of pods per plant significantly as compared to irrigation scheduling at 10 days interval. These results are in conformity with the findings of Bharambe and Varade(1982) and Pawar *et al.* (1993).

Mulching :

The number of pods and their weight $plant^{-1}$ and 100-kernel weight were significantly the highest under polythene mulch and significantly the lowest under no mulch. The higher values of yield attributing characters under polythene mulch may be attributed to initial increase in soil temperature, better retention of soil moisture, increased efficiency of microorganism and reduced crop weed competition. The lower values of yield attributes under no mulch may be due to stressed conditions which has resulted dwarfer plant and less accumulation of dry matter. Similar results were reported by Dayal *et al.* (1989), Sang *et al.*(1987), Hu Wenguang *et al.*(1995) and Duan Shufan *et al.*(1998).

Interaction:

Interaction between irrigation schedules and mulching for different yield attributes was found to be significant.

4.4.2. Yield and Harvest index :

The data regarding mean pod and creeper yield and harvest index as influenced by different treatments are given in Table 27 and shown graphically in Fig. 21(a-b). The mean pod and creeper yield was 18.19 qha^{-1} and 46.55 qha^{-1}, respectively. The mean harvest index was 39.15.

Irrigation scheduling :

The irrigation scheduled at 75 and 100 mm CPE and 10 days interval were found to be at par with each other but increase dry pod, creeper yield and harvest index significantly as compared to scheduling of irrigation at 125 mm CPE. This was ascribed to availability of adequate quantity of water under former irrigation schedules but crop experienced stress conditions under later one. Similar results were reported by Dahatonde (1978), Shelke (1979), Patil (1985), Jadhav *et al.* (1989), and Tiwari and Dhakar (1997). The number of irrigations applied under 75 and 100 mm CPE and at 10 days interval were 9, 7 and 9, respectively but no significant differences were noticed in pod and creeper yield of these irrigation schedules indicating that summer groundnut should be irrigated at 100 mm CPE value for economizing the water use. Patil (1985) also found that 100 mm CPE is optimum for summer groundnut and gives the highest additional profit than rest of the irrigation schedules. Similar results were also reported by Birajdar (1973), Dahatonde (1978).

Table 27. Mean pod and creeper yield and harvest index as influenced by different irrigation schedules and mulches.

Treatment	Pod yield (qha^{-1})	Creeper yield (qha^{-1})	Harvest index
IRRIGATION			
CPE (mm)			
75	20.74	50.83	41.36
100	20.35	51.48	39.78
125	12.36	36.31	35.40
10 DI	19.06	47.59	40.06
SE ±	0.56	1.24	0.60
C.D. at 5%	1.99	4.37	2.12
MULCHING			
Without mulch	14.10	35.40	39.59
Straw mulch	15.56	40.46	38.41
Polythene mulch	25.19	63.80	39.45
SE ±	0.19	1.19	0.81
C.D. at 5%	0.59	3.64	—
INTERACTION			
SE ±	0.34	2.07	1.42
C.D. at 5%	1.03	6.31	4.32
Mean	18.19	46.55	39.15

Mulching :

The application of polythene mulch (7 micron) to summer groundnut increased pod and creeper yields significantly as compared to straw mulch and no mulch. The polythene mulch increased pod yield by 78.65 and 61.89 per cent and creeper yield by 80.22 and 57.69 per cent as compared to no mulch and straw mulch, respectively. Increase in pod and creeper yield under polythene mulch was ascribed due to initial increase in soil temperature which might be helped for better germination, better retention of soil moisture throughout the crop growth period, increase efficiency of soil microorganisms, improve microclimate, reduced crop weed competition and less incidence of sucking pest. These results are similar to

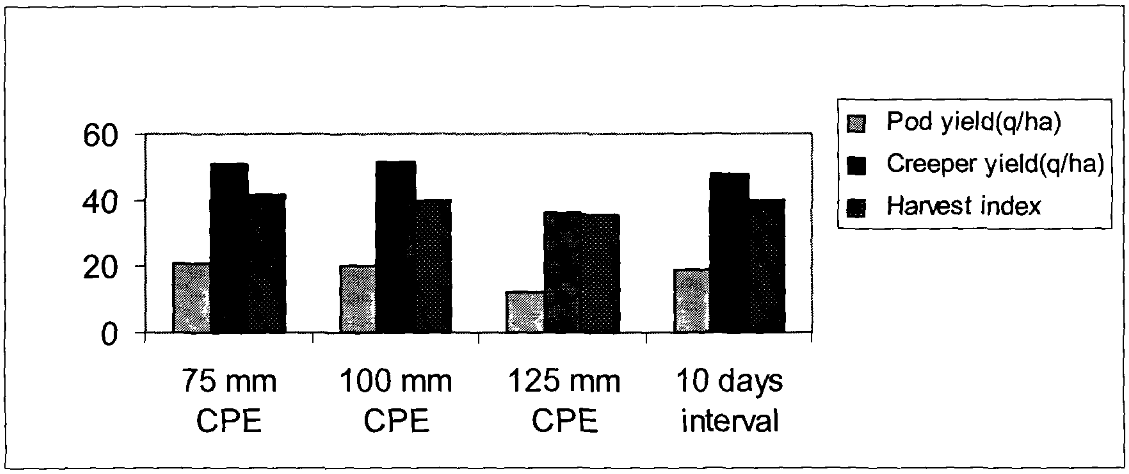


Fig.21a. Mean pod yield, creeper yield and harvest index as influenced by different irrigation schedules.

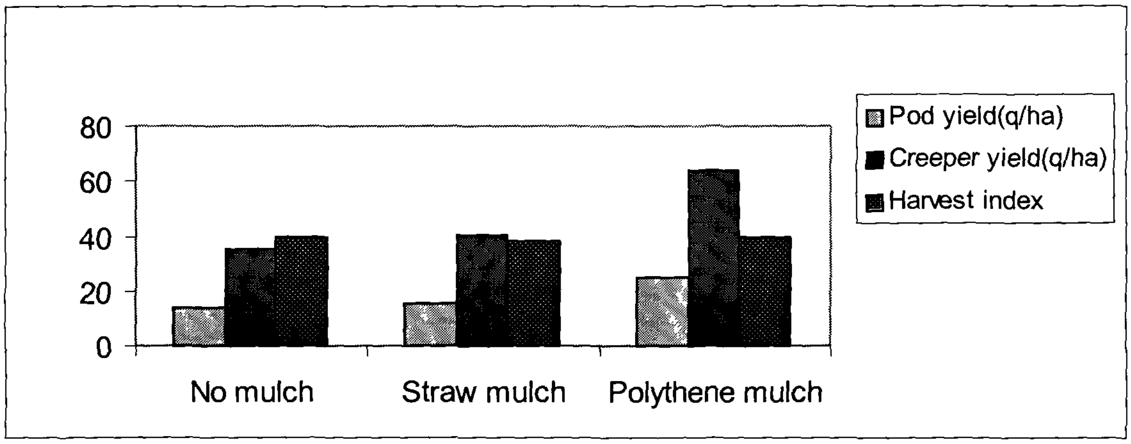


Fig.21b. Mean pod yield, creeper yield and harvest index as influenced by different mulches.

those results reported by Dayal *et al.* (1991), Dayal *et al.* (1995), Hu Wenguang *et al.* (1995), Park *et al.* (1996), Chavan (1999), Nalawade (1999), Anonymous (1999) and Anonymous (2000).

It was further observed that the straw mulch of sugar cane trash also significantly gave more pod and creeper yield as compared to no mulch treatment.

However, harvest index was not influenced significantly due to different mulches under study as it is more or less genetical character.

Interaction :

Interactions effect between irrigation schedules and mulching were significant for pod as well as creeper yield (Table 28).

Table 28. The mean pod and creeper yield as influenced by interaction between irrigation schedules and mulching.

Irrigation CPE(mm)	Pod yield (qha^{-1})			Creeper yield (qha^{-1})		
	No Mulch	Straw mulch	Polythene mulch	No Mulch	Straw mulch	Polythene mulch
75	16.34	17.51	28.40	37.74	42.02	72.75
100	15.17	16.73	29.18	36.57	44.35	73.53
125	10.50	12.06	16.34	31.12	35.79	42.01
10 DI	14.39	15.95	26.84	36.18	39.68	66.91
SE ±	0.34			2.07		
CD at 5%	1.03			6.31		

The pod and creeper yields were significantly the lowest under irrigation scheduled at 125 mm CPE than other irrigation schedules under different mulches (Table 27). It was also observed that the pod and creeper yields were increased significantly under polythene mulch as compared to straw mulch and no mulch under all the irrigation schedules. The irrigation scheduled at 100 mm CPE and application of polythene mulch produced significantly the highest pod yield (29.18

Plate. Effect of no mulch on growth of summer groundnut under 100 mm CPE at pegging stage.

Plate. Effect of straw mulch on growth of summer groundnut under 100 mm CPE at pegging stage.

Plate . Effect of polythene mulch on growth of summer groundnut under 100 mm CPE at pegging stage.

q ha^{-1}). It was at par with irrigation scheduled at 75 mm CPE with polythene mulch (28.40 q ha^{-1}).

4.4.3. Pod yield, evapotranspiration (mm) and water use efficiency (WUE) :

The data regarding pod yield, evapotranspiration and water use efficiency as influenced by different irrigation schedules and mulches are presented in Table 29 and 30 and shown graphically in fig. 22(a-b).

The number of irrigations applied under 75, 100 and 125 mm CPE and 10 days interval irrigation schedules were 9, 7, 5 and 9 at an interval of 9.6, 13.2, 16.3 and 10 days, respectively. The values of evapotranspiration values under these irrigation schedules were 586.57, 492.31, 400.33 and 630.30 mm, respectively.

Table 29. Mean number of irrigations, interval between irrigations, pod yield evapotranpiration and water use efficiency as influenced by different schedules.

IRRIGATION CPE (mm)	No. of irrigation	Av. Irrigation interval (days)	Pod yield (q ha^{-1})	ET (mm)	WUE (kgmm^{-1}ha^{-1})
75	9	9.6	20.74	586.57	3.54
100	7	13.2	20.35	492.31	4.13
125	5	16.3	12.36	400.33	3.09
10 DI	9	10	19.06	630.30	3.02
Mean	7.5	12.3	18.19	527.40	3.45

The water use efficiency under different irrigation schedules varied between 3.02 and 4.13 kgmm^{-1}ha^{-1} . The pod yield did not show significant difference between irrigation schedules of 75 and 100 mm CPE but the maximum water use efficiency of 4.13 kgmm^{-1}ha^{-1} with minimum 7 irrigations turns was obtained with irrigation scheduling at 100 mm CPE suggesting that summer

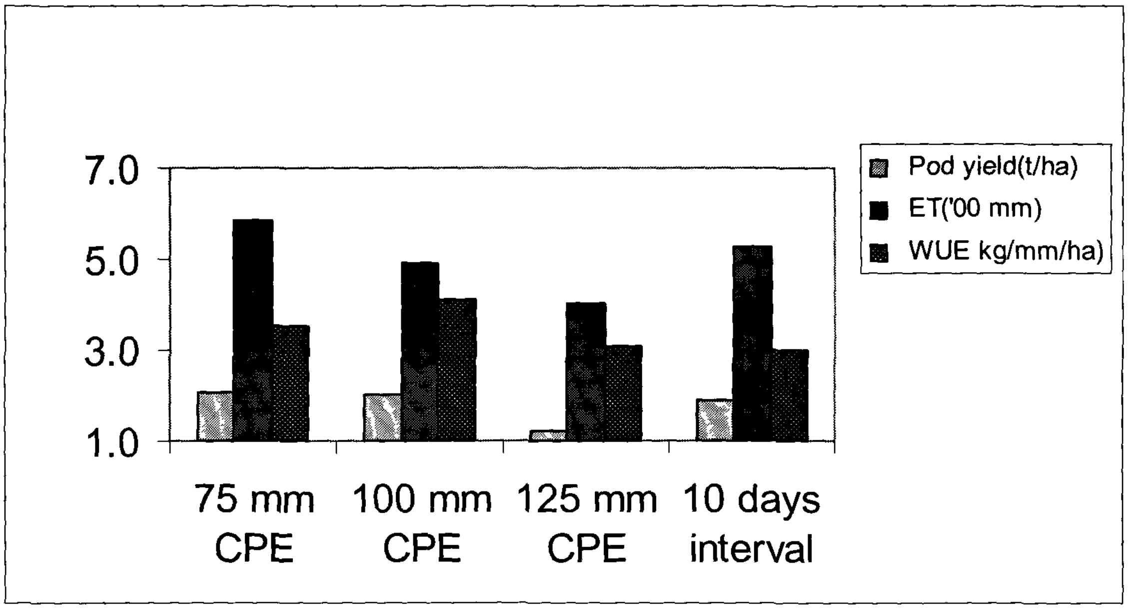


Fig.22a. Mean pod yield (tha^{-1}), evapotransipiration (mm) and water use efficiency ($kgmm^{-1}ha^{-1}$) as influenced by different irrigation schedules.

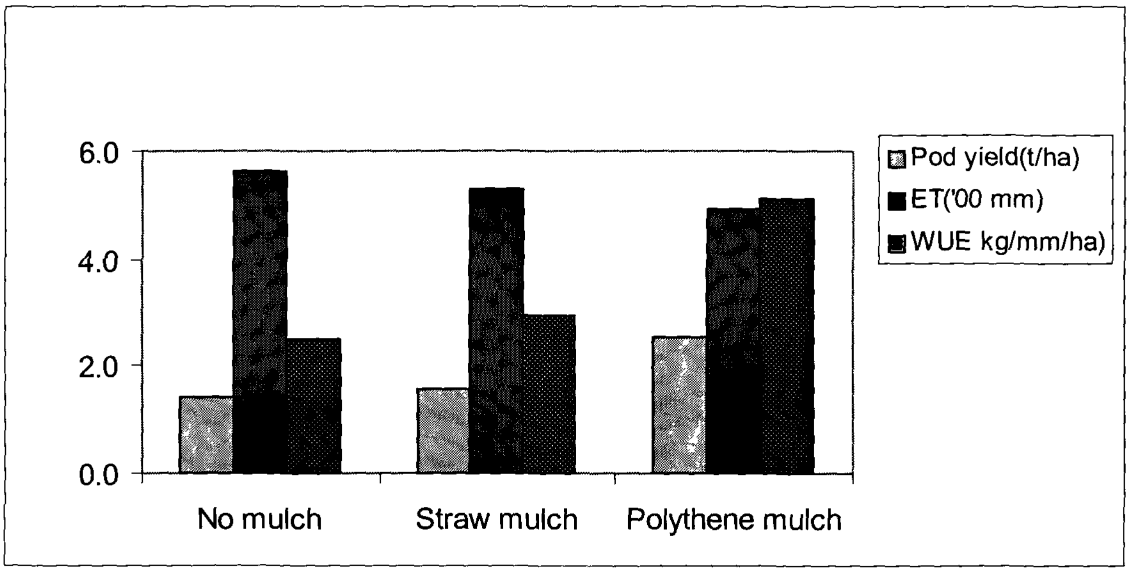


Fig.22b. Mean pod yield (tha^{-1}), evapotransipiration (mm) and water use efficiency ($kgmm^{-1}ha^{-1}$) as influenced by different mulches.

groundnut be irrigated with 100 mm CPE value for economizing the water use by the crop.

Table 30. Mean pod yield, evapotranspiration and water use efficiency as influenced by different mulches.

MULCHING	Pod yield (q/ha)	ET (mm)	WUE $kgmm^{-1}ha^{-1}$
No mulch	14,10	562.33	2.51
Straw mulch	15.56	527.37	2.95
Polythene mulch	25.19	492.44	5.12
Mean	18.19	527.40	3.53

The evapotranspiration under different mulches varied between 492.44 and 562.33 mm. The water use efficiency was the highest under polythene mulch (5.12 $kgmm^{-1}ha^{-1}$) followed by straw mulch (2.95 $kgmm^{-1}ha^{-1}$) and no mulch (2.51 $kgmm^{-1}ha^{-1}$) indicating that the water is most efficiently utilized under the polythene mulch. It would be therefore, advisable to use polythene mulch to summer groundnut for maximizing pod yield and economizing the water use by the crop.

SUMMARY AND CONCLUSION

5. SUMMARY AND CONCLUSION

5.1. Summary :

The field investigation entitled "Studies on microclimate of summer groundnut (*Arachis hypogaea* (L.)) under different irrigation schedules and mulches" was carried out during summer season of the year 1999. The experiment was laid out in split plot design with 3 replications. The main plot treatments comprised of 4 irrigation schedules *viz.*, 75, 100, 125 mm CPE and irrigation at 10 days and sub plots treatment comprised of 3 mulches *viz.*, no mulch, straw mulch and polythene mulch. The gross plot and net plot size was 6.00 m x 4.80 m and 5.10 m x 4.20 m, respectively. The crop was dibbled on February 2, 2000.

The micrometeorological observations were recorded on soil moisture, soil temperature, canopy temperature, spectral characteristics, stomatal conductance, resistance and transpiration of summer groundnut. The observations were recorded just before the schedule of irrigation and 48 h after irrigation. The diurnal pattern of stomatal conductance and transpiration was recorded at 0600, 0800, 1000, 1200, 1400, 1600 and 1800 h with the help of LI-COR 1600 steady state porometer at the initiation of branching, 50% flowering, pod development and at harvest stage. The biometric observations were recorded from 28 days onwards at an interval of 14 days.

The mean seasonal soil temperatures at 5 and 15 cm depth were comparatively more under irrigation scheduled at 125 mm CPE followed by irrigation scheduled at 100 mm CPE. There was no much variation in mean seasonal soil temperatures between 75 mm CPE and irrigation scheduled at 10 days interval.

Seasonal changes in canopy temperature and canopy -air temperature differential indicates that these values were the highest before irrigation and the lowest 48 h after irrigation. The values of these temperature were comparatively higher under stressed conditions of irrigation scheduled at 125 mm CPE followed by 100 mm CPE.

It was observed that stomatal conductance and transpiration rates decrease with increase CPE values. Whereas, stomatal resistance showed reverse trend. The abaxial stomatal conductance was more than adaxial. Whereas, resistance showed reverse trend. The transpiration rate was identical under irrigation scheduled at 75 mm CPE and 10 days interval but it was comparatively more than 100 and 125 mm CPE at all the days of observations.

The reflectance in blue, green, red and near infrared wave bands was significantly low under irrigation scheduled of 75 mm CPE than 125 and 100 mm CPE particularly during the advanced crop growth stages indicating more absorption of energy.

In general, stomatal conductance was low in early morning, rise gradually to the maximum value about 12 h coinciding with solar noon and decrease in the afternoon. Stomatal conductance was increased from branching to harvest. The transpiration rate on the abaxial leaf surfaces exceeded that on the adaxial leaf surfaces. Transpiration rate also peaked at 12 h coinciding with solar noon. The stomatal conductance and transpiration rates were the least under 125 mm CPE followed by 100 mm CPE and 75 mm CPE and 10 days interval.

In important biometric attributes *viz.*, plant height, number of branches, leaf area and dry matter plant^{-1} and yield contributing characters *viz.*, number of pods, and their weight per plant and 100 kernel weight were significantly more under scheduling of irrigation at 75 mm CPE followed by 10 days interval and 100 mm and 125 mm CPE. However, irrigation scheduled at 75 mm and 100 mm CPE and 10 days interval were found at par with each other but significantly increased dry pod and creeper yields and harvest index as compared to scheduling of irrigation at 125 mm CPE. The number of irrigations applied under 75 mm and 100 mm CPE and 10 days interval were 9,7 and 9, respectively. But no significant differences were noticed in pod and creeper yields in these irrigation schedules indicating that summer groundnut can be irrigated at 100 mm CPE for economizing the water use.

The evapotranspiration values under different irrigation schedules ranged between 400.33 mm and 630.30 mm and the water use efficiency between 3.02 and 4.13 $kgmm^{-1}ha^{-1}$. The water use efficiency was the maximum (4.13 $kgmm^{-1}ha^{-1}$) under irrigation scheduled at 100 mm CPE.

The mean seasonal soil temperature was more under polythene mulch followed by no mulch and straw mulch. It was also observed that seasonal canopy temperature and canopy –air temperature differential values remain higher under polythene mulch than no mulch and straw mulch. These values also more under no mulch than straw mulch.

The stomatal conductance of abaxial surfaces was more than adaxial sufaces under all the mulches. The stomatal conductance of both abaxial and adaxial surface was more under polythene mulch than no mulch and straw mulch. However, reverse trend was observed for stomatal diffusive resistance, where the values were more under no mulch followed by straw mulch and polythene mulch. Transpiration rate was comparatively more under polythene mulch followed by straw mulch and no mulch owing to availability of adequate soil moisture for evaporative demand.

The reflectance in blue, green, red and near infrared wave band was significantly low under polythene mulch than no mulch and straw mulch on most of the days of observations indicating more absorption of energy in these wave bands under polythene mulch.

The stomatal conductance and transpiration rate in diurnal pattern was more under polythene mulch followed by no mulch and straw mulch at branching, 50% flowering, pod development and harvest stages.

The important growth attributes *viz.*, plant height, number of branches, leaf area and dry matter per plant were significantly more under polythene mulch followed by straw mulch and no mulch at all the days of observations. The number of nodules and their weight per plant was also significantly more under polythene mulch than straw mulch and no mulch at branching, 50% flowering and at harvest. The important yield contributing characters *viz.*, number of pods and their weight per plant and 100 kernel weight were significantly the highest under polythene mulch and significantly the lowest under no mulch.

The application of polythene mulch (7 micron) to summer groundnut significantly increased pod and creeper yields as compared to straw and no mulch. The straw mulch of sugarcane trash gave significantly more pod and creeper yield than no mulch.

The irrigation scheduled at 100 mm CPE and application of polythene mulch produced significantly the highest pod yield (29.18 qha^{-1}) and it was at par with irrigation scheduled at 75 mm CPE with polythene mulch.

The evapotranspiration under different mulches varied from 492.44 to 565.33 mm. The water use efficiency was the highest under polythene mulch (5.12 $kgmm^{-1}ha^{-1}$) followed by straw mulch and no mulch indicating that water is most economically utilized under polythene mulch. It would be, therefore, advisable to use polythene mulch to summer groundnut for maximizing of the pod yield and economizing the water use.

5.2. **Conclusions :**

1. The soil temperature, canopy temperature and canopy–air temperature differential values were less under 75 mm CPE followed by 10 days interval, 100 mm and 125 mm CPE. Whereas, stomatal conductance and transpiration rate showed reverse trend. The reflectance in blue, green, red and near infrared wave band was significantly less under 75 mm CPE and 10 days interval than 100 mm and 125 mm CPE irrigation schedules indicating better moisture availability under former irrigation schedules.
2. The irrigation scheduled at 75 mm and 100 mm CPE and 10 days interval were found to be at par with each other but, significantly increased dry pod and creeper yields and harvest index as compared to scheduling of irrigation at 125 mm CPE. The number of irrigations applied under 75 mm and 100 mm CPE and at 10 days interval were 9,7 and 9, respectively but no significant differences were noticed in pod and creeper yields of these irrigation schedules indicating that summer groundnut be irrigated at 100 mm CPE for economizing water use. The evapotranspiration

under 100 mm CPE was 492.31 mm with the maximum water use efficiency 4.13 kg $mm^{-1}ha^{-1}$.

3. The soil temperature, canopy temperature, canopy–air temperature differential were higher under polythene mulch followed by no mulch and straw mulch. Stomatal conductance and transpiration rates were comparatively more under polythene mulch followed by straw mulch and no mulch. The reflectance values in blue, green, red and near infrared waveband were significantly lower under polythene mulch than straw mulch and no mulch indicating more absorption.
4. The pod and creeper yields increased significantly under polythene mulch as compared to straw mulch and no mulch. The water use efficiency was also the highest under polythene mulch (5.12 $kgmm^{-1}ha^{-1}$) indicating that the water is most efficiently utilized under polythene mulch. It would be therefore, advisable to use polythene mulch to summer groundnut for maximizing pod yield and economizing water use.

The above conclusions, however, are based on one year's results. For confirmation of these results, the investigation needs to be repeated.

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6. LITERATURE CITED

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in

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